Systems Engineering Portfolio

SYSE 590 Integrative Workshop

Portland State University
Systems Engineering
Matthew Nguyen
Spring 2007

Revision A3 Updated May 28, 2007

Contents

1.0 Systems Engineering Background

Portland State University's Systems Engineering program allows practicing engineers to integrate their disciplines in the development of complex products and processes while focusing on customers' needs throughout the product life cycle of design, testing, manufacturing, operation, and future product planning. Systems Engineering enhances time, cost, and performance by integrating multiple disciplines and providing quantitative methods for business and technical decision making.

This type of focus helps define the needs of a system and required functionality early in the development cycle. The design synthesis and system validation is then accomplished while considering the complete problem. The number of elements considered during analysis includes the following:

- Operations
- Performance
- Test
- Manufacturing
- Cost & Schedule
- Support
- Disposal

The integration of all the disciplines and specialty groups into a team effort form a structured development process that proceeds from concept to production to operation. This implementation enables engineers to function in an interdisciplinary fashion while allowing application of their area of engineering specialty toward a global encompassment of development of a product, process, or service, rather then just one specific part.

1.1 Learning Objectives

The Systems Engineering Department's learning objectives for this program include the following abstracts:

- To improve the students' ability to engineer complex products, processes, or services.
- To develop the students' understanding of basic systems concepts and their application to the engineering life-cycle.
- To develop the students' understanding of key systems engineering skills, including team building, communication, synthesis & creativity, problem solving, management of time and resources, database management, and life-cycle viewpoints.
- To build on the students' existing knowledge and project experiences by providing additional domain specialization or project management tied to systems engineering skills.

2.0 Abstract Study Plan for the SYSE Program

A personal study plan objective for the System's Engineering program is to fully understand and utilize the learned systems engineering methods and to apply these methods to current engineering processes. This involvement of integrating systems engineering shall provide for a stronger foundation of analysis and implementation throughout a product or system's life cycle.

2.1 Schedule Outline

General Requirements

The course of study requires 45 credits all taken at the graduate level. The student will be under the supervision of the Director of Systems Engineering, and a faculty advisor from his department of specialty, and an industry advisor knowledgeable with the student's internship/project experience. Core courses will introduce the student to systems methods and its tools. Elective courses will provide advanced domain knowledge mostly in the student's area of specialty. Courses from other departments will enable the student to apply this domain knowledge in an interdisciplinary, integrated manner. The internship/project will be a capstone experience combining both systems engineering and domain-specific approaches in the engineering of a complex system.

The following list of program courses are iterated from Portland State's SE website: http://www.cecs.pdx.edu/Systems/program/masters.html:

Core Courses (Total of 16 Credits; Revised for different CORE classes)

SYSE 591 Systems Engineering Approach 4
EMGT 540 Operations Research.. 4
One of 3 modeling classes
    SYSC 514 System Dynamics.. 4
    SYSC 527 Discrete System Simulation... 4
    SYSC 529 Process Modeling and Simulation 4
SYSE 573 Requirement Engineering.. 4

Elective Courses (Total of 16 Credits)

Each student will be under the advisement of the Director of Systems Engineering and a faculty advisor from one of the following departments: Civil Engineering, Computer Science, Electrical & Computer Engineering, Engineering Management, Mechanical Engineering, and System Science. Elective courses will come from any one of these PSU departments based on a plan of study agreed upon by both advisors and the student. Courses from other universities may be acceptable, as evaluated on a case by case basis, and up to a limit of 15 credits. Systems Engineering courses are also available as electives.

Systems Engineering courses are also available as electives. Internet courses at the present are:

- SYSE 561 Logistics Engineering
- SYSE 510RSK Select Topics, Reducing Risk in Decision Making
- SYSE 510RM Select Topic, Reliability and Maintainability
- SYSE 595 Hardware-Software Integration

Projects/Internships (Total of 9 Credits)

Each student will participate in an industrial experience either as part of a formal internship (SYSE 504) or as part of an industrial project (SYSE 506). These industrial experiences will involve the student, faculty advisors and an industrial advisor. The internship may be full time or part time with nine months of full time employment earning 9 credits. The internship/project must encompass systems level considerations as applied to a product, process or service requiring knowledge from multiple engineering disciplines.

Integrative Workshop (Total of 4 Credits)

A total of four credits of interactive workshop between faculty advisor and student are required. The student will be guided to consolidate their project experience and knowledge from elective courses with concepts from their systems engineering core courses. This interaction could be conducted on-line through the Internet in SYSE 590 Integrative Workshop (IW). Two important concepts in Systems Engineering are integration and management of interfaces, related to both physical components and product development process. The objective of IW is for the student to exercise these concepts as applied to their course work and project work. The workshop will span the student's entire program under the guidance of an advisor, thus giving the time to achieve several goals. One, the student is given feedback as they apply discipline skills in systems settings. Two, the student will be asked to reflect on past approaches as it relates to newer more advanced systems skills. Third, the IW will review systems topics over several terms, thus reinforcing their use. In this way, behavioral change, from engineering specialty thinking to systems engineering thinking, will be achieved. The program also benefits because students continuously assess how well all courses INTEGRATE to achieve Systems Engineering education goals. Workshops will culminate in a student portfolio summarizing the academic knowledge and practical experience students gained while in the Systems Engineering program.

2.2 Progress Report

Currently, the courses I have taken in the program have helped me approach problems in a more systematical and analytical manner. What this translates to being able to look at problems and decomposing them in such a way that a solution or approach can be more easily realized. This entails properly defining requirements and what it takes to fulfill them. The list of fulfilled courses is outlined in the following table, *Table 1 – SYSE Courses*:

Table 1 – SYSE Program Schedule

Year	Course	Credit Type	Course Title	Fall	Winter	Spring	Summer	
2003	SYSE 591	C	Systems Engineering Approach	4				
	SYSE 561	E	Logistics Engineering		4			
	SYSE 595	E	Hardware and Software Integration		4			
	SYSE 575	E	Reducing Risk in Decisions			4		
2004	SYSE 590	C	Integrative Workshop	1				
	SYSE 510	E	Systems Security Interface Engineering	4				
	SYSE 590	E	Integrative Workshop			1		
	SYSE 573	E	Requirements Engineering			4		
2007	SYSE 590	C	Integrative Workshop			1		
2008	*EMGT 540*	*C*	*Operations Research in Engineering Management*	*4*				
	SYSC 514	*C*	*System Dynamics*		*4*			
	SYSE 590	*C*	*Integrative Workshop*	*1*				
	SYSE 506	*C*	*Masters Project*		*3*	*3*	*3*	
				14	15	13	3	45

The following is a forecasted list of core Systems Engineering are to be taken in the future (items in italics in Table 1):

Core Courses:

SYSC 514 Systems Dynamics
EMGT 540 Operations Research in Engineering and Technology Management
SYSE 590 Integrative Workshop
SYSE 506 Masters Project

2.3 Assessment

SYSE 591: Systems Engineering Approach (4 credits)
Professor: John Blyler
Engineering of complex hardware, software systems encompasses quantitative methods to understand vague problem statements, determine what a proposed product/system must do (functionality), generate measurable requirements, decide how to select the most appropriate solution design, integrate the hardware and software subsystems and test the finished product to verify it satisfies the documented requirements. Additional topics that span the entire product life cycle include interface management and control, risk management, tailing of process to meet organizational and project environments, configuration management, test strategies and trade-off studies. Prerequisite: Consent of Instructor.

This first course of the program really showed how much a "systems" approach to a design or problem can really result in a more thorough and accurate solution. Part of the course was to apply methods of learning (active learning) to help achieve a complete understanding of the subject matter. I came to appreciate this because it really does work, as exemplified by my application of this methodology today.

SYSE 595: Hardware-Software Integration (4 credits)

Instructor: John Blyler

Systems Engineering is applied to the integration of hardware-software systems, focusing on embedded computer products development and information technology systems. Factors that affect the selection of hardware and software solutions in design will be examined, as well as the use of trade studies to optimize the efficiency of integration issues. Techniques for partitioning of system-level functions and requirements to hardware/software components will be provided, as will practical guidance, through case studies, process templates and design check-lists. Prerequisite: Basic understanding of hardware and software development.

The following is an excerpt of a message I posted in the course's bulletin board. It described what I felt hardware/software integration meant:

> "From what I see, systems engineering plays an intricate role in the integration development in that it allocates and then effectively combines the necessary functions across both hardware and software platforms. You can't assume that the two be developed independently and by some magical process, be integrated. Hardware, which never acts as predicted, cannot be cured by simple software changes. Typically in the design process, integration is accomplished in the late stages and can influence a lot of consequences to the design process, most noticeably: cost and schedule. Systems engineering relieves this by decomposing and interpolates before complex problems are discovered, which a lot of times is towards the end of a process, translating to big overhead for engineering costs.
>
> Though systems engineering is reiterative and time-consuming, most corporations employ it just because it truly does optimize costs and schedule in the long-run. It leads to more efficient implementations while improving overall system performance, reliability and cost effectiveness."

SYSE 575: Reducing Risk in Decision Making (4 credits)

Instructor: John Blyler

This special topics course will examine the concepts, techniques and tools for managing risk and making decision as key components of the systems engineering process. In this course, risk connotes a measure of the probability and severity of an undesired event. This course begins with an overview of the risk management (identifying, assessing, monitoring, and mitigating) and decision process. Differences between mission critical and non-mission critical programmatic risk will be emphasized. Other topics include the limits of expected value-based risk analysis, decision making strategies such a max/min, min/max and regrets. Formal methods in risk analysis, elementary decision analysis and decision trees, multi-objective decision making, pareto techniques, optimality, and trade-off analysis will be covered. Risk and decision techniques will be contrasted with the interfacing processes of program management and software engineering, from both the government (DOD) and industrial perspectives.

SYSE 561: Logistics Engineering (4 credits)

Instructor: Benjamin Blanchard

This course will concentrate on logistics from a systems engineering perspective. Systems will include a mix of products and processes, materials, equipment, software, people, data, information, and services, within some form of hierarchy. The design for supportability/serviceability, the production and effective distribution of customer use, and the sustaining maintenance will be addressed on a total system life-cycle basis, with particular emphasis in the early phases of the development of new systems and/or reengineering of existing systems. Prerequisites: Basic knowledge of systems engineering concepts and statistics.

SYSE 510: Systems Security Interface Engineering (4 credits)

Instructor: Ike Eisenhauer

Interface management and integration engineering are two primary functions of Systems Engineers. These functions are becoming more and more important as the systems we design become more and more complex. This course covers the systems engineering approach to integration and interface management of complex systems. For application, this course concentrates its examples on the concerns of integration and interface management of human and automata security principals. While much the current concepts surrounding security apply to "information security" (ISEC) this course treats ISEC as only one of the vast application areas for security. Course goals include: Developing an understanding of system security issues, learning how to manage integration and interfacing of systems and system components, apply Systems Engineering Techniques to System Security Design, view Security Policy Development as a Systems Engineering Evolution, and learning techniques to manage risk inherent in system security issues.

SYSE 590: Integrative Workshop (1-4 credits)

Professor: Herm Migliore

Systems Engineering is an acquired behavior to be developed throughout the Masters degree program. Students and faculty advisors will engage in creative workshop activities integrating technical specialty skills and project experience invoking systems engineering applications of communication, synthesis and creativity, team building, problem solving, management of time and resources, and system life-cycle thinking. A student portfolio will document the program plan and document that the desired behavioral change is taking place. Prerequisite: Consent of Instructor Hours of credit: Total of 4; variable each term.

With just the required "portfolio" for this course, I can see how systems engineering can and should be used in practical application. Fulfilling the requirements for this portfolio thus far, including program and courses evaluation and assessment, defining objectives, and reflection of methodology, is a true statement of systems engineering in that "no stone is unturned". In essence, this thoroughness and completeness achieves a higher level product.

SYSE 573: Requirements Engineering (4 credits)

Instructor: Dorothy McKinney

This course provides the knowledge and skills necessary to translate needs and priorities into system requirements, and develop derived requirements, which together form the starting point for engineering of complex hardware/software systems. The student will develop an understanding of the larger context in which requirements for a system are developed, and learn about trade-offs between developing mission needs or market opportunities first versus assessing available technology first. Techniques for translating needs and priorities into an operational concept and then into specific functional and performance requirements will be presented. The student will assess and improve the usefulness of requirements, including such aspects as correctness, completeness, consistency, measurability, testability, and clarity of documentation. Case studies, many involving software-intensive systems, will be used.

3.0 Program Reflection

3.1 Relationship of Past and Newly Learned Systems Fundamentals

Prior to entering this program, any "systems engineering" fundamentals I believe I have learned through schooling were only generic fundamentals and engineering philosophies that were adopted from the outline of courses and methods of application. The inherited methodology I feel served as a baseline to this systems engineering program as its philosophy extrapolated from assumed fundamentals and built a more concrete and more defined systems approach to whatever design or problem at hand. The "tools" I learned would help any engineer approach or analyze a problem in a more efficient way, make decisions based on a more accurate analysis of quantitative and qualitative data while considering all types of risks and alternatives, and understand more clearly the criticalness of the many facets of a system's or product's life cycle. I look forward to building this foundation in the upcoming courses (both core and electives) as I see how beneficial and essential the systems engineering fundamentals are as applied to any engineering discipline and to any practical application.

3.2 Relationship of the Domain Knowledge from Electives

3.3 Use of System Concepts

The utilization of system concepts is critical in that it helps achieve an optimal system or product, both in costs and design. This system engineering philosophy helps develop and establish insurance that the overall objective of the design is met.

To achieve these requirements, System Engineering methodology involves all phases of the "system loop", from the initial identification of the requirements to the final satisfaction of the customer's requirements and expectations.

The "system loop" is outlined in the following figure, *Figure 1 – System Loop Functional Flow Diagram:*

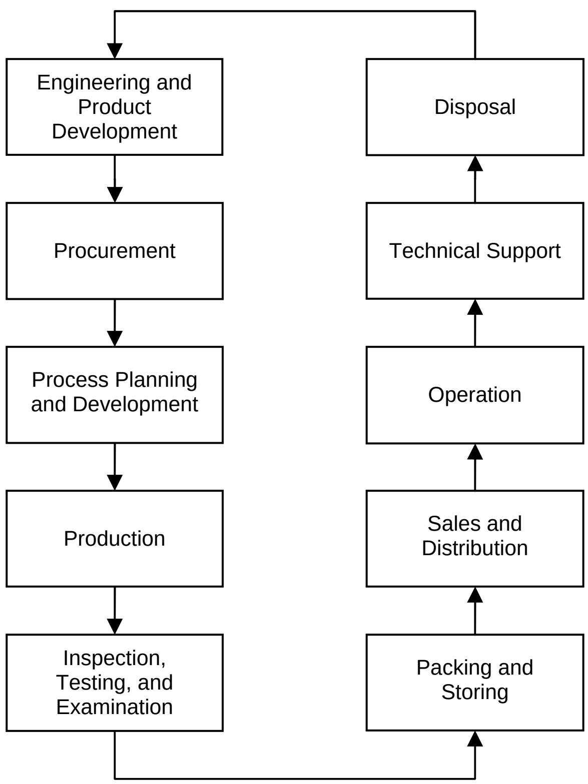

Figure 1 – System Loop Functional Flow Diagram

4.0 Project - Application of Systems Engineering

4.1 Objectives Definition of the Project

As part of the SYSE 506 Project and degree completion, I will be applying learned system methods to develop a successful outsource engineering program in my company. This will be based on outsource engineering and the systems needed to make a program successful, the decomposition on why or why not firms are using them, the metrics used to measure the needed results, and so forth. Previously, my SYSE 506 project was towards an ISO 9001:2000 implementation and certification.

Here's a quick summary on outsource engineering as to what it is today. Outsource engineering has taken a similar direction with outsource manufacturing in that firms are continually competing with each other to reduce product costs in order to stay competitive. The typical salary of an offshore mechanical engineer is $12,000. Compare those wages with those in the U.S., where the average wage for a mechanical engineer was approximately $67,430 in 2003, according to the U.S. Bureau of Labor Statistics. With labor rates at approximately 1/5 of the salary required here, it's difficult to argue why engineering work shouldn't be sent overseas.

Another benefit to outsource engineering besides costs is improving a firm's flexibility in their engineering department. Contract engineering can be used for tasks that are more defined, such as detailing a drawing, programming scripts with a known single or multiple design intents, MRP/ERP work, etc. This allows the mainstay engineers to focus on potentially more complex and dynamic issues that require practical knowledge and experience. Soft engineering skills are also what can differentiate engineering groups. Product design, customer support, project management are some of the soft engineering skills that 1) require practical experience and 2) are more difficult to duplicate. So, by having several "work forces" on a single project, delay in project delivery can be minimized greatly.

For this project, the fundamental basis of FRAT will be used to analyze the requirements needs for engineering outsourcing all the way to the satisfaction of the stakeholders' expectations of final output. The focused approach is important so that any misalignment of output can be repaired at the onset of the evaluation of outsource engineering needs as well as during. At this time, we can also seek for alternatives should some pieces not fit with the expected yield. The main portions of this system analysis of a outsource engineering program involves the following:

1. Analyzing the basis for outsource engineering.
2. Defining a process that will satisfy all stakeholders.
3. Finding alternatives of outsource engineering firms and making the decision on which fits best with the company's objectives.
4. Defining metrics to measure output.

(Possibly more main objectives will be added if found important during the initial analysis).

In any case, to accomplish the above objectives mandate a systematic approach. This is to develop the processes that undertake known issues that may deter the effectiveness and quality of an outsource engineering program. By doing this, engineers and program management and outsourced engineering groups can successfully work together.

Typical means to alleviate or forecast potential problems is optimizing system or project architecture to their maximum before actual implementation. Also what can be done is applying a high focus concentration in the analysis to effectively minimizing total cost and maximizing work output schedule. A mature and well-defined program with the proper lines of communication will achieve this. A program, should a company sees that outsource engineering “makes sense”, should be correctly developed to establish principles, requirements, and practices that effectively protect an organization from problems resulting in poor processes, inadequate resource planning, and a delay in schedule of engineering projects.

4.2 Measurement of the Project Objectives

4.3 Project Implementation

Outsource Engineering Workflow

The following function flow diagram is the expected process loop for an outsource engineering task (Figure 2):

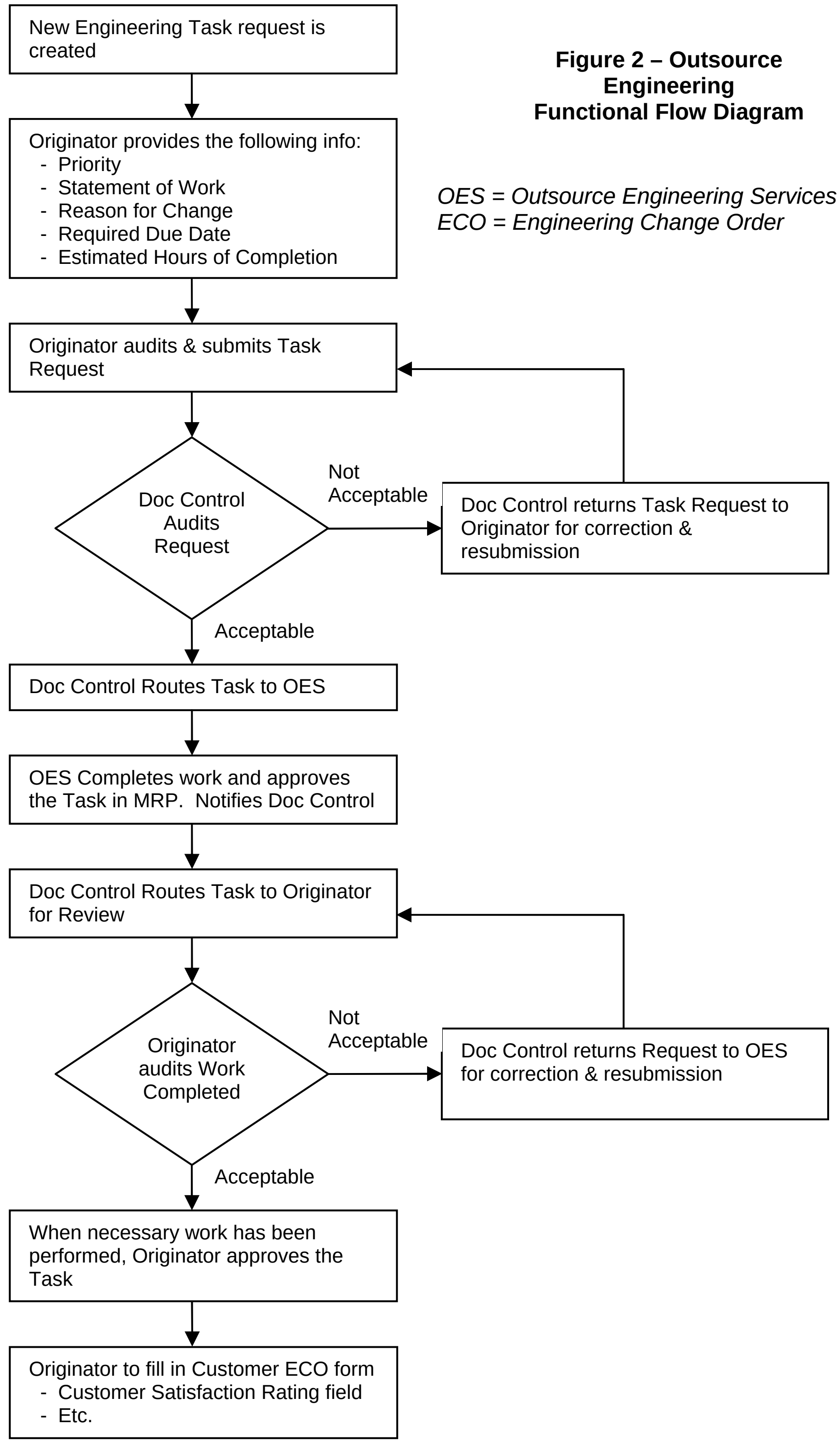

Figure 2 – Outsource Engineering Functional Flow Diagram

OES = Outsource Engineering Services
ECO = Engineering Change Order

4.3 Project Evaluation

5.0 Bibliography

http://www.eas.pdx.edu/Systems/program/index.html, "About the Systems Engineering Program"

Blanchard, B.S., Logistics Engineering And Management, 5th Edition, Prentice Hall, Upper Saddle River, NJ 07458, 1998 (ISBN 0-13-905316-6).

http://www.eas.pdx.edu/Systems/program/descriptions.html, "Course Descriptions"

http://www.eas.pdx.edu/Systems/about.html, "What Is Systems Engineering

6.0 Portfolio Revision History

Ver	Rev	Date	Description of Changes	Originator
A	01	12/4/03	Initial Version A	M. Nguyen
	02	6/02/04	Updated program schedule; added more reflection notes on completed courses; added abstract of project as applied to SE concepts as well as definition and measurement of objectives	M. Nguyen
	03	5/28/07	Revised Section 2.2 for program schedule and expected schedule; Revised Section 4.0 for different project outline	M. Nguyen