Integrative Workshop SYSE 590

Scope:

This document provides a basic synopses of the courses I completed at Portland State University towards my Master’s degree in Systems Engineering. A description of the course is provided as well as the information I gleaned or considered of important in my field. I think it is important for everyone to recognize that as the field of Systems Engineering grows it will develop certain specialties much as Mechanical and Electrical Engineering fields have from when they started to the present day and time. Thus the information in these courses is broad and has many potential applications and what I may consider of key points is not what another may consider based on their background or intended application of the material covered.

Systems Engineering Approach (SYSE 591)

Course Description:

This course covers 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. (per PSU Website Description)

Content:

This course covers the basics of what systems engineering is and how it is applied to complex systems. The course demonstrated how complex systems can be broken down into categories or hierarchies for development and analysis. Technologies’ impact on development and integration of systems was cornerstone of the content of the course and its implementation should be considered. Planning for technologies through development phases and how reviews for these development activities can be addressed and their importance is also covered. The purpose of this course is to define for students the various aspects and considerations of a complex system and the role systems engineering has in breaking these down into manageable technologies or activities for development.

Course Reference Material:

- Systems Engineering Fundamentals [US Department of Defense]
Closing:

The course title is highly accurate for what is covered in the material. This course was highly enjoyable as it evoked a lot of higher level in the approach to engineering to address a systems development. This course highlights a real area of expertise that will be expected out of a systems engineer in that a complex system will need to be broken down into core components to develop, and how that can be accomplished. Additionally it emphasized the importance of a systems engineer to be able to develop not only the planning of engineering effort to translate that planning effort into work item that project or program management can utilize. System Engineers also need to understand how incorporating new technologies can impact the system being considered. This was an excellent course and very relevant to systems engineering in practice based on my experience. I also found the discussion topics for the class enjoyable and informative as well.

System Dynamics (SYSE 514)

Course Description:

This course is a lab and web-based program that introduces the student to the study of the dynamic behavior of continuous systems containing feedback. Building computer models of feedback systems and using the models to study the dynamic behavior of the modeled system in order to enhance understanding, predict how the system might behave under different circumstances, or find ways to improve the "performance" of the system. Such models are often used for forecasting, planning, and process analysis in business systems; for studying growth and homeostatic processes in various scientific disciplines; and for studying feedback control systems in engineering. The models are continuous in nature, and are expressed mathematically as a set of differential equations for various "state" variables. These equations are numerically integrated by the software package in order to simulate behavior over time. The student's time is spent learning how to formulate, calibrate, and explore the dynamic behavior of such models. (per PSU Website Description)

Content:

This course looked at how dynamic systems could be modeled and to understand how influences can affect a system over time. By using models based in mathematics the sensitivity of a systems to certain influences can be ascertained. Things like feedback loops, thresholds, and other factors are explored in the model creation. The course builds from simple models to progressively more complex ones culminating in the final class project. The course content also looks at how these models and expressions can be applied to a broad range of systems.

Course Reference Material:

Closing:

This course was an eye opener and one that I recommend to anyone in a business management related program outside of just systems engineering. The course may pull on math but the equations themselves needed to simulate a system are not overly complex or demanding. What the course teaches that I think is especially lost on business management is that everything is a system at some level and what you do to one part may affect another part of the system. What policies a company undertakes or imposes can have far reaching impacts, this course was excellent in showing how these impacts can be modeled and the time scaling that needs to be considered. People and organizations are as much a system as a computer and this class helps invoke a new way of thinking about the actions you may take and how to try and anticipate that outcome. Sometimes something that would seem inconsequential may in fact have a far reaching impact; hence the old saying of snowballs turning into avalanches. The course showed how making a tweak to the system for a short term gain can have long term cost many times that of the short term gain. I enjoyed this class a lot and the critical thinking skills that it taught.

Requirements Engineering (SYSE 573)

Course Description:

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. (per PSU Website Description)

Content:

The focus of this course was requirements and development of the requirements needed for the development of a product. This course looked at the way in which in which requirements can be written or derived such as technology driven or customer need driven. It also covered some of the issues that can occur with requirement development especially in communication and documentation.

Course Reference Material:

- Requirements Engineering: Fundamentals, Principles, and Techniques  
Closing:

While this course was somewhat abstract I enjoyed it greatly and from my experience as an engineer touched all the key points regarding requirements. Often it is forgotten that abstract thought is required in engineering development. Requirements help solidify that abstract thought into something tangible that can be developed and created. Communication of requirements and understanding their intent is a major issue this course highlighted that and gave practical information on how these things can be addressed. Though the class was on just requirements it is a broad subject as it deals with how things are communicated, negotiated, developed, and proven. The discussion topics for the class were very good and further expanded and brought insight into the course material. The course project helped pull together the concepts we learned about and discussed and was very appropriate. I think the key points this course highlighted were the difficulty in properly communicating requirements and their intent and that requirements do change and evolve with the project and development process. This course is relative to anyone who is in engineering or manages engineering projects; the content of this course will only improve your abilities in those roles and help with success.

Hardware – Software Integration (SYSE 595)

Course Description:

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 well as practical guidance, through case studies, process templates and design check-lists. Prerequisite: Basic understanding of hardware and software development. (per PSU Website Description)

Content:

This course was focused at the time I took on electronics embedded engineering on a large production line design implementation level. It covered things like the programming languages and types of microchips used and their material properties and some of the tradeoffs that would occur for using one or another on levels of thousands or millions of unit builds. This course covered details down to the electronics board strata and gate logic used in microcontrollers.

Course Reference Material:

- NASA Complex Electronics Guidebook for Assurance Professionals
- The Design Continuum: Design Styles [Nadamuni / Smith] SOFT-WW-DP-0065
Closing:

I know this course was revamped significantly since I took it so I would still encourage that it be taken based on the changes that I know have been implemented. The course required one to have a fairly good background in embedded engineering and software code writing. This is where I think the issue occurred for me and the course, as I wanted to take a high level systems approach and learn about software, hardware, and electronics integration and tradeoffs from that level. From my background most American industry is not producing high technology products in the hundreds of thousands or millions anymore with some exceptions like Intel. For me this course was directed more so at the specialized field of embedded engineering and not the systems engineering level. Does a Systems Engineer need to have some familiarity with this material? Absolutely, if they are going to be engaging engineers in this field and communicating with them on how to address development needs and concerns for a fully integrated product. However a systems engineer can’t be specialized in my opinion to the extent presented, they need to rely on these specialized engineers to handle the details and help them make the big picture decisions. Systems engineers need to be able to think (for example) how all the parts of an aircraft are going to work together at a module/sub-system level, not what microcontroller is used in the avionics display. With that said for an electrical or software engineer that is involved in embedded systems and looking to advance themselves this is a great course, for a mechanical engineer looking to understand engineer disciplines outside their own to be a better systems integration engineer this course may not be what you are looking for.

**Systems Engineering Management (SYSE 510MP)**

Course Description:

This course covers the essentials of systems engineering management and its critical interconnection to program/project management. Systems engineering is the integration of several engineering fields into an efficient and effective process for the overall technical management of programs and development of systems and products. Students will gain detailed knowledge in management techniques applicable to activities within Systems Engineering, including trade-off studies, technical performance measurement, cost-effective process tailoring, technical reviews and audits, and others. Several case studies projects will be studied throughout the course to illustrate key concepts and management techniques. [per PSU Website Description](https://example.com)

Content:

This course covered a broad array of items and topics that go into planning and development of a project and the many things that need to be considered as part of that process. This included whether the organization was Functional, Project, or Matrix based for personnel resources and how projects need to calculate the costing of personnel resources. Analysis of the project plan was also included in how to weight items and account for them during the planning phase, and the intended life cycle of product being developed. The course material also presented system design decision processes for
evaluating the both the design and technology paths that could be under consideration. Capability road mapping and organizational thinking with respect to design development and resource/personnel development concepts are also presented as part of the course material.

Course Reference Material:

- Essentials of Project and Systems Engineering Management
- Systems Engineering Principles and Practice

Closing:

There were several other topics covered other than the ones listed above in the course content, however I fell these were the major topic points. This course is listed as an elective but in my opinion it should be a core class of the program. The topics covered are ones that will inevitably encountered by a Systems Engineer during the course of their career. It brings to light the view and items that project/program managers will be concerned with and will expect a systems engineer they are working with to help with. Also it is my experience that systems engineers are often tasked with managing at least small projects so knowing how to plan and account for some of the items associated with a project plan is good back pocket information to have. As a systems engineer it may be come your responsibility to facilitate a design path for development this not only means taking into account technical concerns but potential business concerns as the course covers. This is a solid course and based on my experience in the field very relevant to systems engineering and as such I would recommend this course to anyone planning to study in this program as the elective to take.

**Operations Research in Engineering and Technology Management (EMGT 540)**

Course Description:

Resource optimization is studied through mathematical programming. Emphasis is placed on applying linear programming, and goal programming to engineering management decisions. Problem formulation, mathematical model building, basic principles behind the Simplex algorithm, and multiple objective linear optimization via goal programming are included in the course. Post-optimality analysis is studied from the viewpoint of technology management. ([per PSU Website Description](#))

Content:

This course looked at how to solve problems of efficiency based on statistical modeling. Database programs and tools such as Excel are used to capture relevant data to the problem and then mathematical equations are applied to present a potential solution or series of solutions. This course explores critical thinking techniques, how to express problems using mathematical terms, and how to
model solutions. Course material showed how engineering and business plans could be improved by modeling the problem trying to be solved and applying mathematics to help determine a best fit solution.

Course Reference Material:


Closing:

This course was challenging and rewarding for me and helped me understand new ways in which to look at solving problems in a more logical way. One of the best examples of this was how inventory could be arranged in a warehouse relative to shipping doors and docking of trucks that would be delivering certain goods from that warehouse. Applying the model showed how efficiency gains could be made and what a potential cost savings could be based on the data entered in both time and money. The courses challenge was in beginning to think about what the problem that really needed to solved was and how to express that problem. This required good critical thinking skills. The other challenge was in creating a mathematical equation for the problem, this requires some brushing up on those algebra and differential equation skills that may have gotten a little rusty. The concepts and problem solving techniques presented in this course are very relevant to today and how businesses are moving large corporations like UPS are already using this extensively. This is not say that you can apply this to all problems from the ground up but as we learned from our class project it can help feed into the more hands on decision making and problem solving that people engage in.

Reducing Risk in Decision Making (SYSE 575)

Course Description:

This 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. (per PSU Website Description)
Content:

This course explains the different types of risks that can be indentified and how to categorize them and develop mitigation plans. The key element with risks is to understand their contributing factors and how those factors can be monitored and planned for and around for execution of any mitigation plan. This Course covers how mathematics can be applied to a risk to determine its likely hood of occurring, this along with a known severity impact of the risk occurring allows for decisions to occur on whether the risk is worth pursuing or not. Understanding critical paths of a project and the economic impact of an issue and the risk of that issue occurring are important in business decision making. This course helps define a logical approach to risk identification and assessment practices that can be applied to any subject or project.

Course Reference Material:

- Risk Assessment and Decision Making in Business and Industry (2nd Ed) [Koller] ISBN 1584884770
- Probabilistic Risk Assessment Procedures for NASA Managers and Practitioners (Version 1.1) [Stamatelatos]

Closing:

This course did an excellent job or explaining why risk planning is so important to planning and decision making and provide many real life types of examples. This course provided clear and simple to complex modeling of risk assessments from contributing factor diagrams to the use of Bayesian Analysis and Monte Carlo Modeling. This course showed how risk will always exist but it can be mitigated or the likely hood of it occurring can be reduced with proper planning. One of the great aspects of this course from my perspective was how it presented probability of occurrences in making decisions. Using the probability of various things from people to resources being available when needed to complete a project at different phases really showed a new and unique to look at risks and determine what might likely occur to make informative decisions for planning of things like project timelines. This course in my opinion is not only good for systems engineers who may need to run such assessments for things they may be in charge but project and programs managers. If time in planning phases was allowed to for some if these types of risks assessments to occur projects would be in a far better place for execution

Reliability Engineering (EAS 561)

Course Description:

Failure is a fact of engineering. No product or system can be assumed to work correctly 100% of the time. The engineering effort to even attempt to design such a system would be both time and cost prohibitive. In light of that, the reliability of systems cannot be ignored and must be studied to ensure,
at least, we grasp the reality we are dealing with. This course provides an in depth study of the engineering and management of the reliability space. Including describing and quantifying reliability, as well as examining the modeling, test design, trade off analysis required of engineers involved with products and systems that do not perform 100% correct at all times. (per PSU Website Description)

Content:

This course utilizes statics and probability to examine chances of occurrences of failure and how that data can be used to make assumptions about an engineering design, manufacturing process, support and sustainment, and business decisions. The course discussed how distributions can be plotted to determine statistical like hood of meeting a goal or an occurrence. The material covered testing for reliability using highly accelerated life cycle testing (HALT) to generate data that can be applied to a more long term of products likely performance. The course defines the difference between steady-state availability and reliability of a system and covers different methods and definition of testing for reliability.

Course Reference Material:

- Practical Reliability Engineering (4th Ed):

Closing:

This was an interesting course for me on two levels: one, this is the second time I have taken this material as it was also a course with the exact same text book in my Bachelor’s Program; and second, that I have more real life industry experience with this topic than I did that initial time. I enjoyed the points and topics the instructor brought up for discussion, and it really emphasized that reliability is something that is as much quantifiable is it a perspective of individuals. As the Instructor properly pointed out Systems Engineers often act as the information brokers of a project or program so understanding the requirement and how reliability is expressed is important. However, getting into the some of the level of statistical analysis present in the text book material is not necessarily needed so much as a general understanding the information and being able to present and pass that along in a meaningful way. Reliability of system at the end of the day is going to be determined by the end users perception of the system. The Weibull plots and statistical models only help in generating a number that will then need to be interpreted towards an expression of reliability. Reliability is will be always be function of required operation characteristics and human perception.