SE3100: Fundamentals of Systems Engineering

Contact Information

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Course Description

SE3100 Fundamentals of Systems Engineering (3-2)
Introduction to systems thinking and the processes and methods of systems engineering. The course covers fundamentals of systems engineering and system architecting, requirements analysis, functional analysis and allocation, preliminary system architecture, systems analysis, system design, and the basics of test and evaluation. Various perspectives, from frameworks, processes, and standards, such as the DoD Architecture Framework (DoDAF), DoD Joint Capabilities Integration and Development System (JCIDS), EIA 632, ISO 15288, IEEE 1220, IEEE 1471, and the International Council on Systems Engineering (INCOSE) models, are presented. Students analyze case studies. Students also use spreadsheet software for modeling and analyzing requirements and conceptual design alternatives. The course includes the application of fundamental systems engineering processes and methods to an integrative project, as well as development of communication skills through oral presentations and written reports. Prerequisite: None.

Course Goal & Outcomes

The goal of this course is to enable you to practice the fundamentals of systems engineering. That is, you will not be experts in every aspect of the discipline, but you will be well past novices, demonstrating skills expected of all systems engineers. At the core of systems engineering is problem solving in a disciplined and rational manner. The basic approach is three-fold: understanding a problem, examining alternative potential solutions, and verifying the chosen solution really solves the problem. You will also begin to develop attributes enabling you to think and work as systems engineers like critical thinking, teamwork, communication, ethics, fair mindedness, tolerance for ambiguity, attention to details and systems thinking.

Course Learning Objectives

Specifically, you will be able to (based on these course learning objectives):

- **Module 1. Systems Engineering Basics**
  - Understand Systems Engineering Basics
  - Understand Generic Life Cycle Stages
  - Understand Cross-Cutting SE Methods
  - Understand Communication
  - Understand Ethics

- **Module 2. Mission Analysis**
  - 4.1 Mission Analysis
    - Prepare for Business or Mission Analysis
    - Define the problem or opportunity space
    - Characterize the solution space
    - Evaluate alternative classes
    - Select the preferred alternative solution class(es)
    - Manage the Business or Mission Analysis
  - Understand Interoperability
  - Understand RMA

- **Module 3. Stakeholder Needs and Requirements Definition**
  - 4.2 Stakeholder Needs and Requirements Definition
    - Prepare for Stakeholder Needs and Requirements Definition
    - Define Stakeholder Needs
    - Develop the Operational Concept and Other Life cycle Concepts
    - Transform Stakeholder Needs into Stakeholder Requirements
    - Analyze and Maintain Stakeholder Requirements
    - Manage the Stakeholder Needs and Requirements Definition

- **Module 4. System Requirements Definition**
  - 4.3 System Requirements Definition
    - Prepare for System Requirements Definition
    - Define System Requirements
    - Analyze System Requirements
    - Manage System Requirements

- **Module 5. Architecture Definition**
  - 4.4 Architecture Definition
    - Prepare for Architecture Definition
    - Develop architecture viewpoints
    - Develop models and views of candidate architectures
    - Relate the architecture to design
    - Assess architecture candidates
    - Synthesize the selected architecture
    - Manage the selected architecture
    - Manage the architecture along the system life cycle

- Understand Architecting methods
- Understand Function-based methods
- Understand Interface management

- **Module 6. Design Definition**
  - 4.5 Design Definition
    - Prepare for Design Definition
    - Establish design characteristics and design enablers related to each system element
    - Assess alternatives for obtaining system elements
    - Manage the design

- **Module 7. System Analysis**
  - 4.6 System Analysis
    - Prepare for System Analysis
    - Perform System Analysis
    - Manage the system analysis
  - Understand Affordability
  - Understand Value Engineering

- **Module 8. Implementation Through Validation**
  - 4.7 Implementation
    - Understand Preparation for Implementation
    - Understand Performing Implementation
    - Understand Managing the Results of Implementation
  - 4.8 Integration
    - Understand Preparation for integration
    - Understand Performing Integration
    - Understand Managing integration
  - 4.9 Verification
    - Understand Preparation for verification
    - Understand Performing verification
    - Understand Managing verification
  - 4.10 Transition
    - Understand Preparation for the Transition
    - Understand Performing the Transition
    - Understand Managing Results of Transition
  - 4.11 Validation
    - Understand Preparation for Validation
    - Understand Performing validation
    - Understand Managing results of validation
  - Understand Tailoring of Systems Engineering Processes
  - Understand Prototyping

- **Module 9. Lifecycle Considerations**
  - 4.12 Operation
    - Prepare for Operation

        - Understand Performing Operation
        - Understand Managing results of operation
    - 4.13 Maintenance
        - Prepare for Maintenance
        - Understand Performing Maintenance
        - Perform Logistics Support
        - Understand Managing Results of Maintenance and Logistics
    - 4.14 Disposal
        - Prepare for Disposal
        - Understand Performing Disposal
        - Understand Finalizing the Disposal
    - Understand Agreement Processes
    - Understand Specialty Engineering Activities

- **Module 10. Life Cycle Management**
    - Understand Technical Management Processes
    - 7.1 Life Cycle Model Management
        - Establish the Process
        - Understand Assessing the Process
        - Understand Improving the Process
    - Understand Organizational Project-Enabling Processes

- **Communication**
    - Prepare and deliver an oral presentation
    - Prepare and deliver a written report

- **Critical and Systems Thinking**
    - Apply critical and systems thinking to systems engineering project products

- **Engineering Ethics**
    - Understand Engineering Ethics as applied to systems development as summarized in the National Society of Professional Engineers (NSPE) Code of Ethics
    - Apply ethical standards and behavior during course-related activities in accordance with the NPS Honor Code

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Multiple Contexts for Learning

The course is structured for an on-line learning environment. The course materials are available in the NPS learning environment, *Sakai*. The course credits are listed as (3-2) which indicates that there are 3 lecture hours, and 2 lab hours for this class per week – over a 10 week class meeting schedule over the quarter period. We are scheduled to meet for 3 hours each week using the on-line synchronous learning environment, *Blackboard Collaborate*. During each class period, learning activities will be accomplished by the class, typically in small groups. The first part of the class will be devoted to accomplishing some basic method or tool based activity, with the second part focusing on

applying that same method or tool to your individual project.

As a student, your learning will be facilitated through different contexts: lecture, individual work, face-to-face and online instructional exercises that reinforce:

- *Individual study and preparation*: Readings and assignments will be utilized in activity-based classes. Optimizing the benefits of in-class activities requires advance reading and preparation.
- *In-class analysis, concept development, and integration*: Thoughtful participation and interaction during class is vital to applying concepts and developing competencies. Your participation should demonstrate a mind taking charge of its own ideas, assumptions, inferences, and intellectual processes.
- *Sakai* provides a learning space with organized materials and resources that will support study and preparation for lecture and in-class exercises. Please note that in-class activities are dependent upon advance preparation and exercises. Each weekly module in our Sakai course site (accessed via https://cle.nps.edu) conforms to the following structure:

    1. Summary of content and key learning objectives, with connections to other class materials.
    2. Assigned readings and class preparation requirements.
    3. Assessments of learning: Assignments and activities that incorporate discussion of readings, formative assessments, exercises, and writing assignments; all of which are oriented toward students being able to process and integrate what is covered in modules. Much feedback will be formative to guide and deepen your understanding; you are expected to apply feedback in all assignments. Quizzes and tests are used as efficient measures for mastery of foundational content, knowledge, related to systems engineering, for example "define the term system" and "identify the objectives of functional analysis."
    4. Individual Project activities and assignments.

    Your weekly work flow should be: open the module for the week → read the introduction and learning objectives → read the required material (textbook or other hand-outs) with those learning objectives in mind → participate in the class activities → reflect and integrate information learned in the class activities → complete the weekly quiz → do the assignment → iterate on the integrated project activities and report based on feedback and analysis.

- *Time management & approaches to learning and study:* Successful students pace themselves and schedule 10-12 hours weekly for class attendance, study, and preparation, and completion of quizzes and assignments - which is standard for a 4-credit class in most institutions of higher education. Prior to each class session, it is essential to open the module for the week, read the introduction and learning objectives which focus reading the required material (textbook or other hand-outs). Having done this, you can optimize the benefits of the lecture and discussion, more fully participate in lab activities, and accurately complete the assignments. If you find you are spending more than 10-12 hours per week, and you feel that it is too much for

you to balance, try to find ways to become more efficient, or simply cut off your study and learning activity time when you reach your limit – parse out the time to tasks and stick to it to limit your efforts – you will probably find you can be quite successful even when you have to limit yourself this way.

Be sure to review the NPS Honor Code as defined in NAVPGSCOLINST 5370.4B, available on Sakai.

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Assessment

As graduate students you are expected to transfer and apply formative feedback to the project and assessments of learning. Learning in this course is developmental and your progress in achieving the course outcomes will be evaluated periodically throughout the quarter. Assignments will include reflective writing to integrate and apply course concepts, individual project-specific tasks and professional artifacts.

- Quizzes on foundational knowledge content from the INCOSE SE Handbook, administered via Sakai (30%) - one quiz each week for a total of ten at 3% each
- Final Exam implemented as a "simulated" INCOSE ASEP/CSEP knowledge exam (10%)
- Individual project consisting of
    - Individual project deliverables (35% - 7 parts at 5% each)
- And either
    - Formal final project report (20%) and Final individual presentation (5%)
- or
    - Informal final project report (10%)

The individual project will be introduced the first week of class, with details provided in our Sakai course site. The final deliverable is a written report that demonstrates the fundamentals of systems thinking and implements the methods of systems engineering. It is expected that you will do your own work and submit only your own work for examinations and assignments, unless otherwise indicated for a specific item.

Homework will typically be assigned on the class session day and be due 10 days later, following the next class session. This gives you two weekends to work the assignment, with a week in between if you have questions, and a class session to ask questions the weekend before the assignment is due.

Quizzes will typically be available the week BEFORE the associated module topic (with the exception of Quiz 1), so you can review your reading comprehension using the quizzes before the module session on Friday. The quizzes will be open the entire week after the module session so you can use that time to retake quizzes, if needed. Since there will be a module session in the middle of each quiz period - you have an opportunity to ask questions about the quiz questions if you have a question or concern about the quiz - and can clear that up before the final quiz due date.

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Grades

The course is implemented through adult-based learning theory or "androgogy". Adrogogy maintains that adults learn best when they have a flexible but challenging learning environment. Instead of traditional tests, a variety of assessment opportunities will be made available. You choose how much you would like to do for learning in this course. What you choose leads to achieving the grade you desire. This allows you to direct your learning in the manner that best suits your learning objectives.

Each assignment has a level of achievement described with a rubric. The rubric is a specification of the level of learning expected for the respective assessment. If the assignment or quiz meets the specification, you have demonstrated a level of learning for the assessment, and you will get full credit. If not, you will not get any credit, but you will get feedback on where your submission falls short of the goal, using the rubric as the basis for the feedback.

Quizzes

For the series of 10 module quizzes, these may be taken/retaken as many times as desired to achieve 80% or better. Each quiz will be open for 2 weeks. A score of 80% completed during the period that the quiz is open is full credit, less than 80% or non-completion during the period the quiz is open is no credit. The quizzes follow an INCOSE ASEP/CSEP question format, and all questions are taken directly from the INCOSE SE HB 4e, covering only the section(s) of the handbook for the module reading assignment.

Final Exam

The final exam consists of 100 questions, using the same question format as the weekly quizzes. A score of 80% completed during the period that the final exam is open is full credit, less than 80% is counted at the actual exam score, and non-completion during the period the final exam is open is scored as no credit. The final exam follow the INCOSE ASEP/CSEP exam format, and all questions are taken directly from the INCOSE SE HB 4e, covering all the reading assignments from all the course modules.

Systems Engineering Project

A series of 7 individual (but interrelated) project assignments are aligned as one with each of the modules 1 – 7. Each is based on the major SE methods associated with the SE processes from the INCOSE HB 4e. Each assignment is assessed to a specification rubric. A project assignment completed satisfactorily to the rubric specification during the period that it is open is full credit, less than satisfactory or non-completion during the period it is open is no credit.

Final Integrating Project Report

An integrating project report is to be completed and assessed against specification rubric. An integrating project report completed satisfactorily to the rubric specification during the period that it is open is full credit, less than satisfactory or non-completion during the period it is open is no credit.

For a desired grade of B: The form of the integrating project report is informal consisting of resubmitting the 7 project assignments, editing them to show a consistent set of activities and products, incorporating iterations among the steps throughout the process such that previous step results are consistent with the final project outcomes, and describing the major iteration changes you had to make as the project progressed. An informal integrating project report completed satisfactorily to the rubric specification during the period that it is open is full credit, less than satisfactory or non-completion during the period it is open is no credit.

For a desired grade of A: The form of the integrating project report is formal consisting of resubmitting the 7 project assignments, and editing them to show a consistent set of activities and products, incorporating iterations among the steps throughout the process such that previous step results are consistent with the final project outcomes. In addition, the report will include aspects of a formal report, with elements such as a cover page, table of contents, tables of figures and tables, an introduction, background, transition paragraphs between sections, chapter summaries, and conclusions and recommendations. A formal project report completed satisfactorily to the rubric specification during the period that it is open is full credit, less than satisfactory or non-completion during the period it is open is no credit.

Final Integrating Project Presentation
For a grade of A only: A final project presentation is to be completed and assessed against final project presentation specification rubric. A final project presentation completed satisfactorily to the rubric specification during the period that it is open is full credit, less than satisfactory or non-completion during the period it is open is no credit.

Overall Grading Summary

*For a grade of **C***
Complete each of the 10 quizzes on time with each quiz grade 80% or higher, and
Complete Final Exam on time with grade of 80% or higher, and
Complete each of the 7 project individual assignments on time and satisfactory based on given individual assignment rubric.

*For a grade of **B***
Complete all requirements for a C, and
Create an integrating project informal report, on time and satisfactory based on given rubric.

*For a grade of **A***
Complete all requirements for a B, and
Create an integrating project formal report on time and satisfactory based on given rubric, and
Conduct final project presentation, on time and satisfactory based on given rubric.

Note: achieving a plus or minus on a particular grade (except for an A+ since that grade does not exist at NPS) is possible for the overall course grade based on project informal or formal report or presentation exceeding or partially meeting rubric specifications.

Tokens
Given the nature of the application of learning, such as latency in understanding or figuring out how to apply a method, the inherent subjectivity of rubrics, and the variability in your ability to balance daily life/work/school expectations, **each student will be given five (5) tokens to redeem at any point** during the class. A single token can be used to extend an assignment or a quiz initial deadline or have an assignment re-assessed if found to be unsatisfactory upon resubmission. For assignments, each is assessed upon submission. If you fall short of the rubric specification, items will be noted, and you will be given one week to address the shortcomings – no token needed – all assignments get a one-week resubmission, if needed. If you end up needing more time to meet the specification for the assignment, or if your resubmission is short of the specification, then you can use a token to continue working on that assignment for another week. Tokens may not be given to other students, and have no residual cash value. Tokens cannot be used to replace an assignment, quiz, or exam.

Prerequisites and Technical Requirements
A working knowledge and proficiency with basic computing and office automation is required. That means you can organize and manage files and folders in your operating system; receive and submit electronic course materials; effectively use a word processing program (create, format, edit, save, and distribute documents); send and receive e-mail with attachments; and navigate, search, download, and execute files from the Internet. If you can use tools like browsers (such as Chrome, Mozilla Firefox or Internet Explorer), MS Word, MS Excel, Adobe Reader, and MS Powerpoint, you meet this prerequisite.

Textbook & References
- International Council on Systems Engineering. *Systems Engineering Handbook, 4th Edition,* INCOSE-TP-2003-002-04 2015. John Wiley & Sons, Inc. 2015. ISBN 9781118999400.
- Defense Acquisition University. *Defense Acquisition Guidebook, Chapter 3, Systems Engineering*. Fort Belvoir, VA: Defense Acquisition University Press, 2017.
- System Architecture: Strategy and Product Development for Complex Systems, Crawley, Cameron, and Selva, Pearson, 2015, ISBN-13: 978-0133975345, ISBN-10: 0133975347
- Other references listed on Sakai site.

Late Policy
Each module specifies due dates for assignments to facilitate pacing and interaction in the course. Your attention to the dates will contribute to an effective learning community and ensure that you help one another build and improve your knowledge. Please note the use of Tokens to help you with workload management. Late work will only be accepted with *prior* approval, always granted for acceptable reasons. Work will *not* be accepted after the required dates, unless **prior** arrangements have been made.

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Schedule

Week	Date	Topic	Reading and Preparation	Assignment
1	9/25/18	Module 1: Course Overview, Communication, Ethics Systems Engineering Basics	INCOSE Handbook 2.1-2.5, 2.9, 3.1-3.4, 9.1-9.4, 10.9, 10.13; DAG Chapter 3; System Architecture (Crawley, et al.) 1-3; Code of Ethics for Engineers	Quiz #1
2	10/2/18	Module 2: Mission Analysis	INCOSE Handbook 4.1, 5.7.2.5, 5.7.2.6, 10.4, 10.8; DAG Chapter 3; System Architecture (Crawley, et al.) 10	Quiz #2 Project Idea
3	10/9/18	Module 3: Stakeholder Needs and Requirements Definition	INCOSE Handbook 4.2, 5.7.2.5, 5.7.2.6; DAG Chapter 3; System Architecture (Crawley, et al.) 11	Quiz #3 Project Mission Analysis
4	10/16/18	Module 4: System Requirements Definition	INCOSE Handbook 4.3; DAG Chapter 3; System Architecture (Crawley, et al.) 3.1-3.3, 4, 5.2-5.4	Quiz #4 Project Stakeholder Needs and Requirements Definition
5	10/23/18	Module 5: Architecture Definition	INCOSE Handbook 4.4, 5.7.2.5, 5.7.2.8, 9.3, 9.6; DAG Chapter 3; System Architecture (Crawley, et al.) 6, 7, 8, 13, 16.4	Quiz #5 Project System Requirements Definition
6	10/30/18	Module 6: Design Definition	INCOSE Handbook 4.5, 4.4.2.6, 10.7, 10.10, Appendix D; DAG Chapter 3; System Architecture (Crawley, et al.) 4, 9, 12	Quiz #6 Project Architecture Definition
7	11/6/18	Module 7: System Analysis	INCOSE Handbook 4.6, 5.3, 10.1, 10.14; DAG Chapter 3	Quiz #7 Project Design Definition
8	11/13/18	Module 8: Implementation, Integration, Verification, Transition, Validation	INCOSE Handbook 4.7 - 4.11, 8, 9.5, 10.6; DAG Chapter 3	Quiz #8 Project System Analysis
9	11/20/18	Module 9: Lifecycle Considerations	INCOSE Handbook 4.12, 4.13, 6, 10.2-10.5, 10.8, 10.11, 10.12; DAG Chapter 3	Quiz #9
10	11/27/18	Module 10: Life Cycle Management	INCOSE Handbook 5, 7, 9.7-9.9; DAG Chapter 3	Quiz #10 Final Integrating Project Report
11	12/4/18	Student Presentations (Student project presentations in-class)	None	Student Project Presentations
12	12/11/18	Finals Week		Final Exam Due

The readings are to be completed before the class during which they will be discussed. Details for readings, assignments, due dates are provided in the Modules for each topic on Sakai. Details related to each module reading and preparation can be found on Sakai.

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