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# Curriculum Alignment Use Case for Competency Frameworks at the Naval Postgraduate School


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# Overview

- Systems Engineering Career Competency Model (SECCM): Introduction, Project Scope and Possible Applications of the Model
- Naval Postgraduate School's (NPS) Framework
- Curriculum Alignment Use Case
- NPS SE Course Example
- Learning Objective Analysis
- Competency Analysis
- SE Course Overall Results Analysis

# SECCM Project Scope



- The SECCM project goal is to create a foundational model that any US government defense organization can use as a resource, requiring minimal changes to tailor and meet individual organizational needs **to describe competencies and related KSAs for systems engineering tasks.**

- Due to the importance of having a model verified for human resource (HR) functions, NPS is collaborating in the model verification process with the U.S. Office of Personnel Management (OPM) in an effort to make a model that is useful for all of the U.S. Department of Defense (DOD).

# What are Systems Engineering Competencies?

System Engineering (SE) competencies are defined as the knowledge, skills, and abilities (KSAs) necessary for a systems engineer to perform tasks related to the discipline.

# Applications of a Verified SECCM

- Can be used within DOD for self-selection, recruitment selection, education and training applications.
- Can be used to guide career choice and self-selection by describing in detail what is required to be successful at particular job-role.
- Assist HR tremendously in finding the “right fit” for the position because applicants would have a really good understanding of what KSAs are needed for the position prior to applying for it.
- Assist with leadership development and career development plans. The appropriate training and development plans could be created based on the results of the verified competency model.
- Courses can be created to bridge specific competency gaps by developing specific competencies.
- Competency Assessment tools could also be derived to supplement academic qualifications of applicants (Patterson et al. 2000).

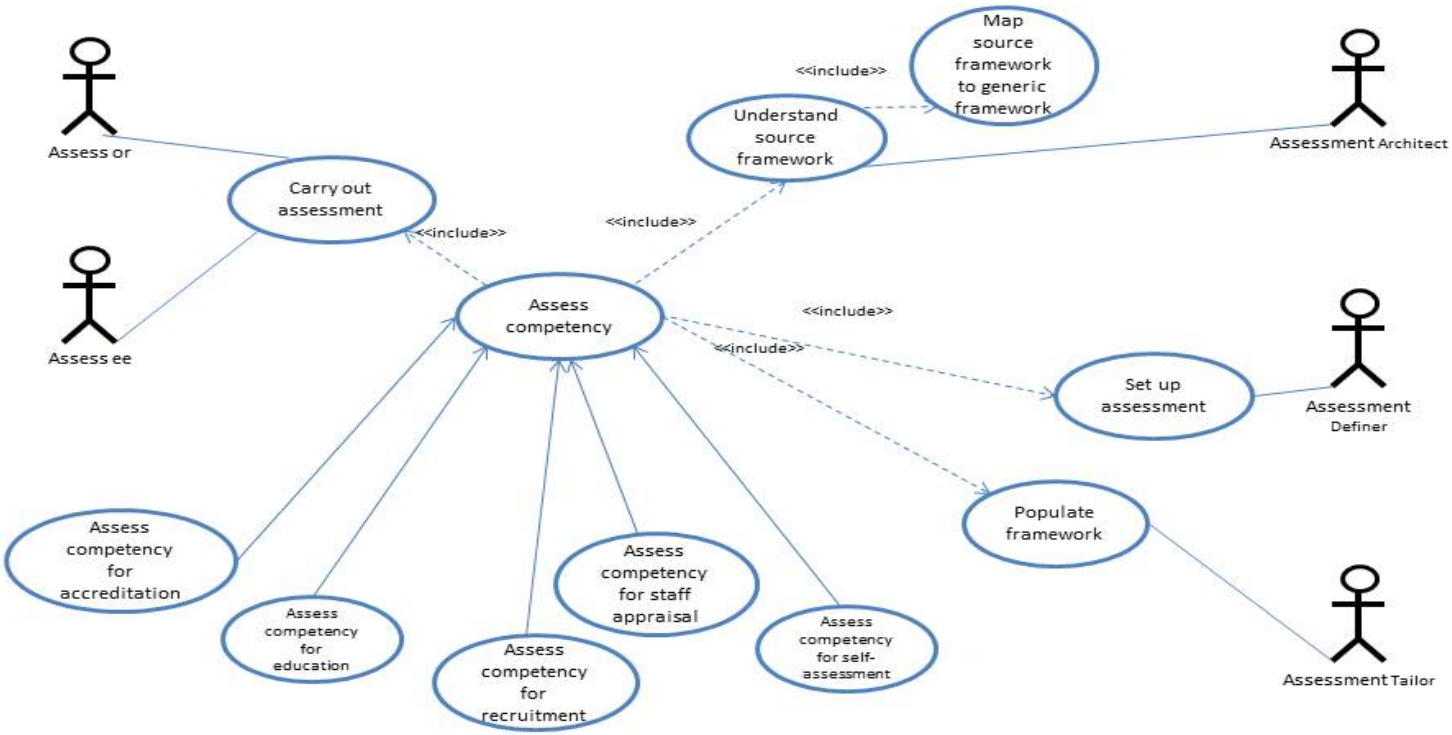
# Project Scope in Relation to a Verified SECCM



- NPS is using the SECCM to inform the continuous improvement of its systems engineering Master's program curricula to ensure that its graduates have the competencies required to meet defense systems engineering educational needs.

- **Project scope**: describe the use of a systems engineering competency model for curriculum alignment, accreditation, and course development purposes.

- An application to systems engineering course development will presented, showing alignment of course learning objectives and the INCOSE CSEP exam with an analysis of mapping to the competency framework.




Holt and Perry's Universal Competency Assessment Model
(Holt and Perry 2011; from Hahn et al 2016)

# NPS Competency Framework



- The SECCM is categorized using the U.S. Office of Secretary of Defense (OSD) Engineering (ENG) Competency Model structure, so the competencies and related KSA provide an excellent basis for informing the alignment of our curriculum [as a defense oriented graduate school].

- Each curriculum has a set educational skill requirements (ESR) that specify sponsor-related educational outcomes. In addition, accreditation bodies WASC and ABET require a set of processes to define and assess student outcomes and maintain an educational continuous improvement program. The NPS SE department is using the SECCM to align our masters degree programs to our educational outcomes considering departmental, ESR, WASC, and ABET needs.

- The SECCM KSA are phrased in terms of Blooms Taxonomy, so they lend themselves directly for use as course learning objectives throughout a curriculum.

# NPS Master's Program Curricula

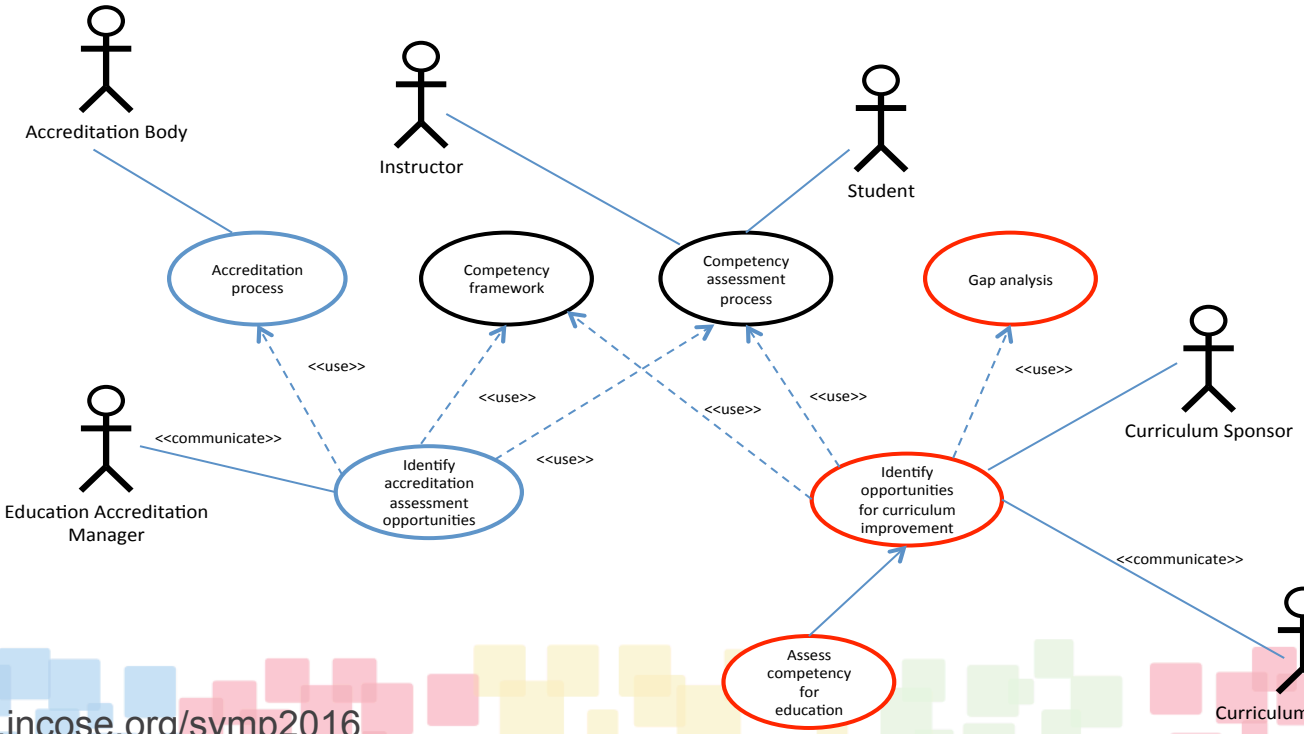
The NPS curriculum focuses primarily on educating students for defense systems-related careers.

The masters programs are identified using curriculum numbers, which tailor the degrees to different audiences within defense communities

| Curriculum Number | Title | Focus |
|---|---|---|
| 308 | Master of Science in Systems Engineering and Analysis | Educating junior active duty naval officers in the unrestricted line communities to become requirement setters in senior Pentagon roles. |
| 311 | Master of Science in Systems Engineering (Distance Learning) or Master of Science in Engineering Systems (Distance Learning) | Educating civilians and active duty officers in systems engineering. |
| 312 | Master of Science in Systems Engineering (Distance Learning) or Master of Science in Engineering Systems (Distance Learning) | Educating active duty officers test pilots in systems engineering. |
| 580 | Master of Science in Systems Engineering or Master of Science in Engineering Systems | Educating restricted line active duty Engineering Duty Officers (EDO) for naval engineering careers. |
| 721 | Master of Science in Systems Engineering Management | Educating civilians and military officers in systems engineering management. |

# Curriculum Alignment Use Case

NPS used the method described by Los Alamos National Laboratory (LANL) for depicting our use case (Hahn et al 2016)



# Narrative Description of NPS Curriculum Alignment Use Case

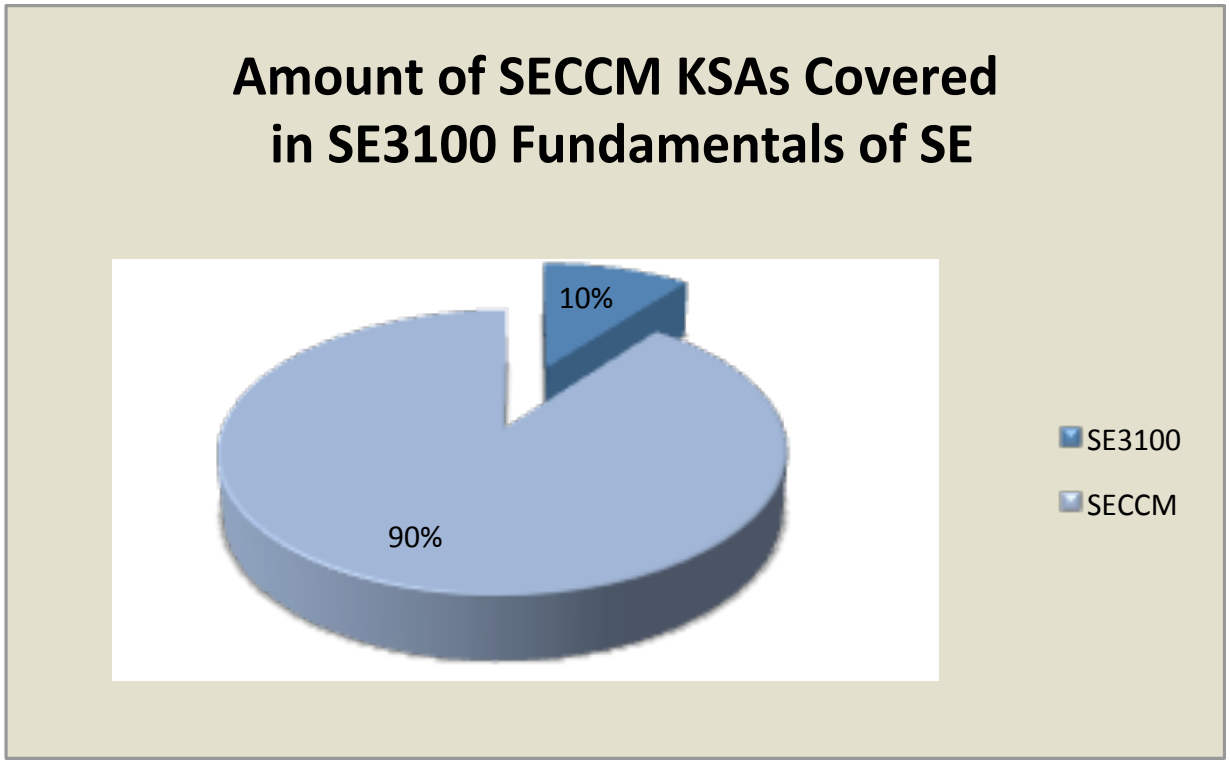
| Use Case Name | Curriculum Alignment |
|---|---|
| Preconditions | Use cases "Set up competency framework" and "Assess competency for education" have been successfully completed |
| Actors | • Curriculum Sponsors (NPS Education Sponsors)<br>• Accreditation Bodies<br>• Curriculum Manager (Education Provider Faculty/Administrators)<br>• Education Accreditation Manager (Education Provider Faculty/Administrators)<br>• Instructors (Education Provider Faculty/Administrators)<br>• Students |
| Triggers | Curriculum Review, Educational Oversight Committee Review, ABET Review |
| Primary flow of events | 1. The use case begins when the Education Provider reviews curriculum<br>2. Educational Sponsor communicates competency framework to Education Provider<br>3. Education Provider aligns curriculum to competency framework<br>4. Education Provider assesses effectiveness of education in meeting stated student outcomes for the curriculum<br>5. Education Provider schedules regular reviews with Education Sponsors to communicate educational effectiveness<br>6. Education Provider implements changes to curriculum to improve student outcomes |
| Alternate flow | At Step 4 and/or 5, assessment and communication may include direct interactions with students |
| Issues | Education Sponsors define ESR for their curricula, and these must be harmonized with the SECCM to provide a reasonable context for defining appropriate student outcomes. |

# NPS SE Course Example



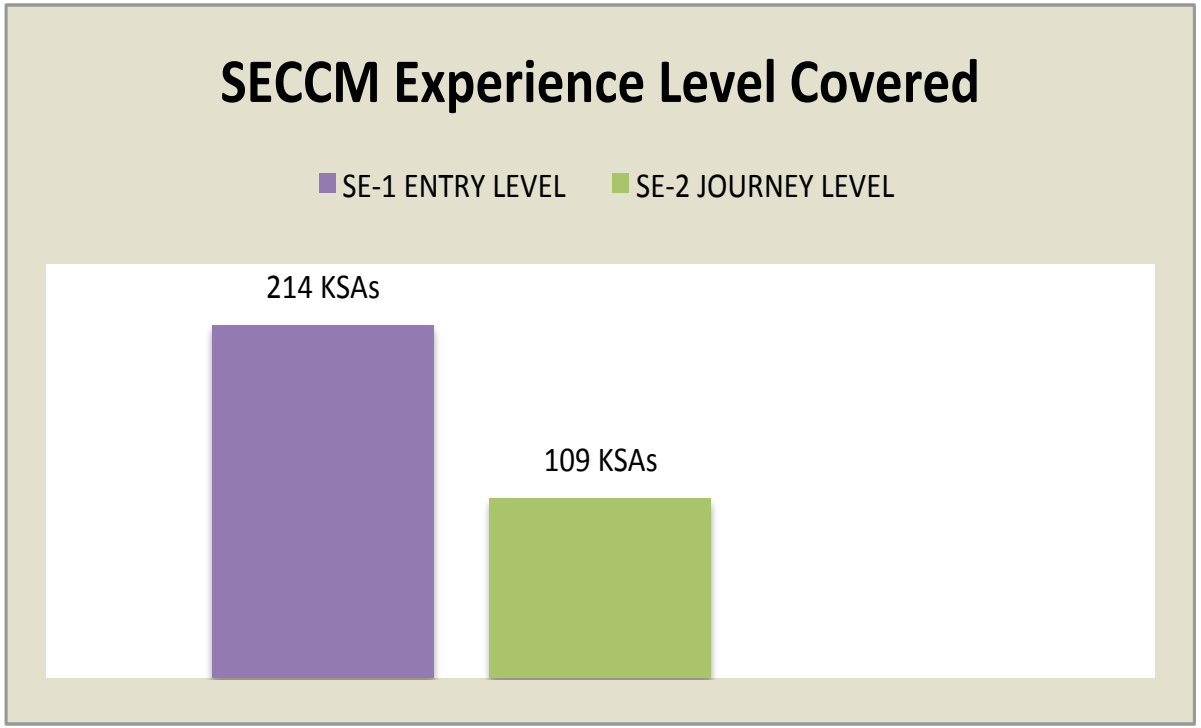
- A specific example is for the NPS Fundamentals of Systems Engineering course, SE3100.
- This course is required for all of our systems engineering masters programs, as it educates students in the foundations of systems engineering.
- The SECCM was used for course gap analysis, allowing for a traceable context for learning, career development, and INCOSE CSEP certification preparation.
- The set of SE3100 learning objectives was compared to the SECCM. The one-quarter course consists of ten weekly modules, each having about six main learning objectives at several different categories of both the Blooms cognitive and affective domains.
- The learning objectives are decomposed into more detailed learning objectives in the context of learning in the overall course structure. The individual learning objectives were compared to the KSA in the SECCM to understand the coverage of the course with respect to overall KSA development.

# Learning Objective Analysis



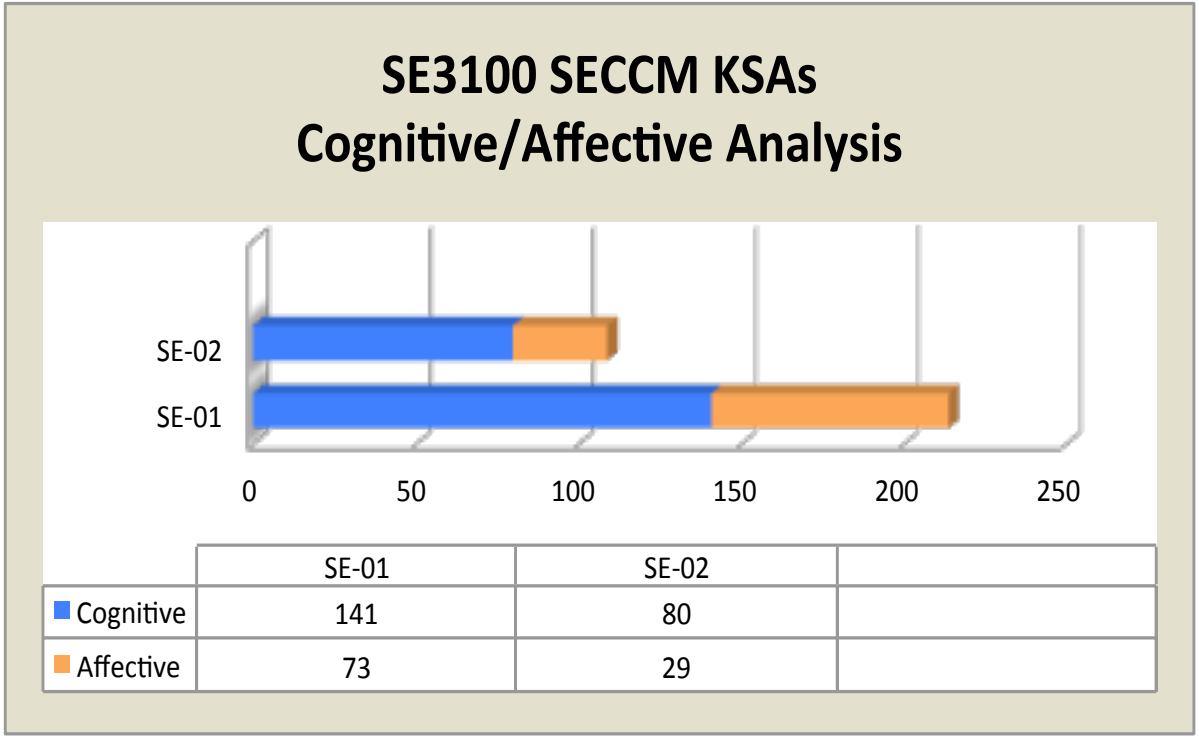

KSA Covered Through Learning Objectives in the Fundamentals of Systems Engineering Course

# Learning Objective Analysis




**KSA Covered Through Learning Objectives in the Fundamentals of Systems Engineering Course**

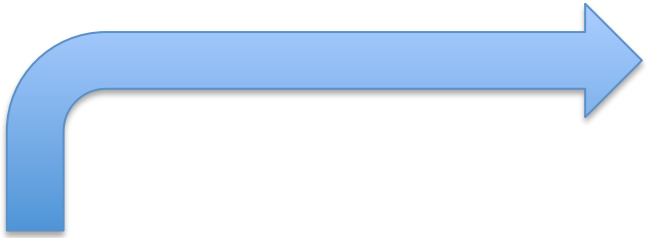
# Learning Objective Analysis




| | SE-01 | SE-02 | |
|---|---|---|---|
| Cognitive | 141 | 80 | |
| Affective | 73 | 29 | |

**KSA Coverage for the Fundamentals of Systems Engineering Course, in Terms of Career Level and Cognitive and Affective Bloom's Taxonomy Domains**

# Affective Domain KSA Breakdown for SE1, Entry-Level, and SE2, Mid-Career Level



For the entry-level career proficiency, about 21% of the KSA are from the affective domain

| **Entry Level (SE-01)** | **KSA** |
|---|---|
| **Affective** | |
| Organize (OR) | 2 |
| Receive (RC) | 4 |
| Respond (RS) | 64 |
| Value (V) | 3 |
| | **73** |
| **Mid-Career Level (SE-02)** | **KSA** |
| **Affective** | |
| Respond (RS) | 25 |
| Value (V) | 4 |
| | **29** |

# Competency Analysis
## *Competencies Covered in SE3100*

| SE Competency | SE3100 | SECCM | % of SECCM Competency Covered by SE3100 |
|---|---|---|---|
| 22.0 PROBLEM SOLVING | 71 | 140 | 51% |
| 26.0 COMMUNICATION | 39 | 98 | 40% |
| 3.0 REQUIREMENTS ANALYSIS | 37 | 105 | 35% |
| 4.0 ARCHITECTURE DESIGN | 56 | 229 | 24% |
| 24.0 PROFESSIONAL ETHICS | 10 | 43 | 23% |
| 2.0 STAKEHOLDER REQUIREMENTS DEFINITION | 23 | 107 | 21% |
| 12.0 DECISION ANALYSIS | 14 | 103 | 14% |
| 1.0 MISSION-LEVEL ASSESSMENT | 1 | 9 | 11% |
| 16.0 REQUIREMENTS MANAGEMENT | 5 | 82 | 6% |
| 29.0 MISSION AND RESULTS FOCUS | 1 | 18 | 6% |
| 35.0 COST ESTIMATING | 2 | 42 | 5% |
| 13.0 TECHNICAL PLANNING | 3 | 70 | 4% |
| 21.0 ACQUISITION | 11 | 363 | 3% |
| 7.0 VERIFICATION | 8 | 356 | 2% |
| 8.0 VALIDATION | 6 | 294 | 2% |
| 14.0 TECHNICAL ASSESSMENT | 1 | 177 | 1% |

# Competency Analysis – Summary of Findings



- SE3100 covers KSA in 16 of the 41 SECCM competencies

- The KSA coverage is greatest for:
  - **Problem Solving competencies**
  - **Communication competencies**
  - **Requirements Analysis competencies**

- These are related to learning objectives that are the focus of this first course in systems engineering, providing the foundation for application in the rest of the curriculum.

# Competency Analysis – Summary of Findings

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- The next set of competencies include
  - Architecture Design
  - Stakeholder Requirements Definition

- Both are covered in the first course, and built on in subsequent courses

- The Professional Ethics competency is also emphasized, not only for systems engineering, but as a basis for learning in the context of engineering education

# SE Course - Overall Results Assessment



- A simulated CSEP exam was offered as a voluntary assessment for the students that did not count towards their overall course grade.
  - Of the 28 students in the class, 21 took the exam, for a 75% participation rate. For the 100 question, computer-based multiple choice test, the results were a mean of 75.38, a median of 80.25, and a standard deviation of 19.12, with 13 of the students achieving a score of 70% or higher.
  - These students expressed a high level of confidence in their preparation to take the actual CSEP exam in the future.
  - The SE3100 course is one of 16 courses in each of our masters programs, so covering 10% of the SECCM is a solid start to developing the competencies and KSA needed for becoming a defense systems engineer.

# Going forward…

The curriculum alignment is continuing for the rest of the courses in the various curricula

# Questions

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