

5.9 IDE Graduate Systems Engineering (ISE)

5.9.1 Program Description

Systems Engineering (SE) is the process by which a customer's needs are satisfied through the conceptualization, design, modeling, testing, implementation, and operation of a working system. There are a range of levels of systems engineering, from product systems engineering used for a standalone product or vehicle platform, to design and integration of so-called "systems of systems" (such as an air operations center or missile defense system), to enterprise wide systems engineering that span an entire organization (such as mobility forces or space command).

The focus on SE becomes especially important in the analysis and synthesis of large and complex systems, such as those that arise regularly in Department of Defense and Air Force problems. Such examples include space systems, missile defense, Battle Management/Command and Control, network-centric systems, and generally most business and combat support Information systems. Over the last few decades, Systems Engineering has matured into its own discipline, with a foundation on system science using tools and repeatable processes from product development and systems engineering management. Recently, with the pervasive deployment of complex interconnected networked systems, the use of architecture has taken a central role in communicating the system of systems and enterprise-wide solutions.

The Intermediate Development Education (IDE) Graduate Systems Engineering (ISE) program is an ABET accredited resident program leading to a Master of Science (MS) degree in Systems Engineering. The ISE program requirements are identical to the Graduate Systems Engineering (GSE) program with the exception that a thesis is not required. In place of the thesis, the ISE program requires a group project (9 credit hours). The ISE program is nominally a four quarter (12 month) program, with students typically entering in May and graduating in the following June. The ISE program is only for in-residence IDE students.

The Systems Engineering program provides a substantial technical foundation in systems architecture, analysis and design as well as opportunity for specialization within a traditional engineering discipline. The program culminates with an individual or group design project typical of a defense system project. In the design study, the student will apply their individual technical expertise, exercise their system design skills, and experience the group dynamics of a team design effort while solving a realistic defense system problem.

Program Educational Objectives (PEOs)

The SE program takes students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively use the tools and techniques of both systems science and traditional engineering disciplines to approach and analyze complex problems, design feasible solutions, and select an appropriate solution. Specific objectives are as follows:

1. A graduate will understand the context of SE and the role of the systems engineer in government and industry organizations.
2. A graduate will thoroughly understand the SE process from mission area analysis through definition of requirements to system development, sustainment, and retirement.
3. A graduate will have skills to effectively evaluate the technical integrity of emerging designs and processes.

5.9.2 Focus Areas

In order to best meet the needs of our customers, discussions with warfighter integration, capability planning, acquisition, product and logistics centers and MAJCOM requirements organizations have focused our Systems Engineering program. For example, Systems Engineers working within the space community, should know the physics of space surveillance and/or the space environment, be knowledgeable in the wealth of unclassified and classified space technologies and systems and apply lessons learned through a sponsored space-related Capstone project. We achieve this requested focus with a set of specified electives and technical specialty courses.

Student will usually satisfy the AFIT SE degree requirements by choosing a focus area. Based on the current needs of the DoD and the Air Force, our primary focus areas are as follows:

- *Space Systems*: Military space vehicles or a satellite are not “contained” systems, because it is functionally part of a networked constellation of satellites and ground stations synergistically performing a needed mission, providing warfighter capability and creating desired effects. The extreme environments in which these systems operate necessitate unique design and development processes.
- *Airborne Systems*: Performance and design analysis of manned and unmanned aircraft will be examined, as well as major subsystems on our aeronautical systems. These include guidance, navigation, C4, radar, propulsion and structures, and include munitions and their effects.
- *Cyber Warfare*: The Cyber Warfare sequence is designed to study, analyze and challenge theories on the application of cyber power (offensive and defensive) to achieve strategic and operational military objectives. Students develop technical expertise and a technical foundation to better understand and analyze communications/ networks, policy, operations, systems and technologies.

5.9.3 School and Program Admission Criteria

FOR IDE STUDENTS ONLY: This degree program is only available to military personnel and DoD civilians selected by their service component for the resident Intermediate Developmental Education (IDE) program.

The general requirements for admission to the Master of Science in Systems Engineering program are as follows:

DEGREE REQUIRED: Any engineering degree (Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science. A degree in science (e.g. physics), math or computer science will be considered on a case-by- case basis. Courses in calculus-based physics and dynamical systems (circuits or engineering dynamics) are required.

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 500V/600Q

GPA REQUIRED: OVERALL - 3.0; MATH - 3.0; MAJOR - 3.0

Waivers to the criteria may be granted (on an individual basis) by the Department of Systems and Engineering Management.

5.9.4 Program Elements

The ISE program requires a minimum of 48 credit hours covering the following program elements: core courses, mathematics or math science requirement, a distribution course requirement, engineering depth to include an applicable education code sequence, an individual thesis or group project, and any additional Air Force and/or ABET requirements. The program elements are discussed below.

1. *Core Courses:* There are four Systems Engineering core courses. These are:

SENG 520 Systems Engineering Design
CSCE 590 Engineering Software Intensive Systems
SENG 640 System Architecture
SENG 653 Concept Definition and Systems Analysis

These courses provide a common breadth of knowledge and the basic building blocks for all Air Force and DoD Systems Engineers. All core courses are 4 credit hours.

2. *Mathematic Requirements:* Students must complete at least one course in graduate mathematics or math science (3-4 credit hours). Students without a background course in probability and statistics must take a course in this area. Appropriate probability and statistics course is:

STAT 583 Introduction to Probability and Statistics

3. *Distribution Requirement*: The distribution requirement includes one analysis-related course. Appropriate courses (3-4 credit hours) include:

- OPER 543 Decision Analysis (3 credit hours)
- QMGT 680 Project Risk Analysis (3 credit hours)
- LOGM 590 Computer Simulation (4 credit hours)

4. *Engineering Depth*: Systems engineering students will also take appropriate engineering and/or applied science courses in the technology area of their thesis or group design project as recommended by their program and/or thesis advisor. While the number of courses in the engineering depth sequence may vary, it is typically three or more courses (technical electives) for 12 or more credit hours.

Candidate technical (or specialty) sequences will be developed by the student and the academic advisor and approved by the curriculum chair. A candidate sequence should be a cohesive group of classes in a single discipline area with at least one 600-level (or above) course. Our focused program sequences include, but are not limited to, the following:

- Airborne Systems
- Space Systems
- Cyber Warfare

5. *Capstone Design Project / Graduate Warfighter Project (GWP)*: The breadth of the systems engineer is generally captured through an understanding of processes, ranging from general systems engineering processes to specialized aspects of component design, manufacturing, testing and operations. Systems engineering education transcends the normal engineering education by requiring a deep understanding of key technical processes and their supporting methodologies and tools. The processes are most effectively understood through repeated application and the resulting lessons learned, with knowledge often captured through substantial team projects and hands-on experience. The capstone of the AFIT systems engineering program is the *Graduate Warfighter Project*. The students typically form a systems engineering team and perform a group design study, which is defended orally. However, in certain situations for part-time or out-of-cycle single-students, an individual thesis may be performed. In any case, the team or individual works on a major project of DoD or Air Force interest allowing the students to apply the systems approach to a real problem in a controlled environment.

The group project for the ISE program will typically be 9 credit hours of SENG 798 spread over three quarters - one credit in the Fall, four credits in the Winter and four more in the Spring.

6. *Elective Coursework:* The Systems Engineering degree requirements are 48 credit hours of which 43-44 credit hours provide by the ISE program coursework and project. The remaining 4-5 credit hours of coursework may be used to meet any prerequisites, elective courses, or for addition technical depth.

7. *Air Force Requirements:* All full-time Air Force students are required to carry an average of twelve credits per quarter.

8. *ABET Requirements:* Any student not meeting ABET requirements from their undergraduate program is expected to take courses to fulfill those requirements as part of their MS program. An individual assessment of the student's transcript will be made as part of the education plan development process when the student enters AFIT. At this time, the student will be notified of any additional courses required for ABET accreditation. The student's advisor will be responsible for verifying that the program contains sufficient engineering design courses to satisfy ABET requirements. This includes the requirement to take four engineering design courses. Students who cannot satisfy all ABET requirements for the Master of Science in Systems Engineering (usually due to a non-ABET undergraduate degree) will be awarded the Master of Science degree accredited by the North Central Association of Colleges and Schools.

5.9.6 Course Sequence/ Sample EdPlans

The following is a sample education plan for an IDE student taking an airborne systems track.

Sample Program—12 Month ISE Student Airborne Systems Sequence

Short Term Review

Mathematics
Computer Lab (Tools)
DAU Acquisition/ SPRDE Primer

Quarter/ Course No	Course Title	Credit Hours	Class Type
1st Quarter (Su)			
SENG 520	Systems Engineering Design	4	<i>Core</i>
CSCE 590	Engineering Software Intensive Systems	4	<i>Core</i>
STAT 583	Introduction to Probability and Statistics	4	<i>Math</i>
		12	
2nd Quarter (Fall)			
SENG 640	Systems Architecture	4	<i>Core</i>
AERO 500	Introduction to Aeronautical Systems	4	<i>Eng Depth</i>
SENG 563	Terminal Effects & Conventional Weapons	4	<i>Eng Depth</i>
SENG 798	Graduate Warfighter Project	1	<i>Project</i>
		13	
3rd Quarter (Winter)			
SENG 653	Concept Definition and Systems Analysis	4	<i>Core</i>
AERO 685	Aircraft Systems Engineering	4	<i>Eng Dept</i>
SENG 798	Graduate Warfighter Project	4	<i>Project</i>
		12	
4th Quarter (Spring)			
QMGT 680	Project Risk Analysis	3	<i>Distribution</i>
SENG 590	Aircraft Survivability	4	<i>Eng Depth/Elective</i>
SENG 798	Graduate Warfighter Project	4	<i>Project</i>
		11	
Total Credits		48	