
# DEPARTMENT OF SYSTEMS AND ENGINEERING MANAGEMENT

DEPARTMENT CURRICULUM GUIDE

2010-2011

DEPARTMENT OF THE AIR FORCE

AIR EDUCATION AND TRAINING COMMAND (AETC)

## AIR FORCE INSTITUTE OF TECHNOLOGY

GRADUATE SCHOOL OF ENGINEERING AND MANAGEMENT

Wright-Patterson Air Force Base, Ohio

## 5.8 Graduate Systems Engineering (GSE)

## 5.8.1 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 Graduate Systems Engineering (GSE) program is an ABET accredited program leading to a Master of Science (MS) degree in Systems Engineering. This program is provided to both resident students and part-time students via distance-learning (DL) modality. In residence, it is nominally a six quarter (18 month) program, with students normally entering in September and graduating in March. For distance learning, it is nominally a 24 month to 36 month program, depending on class availability and part-time course load. For more information about distance learning or about this specific program, and to apply, go to AFIT's Extension Services website (http://www.afit.edu/en/dl).

**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. It is expected that graduates possessing these skills will go on to make substantive contributions to capability development within the DoD. Specific Program Educational Objectives (PEOs) are as follows:

1. Graduates will rise to positions of technical and/or programmatic leadership within capability planning, system acquisition and/or sustainment organizations. Examples of leadership positions include Technical Director, Division Chief, Chief Engineer, and System Program Manager/Director.
2. Graduates will employ SE methods and tools across the DoD acquisition life cycle. Examples of SE methods and tools include decision analysis, trade studies, risk

management, requirements management, architecture definition/evaluation and capability assessment.

## Program Outcomes (POs)

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 thesis 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. Finally, the program provides the necessary education to qualify full-time quota students for the academic degree code assigned to them on entry into the program. Program Outcomes (POs), those competencies that students are expected to achieve by the completion of the program, are as follows:

1. AFIT SE graduates will demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement.
2. AFIT SE graduates will demonstrate application of the SE process and methods on contemporary problems of interest to the DoD.
3. AFIT SE graduates will be proficient with many of the tools for implementing the SE process, including development of system architectures, tradeoff and decision analysis, risk management and test planning.
4. SE graduates will be able to identify deficiencies and/or gaps in the current SE body of knowledge, and will be capable of proposing new approaches to bridge these gaps.
5. SE graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.
6. SE graduates will develop a detailed understanding in at least one technical specialty area such as airborne systems, space systems, and cyber-warfare, among others.

## 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.

Students 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:

- *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.

- *Space Systems:* Military space vehicles or satellites are not "contained" systems, because their functionally is 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.

- *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.

- *Logistics (supply chain) Systems*: The Logistics systems sequence is designed to provide students with graduate level education in the fundamentals of Supply Chain Management (SCM), with particular emphasis on Department of Defense (DoD) and Air Force specific applications. Statistical data analysis and basic quantitative modeling, to include linear programming, simulation analysis, and heuristics, are included. Students will be able to apply state of the art analytical and problem solving techniques to Air Force and DoD supply chain management problems.

## 5.8.2 School and Program Admission Criteria

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 for admission to a non-ABET Master of Science program 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

Students in the Wright-Patterson area who do not meet these criteria may register for individual courses as a part-time student (space available) but are expected to meet the above criteria prior to being granted candidacy for the degree. Waivers to the criteria may be granted (on an individual basis) by the Department of Systems and Engineering Management.

## 5.8.3 Degree Requirements

The GSE 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 593 Introduction to Software Engineering
SENG 610 Systems Engineering Management
SENG 640 System Architecture

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 courses include:

STAT 583 Introduction to Probability and Statistics
STAT 527 Introduction to Probability
STAT 537 Introduction to Statistics

Additional math science courses include:
MATH 509 Mathematical Methods in the Physical Sciences
MATH 633 Graph Theory

3. *Distribution Requirement:* The distribution requirement includes a course in decision analysis, risk, simulation, project management, risk, leadership, cost analysis, financial management, economics, information/knowledge management and/or human factors. Primary candidate 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)

Additional distribution courses could include:
IMGT 669 Business Process Improvement (3 credit hours)
IMGT 680 Knowledge Management (4 credit hours)
IMGT 684 Strategic Information Management (3 credit hours)
SENG 560 Human Systems Integration (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 technical sequences include, but are not limited to, the following:

| | |
|---|---|
| Airborne Systems | Decision Analysis |
| Space Systems | Optimization |
| C4ISR Systems | Modeling and Simulation |
| Information Ops/ Cyber Warfare | Reliability |
| Sensors | Software Engineering |
| MASINT | Logistics Systems |

5. *Individual Thesis or Group Project*: 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 group design 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 individual thesis or group project for the GSE program will be minimum of 12 credit hours of SENG 799, typically spread over 3 or more quarters.

6. *Elective Coursework*: The Systems Engineering degree is 48 credit hours. Depending on the number of technical sequence and associated prerequisites, additional credit hours to achieve this 48 total may be necessary, which can be fulfilled by any elective courses.

All full-time Air Force students are required to carry an average of twelve credits per quarter, thus will complete a minimum of 72 total credit hours during the normal 6-quarter resident program. The additional 24 credit hours of coursework will be used by the student to meet any prerequisites and to take a second engineering depth sequence. Remaining coursework may be fulfilled by elective courses found from the AFIT catalogue.

7. *Air Force Requirements:* Some Air Force officers attending AFIT as full-time quota students are assigned an Advanced Academic Degree Code, or education code. The requirements for the education code are normally met by taking at least three classes as part of an engineering depth sequence (or in addition to optional sequences). Currently supported education codes and their corresponding requirements are listed below:

4THY: Operations Research

| | |
|---|---|
| OPER 543 | Decision Analysis |
| OPER 610 | Linear Programming and Network Flows |
| OPER 612 | Nonlinear Programming |
| OPER 621 | Multiple Criteria Decision Making |
| OPER 643 | Advanced Decision Analysis |
| OPER 647 | Queuing System Analysis |
| OPER 561 | Discrete Event Simulation |

4TIY: Optimization

| | |
|---|---|
| OPER 610 | Linear Programming and Network Flows |
| OPER 612 | Nonlinear Programming |
| OPER 613 | Integer Programming |
| OPER 615 | Large-scale System Optimization |

4TJY: Reliability

| | |
|---|---|
| SENG 585 | Reliability in Systems Design |
| SENG 685 | Reliability Engineering |
| SENG 687 | Advanced Topics in Reliability |

or Additional Probability and Statistics course

4TKY: Simulation

| | |
|---|---|
| OPER 660 | Object Oriented Simulation |
| OPER 661 | Simulation Modeling & Analysis |
| OPER 683 | Response Surface Methodology |

8. *ABET Requirements:* Only students possessing an ABET accredited undergraduate degree will be qualified to earn the Master of Science in Systems Engineering. Students admitted to the Systems Engineering program without an ABET accredited undergraduate degree will earn a Master of Science degree accredited by the North Central Association of Colleges and Schools.

## 5.8.4 Course Sequence / Sample EdPlans

The following is a sample education plans for a Distance Learning (DL) thesis student, taking a single course per academic quarter. A student should be able to complete this program in nominally 3 years or 12 academic quarters. However, availability of courses offered via DL modality will determine actual phasing and length of program.

**Distance Learning Master of Science in Systems Engineering (GSE)**
**Space Systems Sequence**

| Quarter/ Course No | Course Title | Credit Hours | Class Type |
|---|---|---|---|
| 1st Quarter () | | | |
| SENG 520 | Systems Engineering Design | 4 | ***Core*** |
| 2nd Quarter () | | | |
| CSCE 590 | Eng of SW Intensive Systems | 4 | ***Core*** |
| 3rd Quarter () | | | |
| SENG 640 | Systems Architecture | 4 | ***Core*** |
| 4th Quarter () | | | |
| SENG 610 | Systems Engineering Management | 4 | ***Core*** |
| 5th Quarter () | | | |
| STAT 583 | Probability and Statistics | 4 | ***Math*** |
| 6th Quarter () | | | |
| MECH 532 | Spaceflight Dynamics | 4 | ***Eng Depth*** |
| 7th Quarter () | | | |
| PHYS 519 | Space Environment | 4 | ***Eng Depth*** |
| 8th Quarter () | | | |
| SENG 631 | Spacecraft Systems Engineering | 4 | ***Eng Depth*** |
| 9th Quarter () | | | |
| QMGT 680 | Project Risk Analysis | 4 | ***Distribution*** |
| 10th Quarter () | | | |
| SENG 799 | Capstone Group Design Project | 4 | ***Core*** |
| 11th Quarter () | | | |
| SENG 799 | Capstone Group Design Project | 4 | ***Core*** |
| 12th Quarter () | | | |
| SENG 799 | Capstone Group Design Project | 4 | ***Core*** |
| **Total Credits** | | **48** | |

The following is a sample education plans for an 18 month resident thesis student. While only one engineering depth sequence is required for graduation, full time GSE students are expected take at least two engineering depth sequences as shown in this program.

**Resident Master of Science in Systems Engineering (GSE)**
**Generic Program**

**Short Term Review**

Mathematics
Computer Lab (Tools)
Object-Oriented Primer
DAU Acquisition/ SPRDE Primer

| Quarter/ Course No | Course Title | Credit Hours | Class Type |
|---|---|---|---|
| **1st Quarter (Fall)** | | | |
| SENG 520 | Systems Engineering Design | 4 | ***Core*** |
| CSCE 593 | Introduction to Software Engineering | 4 | ***Core*** |
| XXXX xxx | Math Course | 4 | ***Math*** |
| XXXX xxx | Tech Elective A I | 4 | ***Eng Depth*** |
| | | 16 | |
| **2nd Quarter (Winter)** | | | |
| SENG 640 | Systems Architecture | 4 | ***Core*** |
| XXXX xxx | Distribution Course | 4 | ***Distribution*** |
| XXXX xxx | Tech Elective A II | 4 | ***Eng Depth*** |
| XXXX xxx | Elective | 4 | ***Elective*** |
| | | 16 | |
| **3rd Quarter (Spring)** | | | |
| SENG 610 | Systems Engineering Management | 4 | ***Core*** |
| XXXX xxx | Tech Elective A III | 4 | ***Eng Depth*** |
| XXXX xxx | Elective | 4 | ***Elective*** |
| | | 12 | |
| **4th Quarter (Summer)** | | | |
| SENG 799 | Thesis | 4 | ***Thesis*** |
| XXXX xxx | Tech Elective B I | 4 | ***Eng Depth*** |
| XXXX xxx | Elective | 4 | ***Elective*** |
| | | 12 | |
| **5th Quarter (Fall)** | | | |
| SENG 799 | Thesis | 4 | ***Thesis*** |
| XXXX xxx | Tech Elective B II | 4 | ***Eng Depth*** |
| | | 8 | |
| **6th Quarter (Winter)** | | | |
| SENG 799 | Thesis | 4 | ***Thesis*** |
| XXXX xxx | Tech Elective B III | 4 | ***Eng Depth*** |
| | | 8 | |
| **Total Credits** | | **72** | |

## 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.

**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. It is expected that graduates possessing these skills will go on to make substantive contributions to capability development within the DoD. Specific Program Educational Objectives (PEOs) are as follows:

1. Graduates will rise to positions of technical and/or programmatic leadership within capability planning, system acquisition and/or sustainment organizations. Examples of leadership positions include Technical Director, Division Chief, Chief Engineer, and System Program Manager/Director.
2. Graduates will employ SE methods and tools across the DoD acquisition life cycle. Examples of SE methods and tools include decision analysis, trade studies, risk

management, requirements management, architecture definition/evaluation and capability assessment.

## Program Outcomes (POs)

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 thesis 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. Finally, the program provides the necessary education to qualify full-time quota students for the academic degree code assigned to them on entry into the program. Program Outcomes (POs), those competencies that students are expected to achieve by the completion of the program, are as follows:

1. AFIT SE graduates will demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement.
2. AFIT SE graduates will demonstrate application of the SE process and methods on contemporary problems of interest to the DoD.
3. AFIT SE graduates will be proficient with many of the tools for implementing the SE process, including development of system architectures, tradeoff and decision analysis, risk management and test planning.
4. SE graduates will be able to identify deficiencies and/or gaps in the current SE body of knowledge, and will be capable of proposing new approaches to bridge these gaps.
5. SE graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.
6. SE graduates will develop a detailed understanding in at least one technical specialty area such as airborne systems, space systems, and cyber-warfare, among others.

## 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.

## 5.9.2 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 for admission to a non-ABET Master of Science program 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.

## 5.9.3 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.

9. *ABET Requirements:* Only students possessing an ABET accredited undergraduate degree will be qualified to earn the Master of Science in Systems Engineering. Students admitted to the Systems Engineering program without an ABET accredited undergraduate degree will earn a Master of Science degree accredited by the North Central Association of Colleges and Schools.

## 5.9.4 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 | ***Core*** |
| CSCE 590 | Engineering Software Intensive Systems | 4 | ***Core*** |
| STAT 583 | Introduction to Probability and Statistics | 4 | ***Math*** |
| | | 12 | |
| **2nd Quarter (Fall)** | | | |
| SENG 640 | Systems Architecture | 4 | ***Core*** |
| AERO 500 | Introduction to Aeronautical Systems | 4 | ***Eng Depth*** |
| SENG 563 | Terminal Effects & Conventional Weapons | 4 | ***Eng Depth*** |
| SENG 798 | Graduate Warfighter Project | 1 | ***Project*** |
| | | 13 | |
| **3rd Quarter (Winter)** | | | |
| SENG 653 | Concept Definition and Systems Analysis | 4 | ***Core*** |
| AERO 685 | Aircraft Systems Engineering | 4 | ***Eng Dept*** |
| SENG 798 | Graduate Warfighter Project | 4 | ***Project*** |
| | | 12 | |
| **4th Quarter (Spring)** | | | |
| QMGT 680 | Project Risk Analysis | 3 | ***Distribution*** |
| SENG 590 | Aircraft Survivability | 4 | ***Eng Depth/Elective*** |
| SENG 798 | Graduate Warfighter Project | 4 | ***Project*** |
| | | 11 | |
| **Total Credits** | | **48** | |

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

**IDE Master of Science in Systems Engineering (ISE)**
**Space 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 | ***Core*** |
| CSCE 590 | Engineering Software Intensive Systems | 4 | ***Core*** |
| STAT 583 | Introduction to Probability and Statistics | 4 | ***Math*** |
| | | 12 | |
| **2nd Quarter (Fall)** | | | |
| SENG 640 | Systems Architecture | 4 | ***Core*** |
| PHYS 519 | Space Environment | 4 | ***Eng Depth*** |
| MECH 532 | Introductory Spaceflight Dynamics | 4 | ***Eng Depth*** |
| SENG 535 | Mil Space Systems and Applications (TS req) | (1) | ***Elective*** |
| SENG 798 | Graduate Warfighter Project | 1 | ***Project*** |
| | | 13-14 | |
| **3rd Quarter (Winter)** | | | |
| SENG 653 | Concept Definition and Systems Analysis | 4 | ***Core*** |
| SENG 535 | Mil Space Systems and Applications (TS req) | (1) | ***Elective*** |
| EENG 571 | Satellite Communications | 4 | ***Eng Depth/Elective*** |
| SENG 798 | Graduate Warfighter Project | 4 | ***Project*** |
| | | 12-13 | |
| **4th Quarter (Spring)** | | | |
| SENG 631 | Spacecraft Systems Engineering | 4 | ***Eng Depth*** |
| QMGT 680 | Project Risk Analysis | 3 | ***Distribution*** |
| SENG 535 | Mil Space Systems and Applications (TS req) | (1) | ***Elective*** |
| SENG 798 | Graduate Warfighter Project | 4 | ***Project*** |
| | | 11-12 | |
| **Total Credits** | | **48-51** | |

Note: For Space Systems track, we recommend the addition of SENG 535 classified seminar, requires TS clearance and permission of instructor.