AFIT Online Systems Engineering
Programs Overview

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The Plan

• The Programs
• Specializations
• Application Process
• General Questions
The Programs:

What does a Systems Engineering degree look like?
AFIT’s Family of SE Programs

• Graduate Systems Engineering Certificate (SEC)
  • Online or resident
  • Standalone or part of a degree program
  • 4 core SE classes, 16 credits

• Masters of Science, Systems Engineering, ABET (GSE)
  • In-residence: nominally 18 month program, 72 credits (12 hours/qtr)
  • On-line (part-time): nominally 3 years long, 48 credits (4 hours/qtr)
  • Thesis required for both on-line and in-residence students

• Masters of Engineering, Applied Systems Engineering (ASE)
  • Nominally a 3 year program, 48 credit hours
  • Like GSE but replaces thesis with analysis track and capstone project
  • Only available to part-time (and online) students

• Doctoral Systems Engineering (DSE)
  • Nominally a 36-month program, including 1-2 years of research
Systems Engineering Certificate

Systems Core
4 Classes
4 hours each

SE Foundations (SENG 520)
Agile Software (SENG 593)
Architecture (SENG 640)
Select One
Advanced Topics (SENG 670)
Project Management (SENG 610)

Core Systems Engineering Tools
Building Block for our Family of Systems Engineering Programs
System Engineering Core

SENG 520 - Foundations of Systems Engineering
This course provides a broad introduction to the systematic approach for the conceptualization, design, and analysis of complex systems within the Department of Defense. Content emphasizes modern model-based systems engineering (MBSE) methods, languages, and tools. A systems modeling tool is used throughout the course for description and engineering analysis of a Defense--related design project.

SENG 640 - System Architecture
This course provides the foundation for developing and evaluating system architectures through an intensive study of the relationships between different types of system representations and the methodologies used to obtain them. Approaches include a variety of model-based systems engineering (MBSE) techniques and heuristics to assess behavior and performance. Students will select a military concept, and iterate its design solution guided by the DoD Architecture Framework (DoDAF).

SENG 593 - Agile Software Systems Engineering
This course will provide a foundation for System Engineers to design and architect software intensive systems. Topics include requirements elicitation, object-oriented modeling including the use of the Unified Modeling Language (UML), design patterns, engineering reliable and reusable systems, iterative development, DoD/AF software guidance, case studies, software management best practices and software estimation. The unique challenges faced by teams when engineering large-scale software-intensive systems (i.e., systems which have a large software component) are explored. This course is an introduction to software engineering technical management for experienced engineers whose area of expertise is outside computer science. Outcomes will enable students to more effectively communicate with users and software developers and make sound management and engineering decisions.

SENG 610 - Project Management
Provides knowledge and tools to manage projects or effectively contribute as a project member. Framed by the systems development cycle, course explains challenges specific to three major project types: systems engineering, software systems, and construction. Basic topics include project life cycle, project planning/selection, cost estimating, scheduling, and risk management. Advanced topics include critical chain analysis, adaptive project management, acquisition logistics and contracting. A one hour lab illustrates course principles using Microsoft Project software.

SENG 670 – Advanced Topics in DoD Systems Engineering
This course advances concepts and analytical solutions beyond traditional in Systems Engineering (SE) processes presented in SENG 520, SENG 640 and SENG 593. Topics of interest will be driven by current DoD challenges and policy, as well as state-of-the-art practices in SE publications. Such topics may include: safety critical systems, air worthiness, Open Systems Architecture (OSA), System of Systems (SoS) management and analysis, the Internet-of-Things (IoT), cloud computing, mission assurance, human systems integration (HSI), or design for resilience/flexibility/modularity.
Interaction with Degrees

• The SE Certificate represents one-third of the requirements for the ASE and GSE programs
  • GSE:
    • Research focused
    • SE Core + One specialization sequence + Three quarter long thesis
  • ASE:
    • Tools focused
    • SE Core + Two specialization sequences + A quarter long capstone project
  • **24 different possible combinations**
• The SE Certificate can also serve elective requirements in select degrees in the Department of Aeronautics and Astronautics

Choose the option that is the right blend of tools and research for you
Systems Engineering (GSE)
Independent Research Focus (Thesis)

SE Foundations
(SENG 520)
Agile Software
(SENG 593)
Architecture
(SENG 640)
Select One
Advanced Topics
(SENG 670)
Project Management
(SENG 610)

Systems Core
4 Classes
4 hours each

Thesis
3 Quarters
4 hours each

Research Tools
2 Classes
4 hours each

Specialization
3 Classes
4 hours each

Thesis
Intensive independent research effort leveraging toolsets gained through coursework.

Statistics
MATH or STAT at 500 or higher
Research Methods
(RSCH 630)

Specialization
Human Systems
Space Systems
Cyber Systems
Energy Systems
Advanced Systems Analysis
Small Unmanned Aerial Systems*
Navigation
Test and Evaluation**

* In-residence only
** Separate selection process
Applied Systems Engineering
Tools Focus (Capstone)

**SE Foundations**
(SENG 520)

**Agile Software**
(SENG 593)

**Architecture**
(SENG 640)

**Select One**

**Project Management**
(SENG 610)

**Advanced Topics**
(SENG 670)

**Statistics**
MATH or STAT at 500 or higher

**Analysis Track (pick one)**
Advanced System Analysis
Test and Evaluation**

**Analytical Tools**
1 Stat + 3 course track
4 hours each

**Specialization**
3 Classes
4 hours each

**Systems Core**
4 Classes
4 hours each

**Capstone Project**
1 Class
4 hours

**Capstone**
Independent research project leveraging toolsets gained through coursework.

**Specialization**
Human Systems
Space Systems
Cyber Systems
Energy Systems
Advanced Systems Analysis
Small Unmanned Aerial Systems*
Navigation
Test and Evaluation**
Nuclear***

* In-residence only
** Separate Competitive Process
*** ASE program only
Specializations:
The options available to customize your degree and your research.
Research

• We seek out defense-focused relevant topics for student research (thesis and capstone)
• Ideally research topics are tied to your work; the work-research virtuous cycle

• ASE: SENG 798 (4 hour capstone – 1 quarter)
• GSE: SENG 799 (12 hour thesis – at least 3 quarters)
Math/Stats and Methods

ASE and GSE require a MATH or STAT course at a 500 level or higher. Online options include:

**STAT 521 - Applied Statistical Data Analysis**
This course provides statistical tools for the analysis of data in the decision-making process. The course covers descriptive statistics, probability theory, and statistical inference. Concepts discussed include methods on how to specify what data is wanted, collect data, extract information from existing sources of data, test the validity of key concepts, estimate problem parameters, and relate one decision variable to another (ANOVA and regression).

**STAT 583 - Introduction to Probability and Statistics**
Basic concepts of probability and statistics with applications are covered. Topics include: Permutations and combinations; random variables; probability distributions; estimation and confidence intervals; hypothesis testing.

**STAT 586 - Probability Theory for Communication and Control**
Selected topics from probability theory are introduced as a basis for applications in the analysis and design of modern communication and control systems. Topics include the concepts of sample spaces, random variables, random vectors, probability densities, probability distributions, discrete and continuous distributions, expectation and moments, characteristic functions, transformations of random variables and vectors, multivariate normal distribution.
Specialization Track

• GSE requires at least one specialization track of your choosing
• ASE requires at least two specialization tracks; at least one must be an analysis track
• Tracks require at least 12 quarter hours with at least one course at a 600 level or higher unless otherwise stated
• A course cannot count for two separate tracks

Domain Specialization Track

Analysis Specialization Track
Specialization Options

**Domain**
- Human
- Space
- Cyber
- Energy
- Small Unmanned Aerial Systems
- Navigation
- Nuclear

**Analysis**
- Advanced Systems Engineering Tools
- Test and Evaluation
Application Process:
How to apply for the degree program and timing
How to Apply

• **Application:** Apply on-line at https://www.afit.edu/ADMISSIONS/AFITApplicationProcess/

• **Eligibility Determination:** Your application will be reviewed for Academic Eligibility based on admissions criteria. If you are eligible you will receive a Letter of Academic Eligibility (LOAE).

• **Program Acceptance:**
  • Data cut-off: 1 Aug 2020
  • **Eligible applicants** will be reviewed the first week of August
  • The number accepted is based on space available (Space-A). Selection amongst eligible applicants is based on academic merit and other factors.
  • Primaries and alternates selected and notified NLT 14 Aug 2020.
  • Primaries who do not enroll by 1 Sep 2020 forfeit their slot to an alternate and can reapply for consideration at a later date.
  • If you are a primary/alternate you will receive an admissions notification.
Admissions Criteria

• Degree: A degree in engineering (e.g., Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science is required. A degree in science (e.g. physics, chemistry), math or computer science will be considered for admission on a case-by-case basis.

• Courses: Calculus-based physics and dynamical systems (e.g., circuits or engineering dynamics) are required. In terms of mathematics, at least multivariate calculus and ordinary differential equations are required.

• GRE: Verbal $\geq 153$ (500 if taken prior to August 2012); Quantitative $\geq 148$ (600 if taken prior to 1 August 2012)

• GPA: Undergraduate GPA $\geq 3.0$ (on a 4.0 scale) overall; $\geq 3.0$ in mathematics (on a 4.0 scale); $\geq 3.0$ in major (on a 4.0 scale)

• Waivers to the above criteria may be granted (on an individual basis) by the Department of Systems and Engineering Management. Therefore, individuals whose academic credentials fall below any of the above criteria may still apply.
COVID-19 Considerations

• GRE
  • Waived until 1 Sep 2020

• Official Transcripts
  • Military officers SHOULD have transcripts on file at AFIT
  • Unofficial transcripts will be accepted provisionally
  • If accepted on data based on unofficial transcripts; student enrollment will be discontinued after six months without official transcripts

• Course Offerings
  • As of Spring 2020 all AFIT courses restricted to online offering
  • It is uncertain how long this temporary expanded online catalog will exist
Selection Factors

• Academic Merit

• Experience – Amount
  • At least one assignment (three years), preferably two (six years)
  • Graduate Reference Curriculum for Systems Engineering
    • Published by INCOSE, the professional society for systems engineers
    • Learning objectives are improved for students with experience

• Experience – Diversity
  • Systems Engineering require collaborating across stakeholders
  • Students are co-learning in group activities; if everyone has an identical background the learning experience is diminished
  • 25% of our students are from outside of developmental engineering: aircrew, space operations, intelligence, SOF, maintenance, etc
  • Civilian and Contractor students
  • Other services and federal agencies
Questions:
A few common questions
Common Questions

• How much does it cost?
  • Due to legislative changes in the last decade, AF employees can attend AFIT with tuition waived (e.g. no cost).

• Isn’t AFIT only for the military?
  • No. We have students who are military, civilian and contractor.

• Can I transfer courses in?
  • Depends; we’ve got a whole OI on the topic

• Thesis or Capstone?
  • Depends; this is based on you and your work
  • The programs are modular and there is latitude to change

• ABET?
Questions?

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Back Up Slides
Interactions:
How the degree interacts with offerings outside of AFIT
AFIT’s Transfer Policy
ENOI 36-167

- Department faculty determine which, if any, courses are eligible for transfer. Determination of the institutional source, content and quality of course work as reflected by the accreditation held by the originating institution shall be the primary criteria used to assess the eligibility of a course for transfer. Department faculty of an AFIT graduate program can accept or reject transfer credits at their own discretion, regardless of the graduate degree program or discipline in which they were earned.

- Transferred courses must be graduate level and a letter grade of "B" or better must have been awarded. No transfer credit will be awarded for coursework taken on a pass/fail basis.

- Transferred courses and their credit may not include any course submitted and used for any previous degree.

- The maximum number of transferable credits is 12 graduate quarter hours per degree, or their semester hour equivalent.

- Credits are not transferable if they were earned more than five years prior to matriculation into the student’s AFIT/EN graduate program.
One Example

Louisiana Technical University
Six Sigma Black Belt Graduate Certificate

- The certified Six Sigma Black Belt is a professional who can explain Six Sigma philosophies and principles, including supporting systems and tools. A Black Belt should demonstrate team leadership, understand team dynamics and assign team member roles and responsibilities. Black Belts have a thorough understanding of all aspects of the DMAIC model in accordance with Six Sigma principles. They have basic knowledge of Lean enterprise concepts, are able to identify non-value-added elements and activities and are able to use specific tools.

- Student are required to take the following courses and earn a grade of ‘B’ or higher in each of these courses to complete the requirements of the Six Sigma Black Belt Certification. Take all four of the following courses:
  - INEN 514: Statistical Analysis of Six Sigma  3 Semester Credit Hours
  - INEN 566: Six Sigma and Quality Control  3 Semester Credit Hours
  - STAT 507: Design and Analysis of Experiments  3 Semester Credit Hours
  - INEN 520: Six Sigma Black Belt Project  3 Semester Credit Hours

Ref: https://catalog.latech.edu/preview_program.php?catoid=7&poid=2623
Notional LTU Transfer
How does it map to AFIT’s transfer policy?

✓ Department faculty determine which, if any, courses are eligible for transfer.
  ▪ The LTU courses map well to our existing statistics and tools requirements.

✓ Transferred courses must be graduate level and a letter grade of "B" or better must have been awarded. No transfer credit will be awarded for coursework taken on a pass/fail basis.
  ▪ The LTU program requires a B or better for the award of a certificate.

✓ Transferred courses and their credit may not include any course submitted and used for any previous degree.
  ▪ Certificates are not considered degrees.
  ▪ Assuming that the student has not applied the course work towards another program.

✓ The maximum number of transferable credits is 12 graduate quarter hours per degree, or their semester hour equivalent.
  ▪ The certificate covers 12 semester hours; equivalent to 20 quarter hours – we will be able to transfer some, but not all of the material
  ▪ There is precedent for similar transfers; three of the 3 semester hour courses would count as three 4 credit hour courses (a total of 12 quarter hours)

✓ Credits are not transferable if they were earned more than five years prior to matriculation into the student’s AFIT/EN graduate program.
  ▪ Assuming that the students have completed the certificate within the last five years
Applied Systems Engineering
Notional Degree with LTU and NWEPP

Systems Core
4 Classes
4 hours each

Capstone Project
1 Class
4 hours

Analytical Tools
1 Stats + Pick 3 SE
4 hours each

Specialization
3 Classes
4 hours each

SE Foundations
(SENG 520)
Agile Software
(SENG 593)
Architecture
(SENG 640)
Project Management
(SENG 610)

Statistics
(STAT 507 - LSU)
Statistical Analysis of Six Sigma
(INEN 514 – LSU)
Six Sigma and Quality Control
(INEN 566 - LSU)
Risk Analysis
(QMGT 680 - AFIT)

Capstone
Independent research project leveraging toolsets gained through coursework.

Nuclear Weapons Effects
(NENG 596)
Nuclear Proliferation
(NENG 591)
Nuclear Weapons Strategy and Policy
(NENG 500)
Human Systems
A Domain Specialization Track

HFEN 560 - Introduction to Human Factors (REQUIRED, pick two additional courses from the list below)
This course examines the study and application of humans and the system interface, including the knowledge of human cognitive/social/physical behavior, capabilities, and limitations. Topics include anthropometrics, sensation-perception, decision-making, mental workload, situational awareness, display/control design, warnings/alerts, human error and accident investigation. Numerous case studies are used to highlight course topics.

HFEN 620 - Human Systems Modeling
This course introduces students to using discrete event simulation to model complex human-machine systems. Through this course students will gain an appreciation of defining systems, processes, and workflows using task network analysis. This course is intended to provide students with the requisite knowledge to construct and validate discrete event simulations as well as use simulation outputs to interpret system behavior and evaluate potential solutions with respect to impacts on system performance, human performance, and operator workload.

HFEN 663 - Human-Computer Interaction
This course covers the principles of human-computer interaction in the design and evaluation of useful, usable interfaces as well as the social consequences of technological innovations. Topics include the joint performance of tasks by humans and machines, the structure of communication between human and machines (including machine response to changes in user state), algorithms and programming of the interface itself, engineering concerns that arise in the design and construction of interfaces, the process of specification, design, and implementation of interfaces, and design trade-offs.

HFEN 665 – Human Agent Interaction
This course explores operator interaction in human-machine teams to understand significant design trade-offs during the design of the Human Agent (H-A) Interface. Topics to be covered include: Task Allocation, Trust, Interaction Styles, Implicit/Explicit Communication, Relevant Human Biases, Automation Classification/Taxonomies and influences of automation limitations. Interface design decisions and trade-offs will be explored through readings from the course text and select academic articles, as well as analysis and development of design options.

HFEN 670 - Human Interaction Technologies
Robust human-system interaction requires information flow between the system and human brain. This course will introduce technologies available to mediate this flow of information, discussing the important characteristics and considerations for input and output technologies. Emphasis will be provided on visual information processing and visual display design. Human auditory processing and various input device technologies will also be discussed.
Space Systems  
A Domain Specialization Track

PHYS 519 – The Space Environment  
The near-earth space environment is that in which artificial satellites and astronauts must operate. This course is concerned with the general conditions encountered in the Earth's atmosphere, the ionosphere, and the magnetosphere, and specific effects studied are spacecraft thermal equilibrium, spacecraft charging, and space-to-ground communications. Other topics include atmospheric chemistry, radiation belts and solar activity.

PHYS 521 – Space Surveillance *

MENG 530 – Chemical Rocket Propulsion  
Development of performance parameters, analyses of combustion, fluid mechanics, and heat transfer as they pertain to rocket engines and motors, comparison of propellants, and analysis of simple rocket flight and staging

MECH 532 – Introductory Space Flight Dynamics  
Formulation and solution of the two-body problem in three dimensions. Orbital elements, reference frames, coordinate transformations, and basic orbital maneuvers. Formulation and description of basic attitude dynamics and control concepts, including spin, dual-spin, three-axis, and gravity gradient stabilization.

ASYS 535 – Military Space Systems & Applications *

EENG 571 – Satellite Communications *

ASYS 631 – Spacecraft Systems Engineering  
This course provides a detailed introduction to the design of complex space systems. The key elements and subsystems of several important classes of space systems are presented. The systematic approach necessary to effectively design space systems is illustrated through case studies. Individual or group design projects are conducted and presented.

ASYS 632 – Satellite Design & Test*

MECH 632 – Intermediate Space Flight Dynamics *

* In-resident offering only at present
Cyber/Information Systems
A Domain Specialization Track

IMGT 561 - Applications of Database Management Systems
This course explores the applications of computer database systems to support organizational and administrative functions. More specifically, the course covers both a user's and designer's perspective: the concept of database management systems (DBMSs); DBMS security, integrity, recovery, and concurrency considerations; DBMS data models (the relations will be emphasized, but the hierarchical, network, and object-oriented models will also be covered), data manipulation, and database design. Additional emphasis is placed on emerging technologies, including, but not limited to data warehousing, data marts, and data mining.

IMGT 657 - Data Communications for Managers (OR CSCE 560 Introduction to Computer Networking)*

IMGT 662 – Database Security*

SENG 570 – Systems Process Improvement (or IMGT 669 – Business Process Improvement)
This course introduces students to the concepts of Business Process Reengineering, Lean, Six Sigma and other related methodologies. The course will take a historical look at why organizations are structured the way they are. Students will then learn to re-conceptualize the organization in terms of systems and processes with the goal of improving the organizations effectiveness and efficiency. The students will then apply Lean and Six Sigma concepts to re-engineered business and system processes to ensure long term process improvement. Topics for this course will also include people, process, technology, and management dimensions of a Lean enterprise with particular focus on systems applications for scientists and engineers. Upon completion of the course students will be well versed in these methodologies and prepared to contribute to any continuous process improvement activity such as AF CPI.

IMGT 680 - Advanced Topics in Data Management and Analysis
The course covers concepts related to data management and data mining for big data analytics. Students will learn basic techniques of data analytics, including emerging methods to store and access large, real-time, web distributed data environments (e.g. noSQL, MapReduce, Hadoop, etc) as well as prominent algorithms used to mine data (e.g., clustering and association rule mining) and perform statistical modeling. This course is targeted towards individuals familiar with databases who would like to further understand the concepts and practices of large scale data analytics. The objective of this course is to familiarize students with the fundamental techniques and tools used to design and analyze large volumes of data.

IMGT 687 - Cyber Systems Security
This course explores the managerial and technological aspects of cyber and systems security (defense and attack) in the Department of Defense (DoD). Information is recognized as a strategic resource vital to military operations and national security objectives. Students will examine relationships and dependencies in support of mission execution, resiliency, and system security inherent in information-based systems and the DoD’s networked infrastructure. Students will also explore engineering concepts and considerations for developing secure systems of interest to the DoD. Upon completion the student will understand and be able to apply concepts and methods for managing the security of cyber and information dependent systems, articulating threats in a globally networked environment, and identifying vulnerabilities associated with modern distributed systems and infrastructure. Lastly, the student will practice communicating effectively through written means.

* In-resident offering only at present
Energy Systems
A Domain Specialization Track

EMGT 560 Future DoD Energy Systems Engineering
This course focuses on the engineering of future energy systems to increase the energy resiliency of Department of Defense (DoD) fixed installations, contingency bases, and individual warfighter equipment that includes ground vehicles, air vehicles, space vehicles and their associated weapons and sensors. The course will provide an in-depth look at energy technologies and provide a systematic approach for their conceptualization, design, analysis, operation, and sustainment. Students will compare the generation and storage of solar, fossil, geothermal, nuclear, hydroelectric, and wind energy systems, and develop analysis skills necessary to determine the best technologies for systems integration when considering technical feasibility, economic feasibility and operational impact. New energy sources, efficiency, conservation and resilience will be discussed.

SENG 582A Aviation Energy Systems Engineering
This course will focus on the engineering of aviation energy systems to optimize their performance and cost. The course will provide an in-depth look at propulsion & avionics energy requirements and then examine current methods of meeting those requirements including internal combustion engines, turbine engines, auxiliary power units and batteries. A model for the conceptualization, design, analysis, operation, and sustainment of aviation energy systems will be developed, and then students will examine emerging technologies including fuel cells, hydrogen, biofuel and all-electric aircraft to determine the best technologies for systems integration when considering technical feasibility, economic feasibility and lifecycle implications.

SENG 604A Contingency Base Energy Systems Engineering
This course will focus on the engineering of contingency base energy systems to optimize their performance and cost. The course will provide an in-depth look at austere location energy requirements including those that result from flight operations, security, billeting and water purification. Then, students will examine current methods of meeting those requirements including diesel generators and spot generation. A model for the conceptualization, design, analysis, operation, and sustainment of contingency base energy systems will be developed, and then students will examine emerging methods to meet requirements including multiple-generator microgrids with battery storage, fuel cells and renewable energy sources to determine the best technologies for systems integration when considering technical feasibility, economic feasibility and lifecycle implications.
Advanced Systems Analysis
An Analysis Specialization Track

SENG 585 - Reliability in Systems Design
The purpose of this course is to introduce students to the probabilistic models and statistical methods used by reliability engineers. This first course gives basic definitions and terminology, investigates parametric lifetime models, non-parametric methods, coherent systems analysis, Markov analysis techniques and an introduction to repairable system analysis. Emphasis will be placed on using these mathematical tools to models RAM as a dynamic process, develop test plans, perform graphical and statistical inference, as well as model product improvement in the development process.

SENG 685 - Reliability Engineering*

SENG 620 - Quantitative Systems Analysis
This course builds on the material presented in SENG 520, presenting additional depth and breadth in topics related to systems engineering. The focus of this course is on the quantitative analysis of engineering-related problems using mathematical/statistical techniques to assist with various aspects of system development, particularly those related to system dynamics, decision-making, and value assessments. Topics may include decision/analysis, utility theory, decision trees, optimization and queuing theory.

SENG 621 – Modeling & Simulation on High Performance Computing*

SENG 570 – Systems Process Improvement
See description under Cyber/Information Systems

SENG 660 – Advanced Design Principles/Design Strategies
This course explores various principles of systems design in the context of complex and uncertain DoD programs, where traditional fixed design and valuation methods may be inadequate. The course establishes the inherent relationship between decision analysis and engineering design, which reveal shortcomings of conventional design approaches. A wide variety of topics will be covered, all relating to non-functional requirements mechanism(s) for a more effective design strategy in the real world of changing system requirements. Topics will include flexibility, modularity, and changeability.

* In-resident offering only at present
Advanced Systems Analysis (Cont)

An Analysis Specialization Track

**SENG 740 – Advanced System Architecture***

**QMGT 680 – Project Risk Analysis**
This course covers the concept of project risk with an emphasis on formal risk analysis methods. The course exposes students to a variety of approaches for evaluating risk and uncertainty as they apply to a dynamic decision-making environment. Topics include defining risk, DoD risk policy, risk identification, risk handling, qualitative and quantitative risk methods. Both analytical and simulation methods for quantifying cost risk will be discussed. In order to cover simulation methods, the general method of Monte Carlo simulation will be introduced.

**HFEN 620 – Human Performance Modeling**
See description under Human Systems

**IMG 561 – Database Management**
See description under Cyber/Information Systems

**IMG 680 – Advanced Data Management (Big Data)**
See description under Cyber/Information Systems

**MECH 620 – Systems Optimization***

* In-resident offering only at present
Small UAS
A Domain Specialization Track

**SENG 550 - Small UAS Concept Definition and Preliminary Design** *
This is the first in a three-course specialty sequence in which systems engineering is applied in depth to an Unmanned Airborne System (UAS). In developing their own UAS, students will address early systems engineering concepts such as mission analysis, concept definition, requirements refinement, and preliminary system design. The course culminates in a preliminary design review of the selected UAS concept.

**SENG 650 - Small UAS Detailed Design** *
This is the second in a three-course specialty sequence in which systems engineering is applied in depth to an Unmanned Airborne System (UAS). In this course, students will iterate and mature their preliminary system design from SENG 550 into a detailed design, with allocated functional and performance requirements. The course culminates in a critical design review of the selected UAS design, to include full traceability of established requirements.

**SENG 651 - Small UAS Test and Evaluation** *
This is the third in a three-course specialty sequence in which systems engineering is applied in depth to an Unmanned Airborne System (UAS). In this course, students must implement their detailed design from SENG 650 through appropriate test planning and execution, making design modifications as necessary to meet system requirements. This course culminates in an operational flight test of the student's design.

* In-resident offering only at present
Navigation
A Domain Specialization Track

EENG 533 Navigation Using the GPS
This course provides a theoretical and practical foundation for understanding the Global Positioning System (GPS). Emphasis is on determining navigational information such as user position and velocity. Topics include satellite orbits, control, space, and user segments, signal structure, measurements, least-squares solution position and clock errors, error sources, dilution of precision, availability, differential GPS, modernization, and Global Navigation Satellite Systems.

EENG 534 Fundamentals of Aerospace Instruments and Navigation Systems
Basic reference frames are defined and coordinate transforms are derived. The applicable laws of mechanics are used along with basic control system theory to analyze the kinematic and dynamic behavior of inertial sensors used in attitude and tracking systems. Vector and matrix notation are used throughout. Topics covered are the earth model, two-degree-of-freedom and single-degree-of-freedom tuned and floated mechanical gyroscopes, laser gyroscopes, linear accelerometers, inertial platforms, and unconventional inertial devices. Non-inertial navigation topics include radar, radio aids to navigation, optical trackers, and satellite navigation. The emphasis is on developing practical mathematical models useful to the guidance and control engineer. Examples are taken from current and planned Air Force systems.

EENG 633 Global Navigation Satellite System Receiver Design
This course covers analog and digital signal processing of Global Navigation Satellite System (GNSS) receivers including GPS. Laboratory projects involve incremental development of a sample-level baseband GNSS signal simulator and processor. Labs culminate in a GNSS software receiver that processes live sky sampled data files to produce pseudo-range and accumulated Doppler range measurements. Topics include: GNSS signal structures, link budget, RF front-end architectures, correlation processing, signal acquisition and tracking techniques (FLL, PLL, DLL), C/N0 and other special baseband functions, bit and frame synchronization, navigation message decoding, channel control state machine design and range measurement computation. Also covers advanced topics such as interference/multipath mitigation techniques and signal quality monitoring.

EENG 644 Alternative Navigation Methods
This course covers several non-GPS navigation techniques which can be used to complement GPS when it is not available. The course covers several current non-GPS navigation approaches, and will include study of the relevant literature and a series of projects which enable the student to interact deeply with the approaches using both simulated and real data.

EENG 635 Inertial Navigation Systems *

EENG 765 Stochastic Estimation and Control I *

* In-resident offering only at present
Test and Evaluation

An Analysis Specialization Track
Admissions limited to AFOTEC sponsored students

OPER 679 - Empirical Modeling
Analysis of experimental and observational data from engineering systems. Focus on empirical model building using observation data for characterization, estimation, inference and prediction.

OPER 688 - Operational Experimentation
Introduction to designing experiments for operational testing and evaluation. This is an applied course intended for operations analysts who perform experiments or serve as advisors to experimentation. A statistical approach to the design and analysis of experiments is provided as a means to efficiently study and comprehend the underlying process or system being evaluated. Insight gained leads to improved system performance and quality.

LOGM 634 - Reliability, Maintainability, and Supportability
Creating and sustaining military capability is the purpose of military leadership and management. Reliability and maintainability (R&M) are component characteristics which define the ability of a product to perform its specified functions throughout its operational life. Component R&M of the military system are primary determinants of military capability. This course teaches fundamental R&M and product warranty concepts. Additionally, probability theory is discussed and employed as a tool to quantitatively define these concepts. Topics discussed include the measures which quantitatively define component R&M, the relationships between reliability, maintainability, and availability, and the prediction of R&M measures.

OPER 689 - Advanced Statistical Methods for Test
This course builds upon the material in the prerequisite course providing advanced coverage in time series modeling, generalized linear models, and advanced experimental design. Examples and projects are focused on problems from the test and evaluation enterprise.
Nuclear Weapons Effects, Policy and Proliferation

A Domain Specialization Track
Specialization only available for ASE program. Must be US Citizen.

NENG 500 - Nuclear Weapons Strategy and Policy

This course provides students with a professional understanding of the historical and current US nuclear policy and the implementation of that policy by the Department of Defense and the Air Force. The course starts with analysis of the current Nuclear Posture Review and then reviews the historical development of nuclear weapons policy and strategy. The course then provides a functional and critical understanding of how national and Air Force policy is implemented through current force structures, nuclear surety, and weapons employment. The course also incorporates current debates and case studies.

NENG 591 - Nuclear Weapons and Proliferation

This course examines the elements and technology involved in building a nuclear weapons capability, including producing or obtaining nuclear fuel; assembling a weapon; fuzing and firing; testing, storage, surety, and delivery; and how a proliferator might clandestinely complete the steps. The course covers elements of the United States nuclear weapon program, from fuel production to the maintenance of a nuclear arsenal at an unclassified level.

NENG 596 - Nuclear Weapons Effects

This course provides an understanding of the unique effects of nuclear weapon detonations: blast, thermal, radiation, electromagnetic, and fallout. Each effect is treated by examining its generation, transmission, and mechanisms of interaction with the environment. The course covers the physical origin of each effect, the manner in which these effects impact targets, and how these effects can shape a battle space both tactically and strategically. The course also covers survivability/vulnerability issues at the unclassified level.