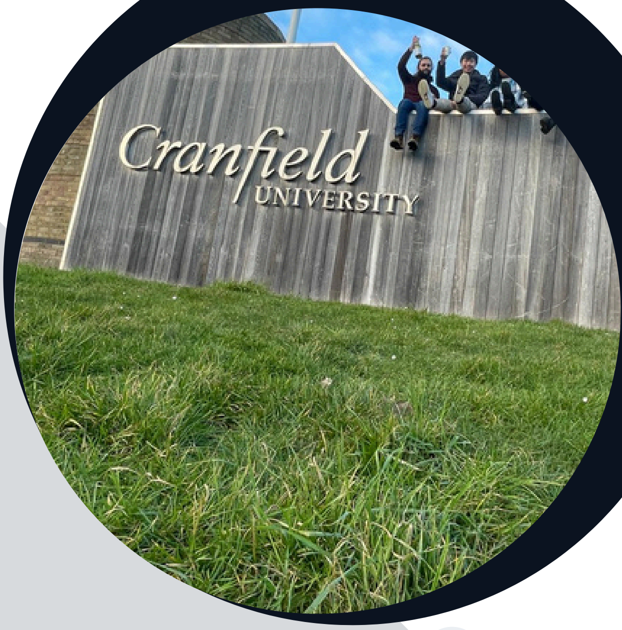
MASTER OF DEFENCE TECHNOLOGY AND SYSTEMS PROGRAMME

INFORMATION BOOKLET FOR 2025 INTAKE



AIR FORCE INSTITUTE OF TECHNOLOGY

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About Temasek Defence Systems Institute

Vision	A premier educational institute for nurturing systems thinkers and thought-leadership in systems thinking in defence and security
Mission	To nurture systems thinkers and leaders to advance Singapore's defence capabilities

Temasek Defence Systems Institute (TDSI) provides the platform to bring together military staff and defence technologies in an education and research environment. TDSI aims to produce graduates who understand the complexities of a military force, so as to be able to create maximum leverage by the integration of operations and technology.

Breadth + Depth

TDSI's flagship programme is the Master of Defence Technology and Systems Programme.

The aim of the programme is to educate and integrate military staff and defence technologists in planning, designing, developing, creating, operating and sustaining integrated military forces of the 21st century.

Students of this unique Masters Programme will learn by experimenting in a practical environment. They will benefit from the bond building, networking and from the interactions among the military staff, defence engineers and scientists to leverage on the opportunity highly essential for an integrated defence development.

The qualities that the students develop by taking on such an in-depth interdisciplinary experience will better prepare them to confront the challenges of the new millennium.

About Master of Defence Technology and Systems Programme (MDTS)

Objectives

This Programme provides postgraduate education in Defence Technology, Systems Engineering and Integration for military officers, defence engineers and scientists. Graduates from the programme will be:

1. Proficient in the underlying scientific principles of key technologies, both current and future, and their physical boundaries. The emphasis will be on technologies in the key capability areas of Manoeuvre War, Precision Strike, Comprehensive Awareness & Communications and Protection/Survivability.
2. Conversant in applying systems engineering methodologies and processes learnt in analysing the integration and interactions of sub-systems in large-scale systems, so as to optimize the total system performance.
3. Capable of conducting technical studies and lead in operational testing and evaluation (OT&E) efforts to expand systems' operating envelops.
4. Skilled in analysing the impact of future technologies on military operational concepts and how future operational concepts drive technological demands.

Minimum Admission Requirements

1. Bachelor of Engineering (with good honours), Bachelor of Science in Physics or Mathematics (with good honours), or an equivalent qualification acceptable to NUS and AFIT;
2. At least 3 years of relevant working experience; and
3. Sponsorship to this Programme by the candidate's employer.

Degrees Awarded

The MDTS is a double-degree programme. The following degrees will be awarded to students who successfully complete all the relevant courses, projects and research thesis at NUS and AFIT:

Master of Science (Defence Technology and Systems) degree by NUS	&	**Master of Science degree in a relevant discipline** awarded by AFIT

GRE and TOEFL

AFIT requires candidates to submit satisfactory scores on the Graduate Record Examination (GRE) or the Graduate Management Admissions Test (GMAT), as applicable to the programme requested. The recommended GRE scores are at least 153 verbal (500 for GRE taken prior to 1 August 2012) and 148 quantitative (600 for GRE taken prior to 1 August 2012) and the recommended GMAT score is at least 550.

Application and Enrolment Schedule

There is one intake each year for this programme. All applications for the March 2024 Intake must reach Temasek Defence Systems Institute by 15 November 2023.

Applicants will expect to be informed on the outcome of their application sometime in January 2024.

Date	Event
15 July 2024	Application Opens
15 October 2024	Application Closes
January to March 2025	Applicants review Engineering Mathematics (E-Learning)
19 March 2025	• Registration of Students at NUS • Welcome Briefing
24 March 2025	Start of MDTS Programme in NUS
9 September 2025	Students report to AFIT
13 September 2026	End of MDTS Programme in AFIT

Academic Dates

The academic programme is based on quarterly cycles. The dates for these quarters are shown in the below table:

Quarter	Dates	Venue
Q1	24 Mar 2025 to 6 Jun 2025	NUS
Q2	9 Jun 2025 to 29 August 2025	NUS
Q3	9 Sep 2025 to 13 Dec 2025	AFIT, US
	15 Dec 2025 to 2 Jan 2026	Christmas Break
Q4	5 Jan 2026 to 14 Mar 2026	AFIT, US
Q5	23 March 2026 to 1 Jun 2026	AFIT, US
	2 Jun 2026 to 24 Jun 2026	Summer Break
Q6	25Jun 2026 to 13 Sep 2026	AFIT, US

Structure of Programme

The Programme is structured into two parts:

Common Curriculum	• Common modules conducted at NUS • Integration Project conducted at AFIT
Specialised Curriculum	• Specialised modules conducted at AFIT • Thesis Research conducted at AFIT

The structure of this programme is illustrated in **ANNEX A.**

Curriculum

1. Students are required to complete a programme of study comprising the NUS Curriculum and a Specialised Curriculum of the student's choice.

2. A brief description of the courses under the NUS Curriculum is shown in ANNEX B.

3. The courses under the Specialised Curriculum are existing courses in AFIT. ANNEX C describe the courses in each specialisation track.

4. Students are expected to take 18 months to complete the MDTS programme, however, they may extend the NUS Curriculum beyond quarter 1 and quarter 2 if they select the expanded non-TDSI electives or Thesis Project (local). Maximum candidature period is 36 months.

Prerequisites

Students are to ensure that they satisfy the relevant prerequisites courses for the selected specialisation track of the MDTS programme.

Examinations

1. Students will be examined at the end of each quarter of their study for the coursework courses.

2. The Board of Examiners of the respective universities will decide the examination results of the courses offered at each university. Each university will issue the examination results to students reading their respective courses.

3. The universities will exchange results of the students.

Further Information and Contact

1. Students need to provide for their own meals, lodging, transportation, entertainment, books and stationeries. A list of the estimated cost for such expenditure accompanies this booklet.

2. Please visit TDSI's website for more information and updates at https://tdsi.nus.edu.sg/

3. If you need further clarification, you may contact:
Ms Wong Hsiao-Szu <tdswhs@nus.edu.sg> or
Ms Stephanie Quek <squek@nus.edu.sg>

Annexes

Annex A	Master of Defence Technology and Systems (MDTS) Programme Structure
Annex B	MDTS NUS Curriculum Course Description
Annex C	MDTS Specialised Curriculum and Course Description

Master of Defence Technology and Systems (MDTS) Programme Structure

MDTS Programme Structure

The MDTS programme is divided into two parts, the NUS Curriculum and the Specialised Curriculum. Upon completing the courses successfully, students will be awarded the following:

- Master of Science (Defence Technology and Systems) degree by NUS; and
- Master of Science degree in a specialised field by AFIT.

MDTS Programme Structure				
Quarter		Venue	NUS Curriculum MSc (DTS)	Specialised Curriculum MSc (specialisation)
Q1	24 Mar to 6 Jun 2025	NUS	Coursework	--
Q2	9 Jun to 29 Aug 2025	NUS	Coursework	--
Q3	Sept to Dec 2025	AFIT		Coursework & Thesis Research
Q4	Jan to Mar 2026	AFIT		Coursework & Thesis Research
Q5	Apr to Jun 2026	AFIT	Integration Project	Coursework & Thesis Research
Q6	Jul to Sep 2026	AFIT	Integration Project	Coursework & Thesis Research
Q7*	Sep 2026 Onwards	NUS	Coursework or Thesis Project (Local)	

** Students who select the expanded electives or Thesis Project (Local)*

<u>The NUS Curriculum</u> aims to provide students with a broad range of knowledge pertaining to systems engineering and introduction to key defence technologies. Here, the learning emphasis is on systems thinking. The Integration Project will be conducted at AFIT.

<u>The Specialised Curriculum</u> aims to provide students with in-depth knowledge of a specific field in defence technology. Students are required to choose a programme offered in AFIT. The Specialised Curriculum (tracks) comprises another 8-10 required coursework and a “Thesis Research”.

MDTS Programme – NUS Curriculum Overview

Students are required to complete a total of 20 units of Core courses, 12 units of Elective courses and obtain a satisfactory grade for Integration Project. The NUS curriculum is shown in the table below.

NUS Degree: Master of Science (Defence Technology and Systems)		
Pre-programme Refresher Courses (Jan – March)		
Engineering Mathematics (refresher course)		
Probability and Statistics (refresher course)		
Quarters 1 and 2 (Mar to Sep) at NUS Singapore		
Core Courses (20 units)		
DTS5701	Large Scale Systems Engineering	4 units
DTS5702	C3 Systems	4 units
DTS5731	Fundamentals of Systems Engineering	2 units
DTS5732	Artificial Intelligence & Data Analytics	4 units
DTS5735	Cybersecurity	4 units
DTS5736	Systems Design Project	2 units
Elective Courses		
DTS5703	Operations Research	4 units
DTS5733	Sensors & Intelligence	4 units
DTS5734	Guided Systems	4 units
Quarters 3 to 5 (Sep to Jun) at NPS, United States		
	Integration Project conducted at NPS	8 units
Quarter 7 (Sep) onwards at NUS Singapore		
Expanded Elective Courses *at NUS, Singapore*		
DTS5712	Thesis Project (Local)	8 units
EE5112	Human Robot Interaction**	4 units
ME5311	Data-Driven Engineering and Machine Learning**	4 units
ME5418	Machine Learning in Robotics**	4 units

*** Offered by Department of Electrical and Computer Engineering or Department of Mechanical Engineering in NUS Semester 1 (August) or 2 (January).*

MDTS Programme – Specialised Curriculum Overview

The specialised field by AFIT and the associated degree name are shown in the table below.

	Department	AFIT Degree	Specialisation Track
1	**Aeronautics & Astronautics**	Master of Science in Space Systems Master of Science in Aeronautical Engineering	• Space Systems • Aeronautical Engineering
2	**Engineering Physics**	Master of Science in Physics	• Remote Sensing
3	**Operational Sciences**	Master of Science in Operations Research Master of Science in Logistics and Supply Chain Management	• Operations Research • Logistics and Supply Chain Management
4	**Systems and Engineering Management**	Master of Science in Systems Engineering	• Systems Engineering
5	**Electrical & Computer Engineering**	Master of Science	• Guidance, Navigation & Control • Electronic Warfare Technology • Synthetic aperture Radar • Computer Networks • Artificial Intelligence • Remote Sensing

MDTS Common Curriculum
Course Description

Engineering Mathematics (Online Refresher Module)
- Introduction to vector fields, vector algebra and partial derivatives of vector and scalar fields.
- Gradient, divergence and curl.
- Introduction to line, surface and volume integrals; Green's Divergence.
- ODE classification and general solutions.
- First and second-order homogeneous and non-homogeneous ODEs.
- Introduction to error and sensitivity analyses.
- Matrix algebra: introduction and notation; rank, determinants, transpose and inverse; simple elementary row operations and linear independence; eigenvalues and eigenvectors.
- Complex numbers: introduction and geometrical representation; Argand diagram; complex algebra; Euler's representation and De Moivre's theorem.
- Fourier analysis: concept of transforms; Fourier series and orthogonality relations; Fourier transforms and applications.
- Probability axioms and event probability.
- Random variables and their probability distributions.
- Hypothesis testing, conditional probability and expectation.

Probability & Statistics (Online Refresher Module)
Topics include:
- Descriptive Statistics
- Probability Concepts
- Conditional Probability
- Discrete Distribution
- Continuous Distribution, Non-normal, Multivariate

DTS5701 Large Scale Systems Engineering
Large Scale Systems Engineering deals with the complexities of large-scale systems. The Systems Approach and Systems Engineering methodologies are used to understand and conceptualize the key issues in the planning, design and management of large scale systems.

The module aims to help students learn about Large Scale Systems Engineering (LSSE) with theories, stories and case studies on how systems are planned and implemented.

By the end of the module, students are expected to be able to analyse and synthesise systems and design large-scale projects using the LSSE framework taking into consideration their goals, boundaries, stakeholders, complexities, trade-offs, risks and unintended consequences.

DTS5702 C3 Systems
This module provides the key underlying principles and concepts of C3 engineering and their application in the design, development and integration of C3 systems in modern armed forces.

Using a systems engineering approach, the module will also enable participants to have a good appreciation of the key considerations and challenges as well as good engineering practices associated with C3 design and integration with sensor and weapon systems.
Topics related to emerging trends, concepts and technologies will also be covered.

DTS5703 Operations Research

This is an introductory module to operations research which will cover both deterministic and stochastic models for effective decision-making.

Topics include Mathematical programming (overview on models building and sensitivity analysis; computer-based solutions), multi-criteria decision analysis, reliability and maintenance, queueing theory and simulation. Relevant cases on military applications will be discussed.

DTS5731 Fundamentals of Systems Engineering (Online Module)

This module is an introductory module providing an overview of the topic and a flavour of the details which should be more fully explored in depth through other modules. It explains systems, systems engineering, lifecycles, associated activities, products, applications, processes, models, methods and strategies.

DTS5732 Artificial Intelligence and Data Analytics

This is an introductory module to artificial intelligence (AI) and data analytics (DA). It covers various topics of AI and DA.

The AI topics include heuristic search, constraint satisfaction, logic and inference, and natural language processing. The DA topics include data pre-processing, data visualization, classification, model evaluation, decision trees, neural networks, deep learning, association analysis, and clustering.

DTS5733 Sensors & Intelligence

This module introduces sensor and intelligence technologies and their applications in the operational context. It focuses mainly on the most commonly deployed sensor technologies such as Radar and Electro-Optical (EO) sensors as well as established and emerging intelligence areas such as communications intelligence (COMINT), electronic intelligent (ELINT) and Open-Source Intelligence (OSINT).

The underlying technical principles for performance assessments in various environments, such as electronic warfare and design trade-offs will be covered and reinforced through the use of application examples.

DTS5734 Guided Systems

The module covers the principles, technologies and operational aspects of smart weapon systems e.g. guided weapons, precision munitions and unmanned vehicles (UxVs).

The interplay of various sub-systems for target identification & tracking, guidance/navigation, command and control and their impact on mission effectiveness will be examined with consideration of counter-measures and counter-counter-measures. Additional topics include advanced concepts for autonomy, interoperability and teaming and cooperation. The course will include case studies of these weapon systems in actual combat.

DTS5735 Cybersecurity

This module introduces cybersecurity concepts and their applications. It aims to illustrate how systems can fail under malicious activities, and how the threats can be mitigated and managed.

Topics include cryptography, communication channel security, system security, trusted computing, policy making, human factors, etc. Applications such as cloud security, IOT security, security operations centre, AI in cybersecurity, and case studies on well-known attacks will be used to reinforce the learning of various foundational concepts.

DTS5736 Systems Design Project

The purpose of this module is to allow students to practise Systems Engineering Applications in realistic large scale defence/security problem solving.

Students are required to adopt the systems approach in problem definition/framing and applying various technical disciplines taught in this programme, e.g. C3, Sensors and Intelligence, DA/AI, Guided Weapons, Unmanned Systems, Cyber, Operations Research etc., in developing the system solutions. They are expected to conduct systems engineering studies to formulate and synthesize sound and cost effective systems solutions to address the operational requirements and scenario.

EE5112 Human Robot Interaction

The module introduces different modes of human robot interactions, methods for detecting humans, understanding human behaviors and intentions, and methods for humanrobot coordination and collaboration. Human-robot interactions include physical and non-physical (e,g, social) interactions. Physical interactions include human assistance and wearable robotics. Non-physical interactions include natural language understanding, gestures and "body language", and multi-modal interaction fusing different interaction modalities. Human-robot coordination and collaboration include human-robot handovers, robotic assistants and co-workers. User interface design for mutual communications between robot and humans is covered, including social interaction. Several applications and scenarios will be included.

ME5311 Data-Driven Engineering and Machine Learning

The course covers basic linear algebra principles to provide the formalism to reveal coherent patterns and behaviors in data. We will introduce system identification methods, dimensionality reduction techniques, dynamical system theory, inverse problems in their Bayiesian form and machine learning techniques, with a special focus on neural networks. These will provide students with the necessary tools to analyze real-world datasets that are commonly found in practical engineering and scientific applications.

ME5418 Machine Learning in Robotics

The course provides the basics of machine learning, in terms of most commonly used techniques in robotics, including neural networks. The students will apply their learnt knowledge on a robotic task.

MDTS Specialised Curriculum

Important note on suggested matrices

1. The suggested matrices for the various specialisation fields are shown in the following pages. The courses in the matrix are provided as a **guide**. Please work with the AFIT Academic Associate and Program Officer for actual courses. Candidates are to ensure that they satisfy the relevant prerequisites courses for the selected specialisation track of the MDTS Programme. AFIT may, on a case-by-case basis, accredit similar courses that students have achieved earlier.

2. For specialisation tracks which are undersubscribed, the exact courses for the track will be determined by the Academic Associate working with the students.

3. The list of suggested specialisation tracks are established with AFIT. However, this does not preclude a MDTS candidate from applying to read other master degree programme being offered at AFIT, so long as there is agreement between the candidate and the respective sponsor. TDSI will work with AFIT to synchronise the duration of master programme with those of the established specialisation tracks.

4. You may refer to the full list of programmes offered by AFIT at https://www.afit.edu/

1	Department	Suggested Matrix
	Aeronautics & Astronautics	• Space Systems • Aeronautical Engineering

Degree Requirements in Space Systems

In general, a student in the Space Systems program is required to complete at least 48 graduate credit hours for the M.S. degree with a cumulative grade point average of 3.0 or higher. The 48 credit hours include:

- 12 credit hours — Independent Study
- 4 credit hours — Applied Mathematics
- 24 credit hours — Core Courses (may be concurrent with specialty sequence)
- 12 credit hours — Specialty Sequence

TDSI - AFIT Space Systems Program

The Department of Aeronautics & Astronautics is pleased to propose a 12 month program of study satisfying degree requirements and leading to a Master of Science degree in Space Systems with a specialization in space mission design. This four quarter program is summarized in Figure 1.

Fall Quarter: October - December			
ASYS 530 (Introduction to Space Programs and Operations)	MECH 532 (Introductory Space Flight Dynamics)	PHYS 519 (The Space Environment)	MATH 509 (Mathematical Methods in the Physical Sciences)
Winter Quarter: January - March			
PHYS 521 (Space Surveillance)	MECH 542 (Introduction to Finite Element Analysis and Computer-Aided Design)	EENG 571 (Satellite Communications)	Thesis Research
Spring Quarter: April - June			
ASYS 631 (Spacecraft Systems Engineering)	MENG 531 (Space Propulsion and Power Systems)	SENG 699 (Integrated project)	Thesis Research
Summer Quarter: July - September			
MECH 731 (Modern Methods of Orbit Determination)	SENG 699 (Integrated project)	Thesis Research	Thesis Research

Figure 1
Space Mission Design Specialization in Space Systems
TDSI - AFIT

The associated course titles and descriptions are provided in the next section.

Course Descriptions

ASYS 530 - Introduction to Space Programs and Operations
This course examines the history and current status of military space operations. Topics include the history of space flight, the relationships between military and civil space programs, space law, US space policy, military space missions, US military space organizations, and non-US space programs. Introduction to standard space mission analysis software.

Prerequisites/Corequisites: Permission of Instructor

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.

Prerequisites/Corequisites: MECH 532 or Permission of Instructor

EENG 571 - Satellite Communications
The objective of this course is to provide a comprehensive introduction to modern communications principles with particular emphasis on applications to satellite and space communications systems. Topics include: modulation, signals, multiplexing, demodulation, multiple access, coding, orbits, look angles, satellite hardware, earth-station hardware, and link analysis.

Prerequisites/Corequisites: None

MATH 509 - Mathematical Methods in the Physical Sciences
This course covers basic topics in linear algebra and the calculus of several variables. Topics from linear algebra include matrix algebra, solutions of systems of linear equations, real vector spaces, and linear transformations between real vector spaces. Topics from several variable calculus include partial differentiation, directional derivatives, functional transformations and Jacobians, maxima and minima, and integration in two and three variables.

Prerequisites/Corequisites: None

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.

Prerequisites/Corequisites: Undergraduate dynamics or Permission of Instructor

MECH 542 - Introduction to Finite Element Analysis and Computer-Aided Design
Introduce finite element analysis and computer-aided design tools for analyzing, pre-, and post-processing finite element models. Review historical development of finite element analysis and related computational tools. Demonstrate finite element process for truss elements. Program simple finite element code for trusses. Learn graphics software in AFIT computer environment to model one-, two-, and three-dimensional structures. Use preprocessor to create geometric models and associated finite element meshes. Use postprocessor to generate deformed geometry, x-y plots, and contour plots. Present modeling guidelines and adaptive meshing techniques.

Prerequisites/Corequisites: None

MECH 731 - Modern Methods of Orbit Determination
Introduction to probability theory. Statistical mission assessment. Derivation of the methods of the least squares in linear and nonlinear problems. Sequential estimation methods, including numerical instabilities and time weighting. Applications to the problem of determining the updating of the orbital elements of satellites.

Prerequisites/Corequisites: MECH 532

MENG 531 - Space Propulsion and Power Systems
Concept, theory, and performance of chemical and nonchemical propulsion systems for use in space. Typical Systems will include electrical, nuclear, liquid propellant, and exotic space propulsion systems. Concept, theory and performance of power generation methods in space. Systems studied will include low and high power systems intended for short term or long term applications. Chemical, solar and nuclear devices and the energy conversion means for converting energy from these sources into useful electrical power will be studied. An overview of space mission requirements and how they impact propulsion and power system selection. Review of current and future trends in spacecraft propulsion and power generation.

Prerequisites/Corequisites: Undergraduate Thermodynamics

PHYS 519 - The Space Environment
The near-earth environment, from the surface to geosynchronous altitude, is that in which satellites and astronauts must operate. This course is concerned with the radiation, particles, and general conditions encountered in the Earth's atmosphere, ionosphere, and magnetosphere. Specific effects that may be studied include spacecraft thermal equilibrium, orbit decay, spacecraft charging, space-to-ground communications, atmospheric chemistry, Van Allen belts, and solar phenomena.

Prerequisites/Corequisites: None

PHYS 521 - Space Surveillance
This course covers the fundamental physics necessary for an understanding of remote sensors with an emphasis on visible light and infrared systems. Beginning with the sources of electromagnetic radiation, the following aspects of the problem are treated phenomenologically; the interaction of light with matter, atmospheric absorption and scattering, radiometry, optical systems, spectral and spatial resolution and imaging, and electro-optical detectors. Where appropriate, examples are chosen from current Air Force technology.

Prerequisites/Corequisites: None

Degree Requirements for Aeronautical Engineering

In general, a student in the Aeronautical Engineering program is required to complete at least 48 graduate credit hours for the M.S. degree with a cumulative grade point average of 3.0 or higher. The 48 credit hours include:

- 12 credit hours — Independent Study
- 4 credit hours — Applied Mathematics
- 24 credit hours — Core Courses (may be concurrent with specialty sequence)
- 12 credit hours — Specialty Sequence

TDSI-AFIT Aeronautical Engineering Program

The Department of Aeronautics & Astronautics is pleased to propose a 12 month programs of study satisfying degree requirements and leading to a Master of Science degree in Aeronautical Engineering with a specializations in aircraft stability and control and either aeroelasticity or aircraft structures. These programs are summarized in Figure 2.

Fall Quarter: October - December			
ASYS 525 (Linear Systems Analysis)	MECH 500 (Fundamentals of Solid Mechanics)	MATH 521 (Applied Linear Algebra)	AERO 533 (Incompressible Aerodynamics) [1]
Winter Quarter: January - March			
ASYS 565 (Control and State Space Concepts)	MECH 515 (Theory of Vibrations [3]) or MECH 542 (Introduction to Finite Element Analysis and Computer-Aided Design)	MECH 529 (Dynamics and Control of Flight Vehicles)[2]	Thesis Research
Spring Quarter: April - June			
MECH 628 (Aircraft Control)	MECH 662[3] (Intro to Aeroelasticity) or MECH 642 (Finite Element Methods for Structural Analysis I)	SENG 699 (Integrated project)	Thesis Research
Summer Quarter: July - September			
MECH 629 (Aircraft Handling Qualities and Performance)	SENG 699 (Integrated project)	Thesis Research	Thesis Research

Figure 2
Aircraft Stability & Control Specialization in Aeronautical Engineering
TDSI - AFIT

1. May be left open or replaced by an elective
2. May replaced by an aerodynamics or propulsion elective
3. MECH 515 and MECH 662 are paired together, as are MECH 542 and MECH 642

Course Descriptions

AERO 533 - Incompressible Aerodynamics
Dynamics of incompressible, inviscid and viscous flow fields. Topics include kinematics and dynamics of flow fields, potential flow theory, circulation theory of lift, characteristics of airfoils, fixed wings and rotary wings, introduction to laminar and turbulent boundary layers.

Prerequisites/Corequisites: Permission of Instructor

ASYS 525 - Linear Systems Analysis
This course covers the underlying theory of linear time invariant and time varying dynamic systems. The modeling of engineering systems with an emphasis on mechanical systems is covered. Analysis techniques include classical analysis in the continuous time domain and frequency domain as well as modern state space analysis techniques for linear systems.

Prerequisites/Corequisites: Permission of Instructor

ASYS 565 - Control and State Space Concepts
This course covers topics in conventional and modern control theory. The interrelation between conventional and modern approaches is emphasized. Topics include: feedback systems analysis, root locus, Bode, and Nyquist analysis, state space feedback systems analysis, and control system compensation design.

Prerequisites/Corequisites: ASYS 525 or equivalent.

MATH 521 - Applied Linear Algebra
Algebra of matrices, the theory of finite dimensional vector spaces, and basic results concerning eigenvalues and eigenvectors with particular attention given to topics that arise in applications.

Prerequisites/Corequisites: None

MECH 500 - Fundamentals of Solid Mechanics
Analysis of deformation, strain, and stress continuum. Introduction to elasticity, including definitions of stress, strain, compatibility, equilibrium, generalized Hooke's law, and boundary conditions. The Principle of Minimum Potential Energy is applied to beams in tension, shear, and bending. Torsion of bars with non-circular cross-sections is analyzed by applying St. Venant's Semi-Inverse Principle.

Prerequisites/Corequisites: Undergraduate Strength of Materials

MECH 515 - Theory of Vibrations
Free and forced vibrations of damped and undamped systems with a finite number of degrees of freedom. Characteristic frequencies and mode shapes. Generalized coordinates and normal modes. Free and forced vibrations of simple continuous systems; transverse oscillations of strings, longitudinal and torsional oscillations of rods, and bending vibrations of beams.

Prerequisites/Corequisites: MECH 521 or equivalent

MECH 529 - Dynamics and Control of Flight Vehicles
Aerodynamic considerations of lift, drag, and moment. Aerodynamic stability derivatives. Derivation of the aircraft equations of motion. Trim conditions and stability analysis of the linearized equations of motion.

Prerequisites/Corequisites: MECH 521 or equivalent

MECH 542 - Introduction to Finite Element Analysis and Computer-Aided Design
Introduce finite element analysis and computer-aided design tools for analyzing, pre-, and post-processing finite element models. Review historical development of finite element analysis and related computational tools. Demonstrate finite element process for truss elements. Program simple finite element code for trusses. Learn graphics software in AFIT computer environment to model one-, two-, and three-dimensional structures. Use preprocessor to create geometric models and associated finite element meshes. Use postprocessor to generate deformed geometry, x-y plots, and contour plots. Present modeling guidelines and adaptive meshing techniques.

Prerequisites/Corequisites: None

MECH 628 - Aircraft Control
Introduction to aircraft flight control systems. Response to control inputs. Use of classical control theory to analyze and design longitudinal and lateral autopilots. Digital computer techniques and response to random inputs.

Prerequisites/Corequisites: MECH 529; ASYS 565; or equivalent

MECH 629 - Aircraft Handling Qualities and Performance
This course presents an overview of aircraft performance and handling qualities. Topics covered in performance include climb, cruise, and turn performance. The flying qualities portion includes aircraft dynamics, classical aircraft handling qualities, parameters, pilot modeling, pilot ratings, and their prediction.

Prerequisites/Corequisites: MECH 529

MECH 642 - Finite Element Methods for Structural Analysis I
Energy principles. Stiffness analysis of structural members. Formulation of structural problems using finite element methods. Analysis of trusses, frames, plane stress, plane strain, plates, and vibration problems. The course will involve computer programming of finite elements.

Prerequisites/Corequisites: MECH 542 or permission of instructor

MECH 662 - Introduction to Aeroelasticity
Mathematical foundations of aeroelasticity. Static aeroelastic behavior of swept and straight wings, control surface effectiveness, coupled control surface/wing torsional divergence. Free vibration and dynamic response of continuous systems. Unsteady, quasi-steady aerodynamics in subsonic and supersonic regimes. Nonconservative dynamic instability, fluttering systems.

Prerequisites/Corequisites: AERO 533 and MECH 515 or equivalents

2	Department	Suggested Matrix
	Engineering Physics	• Remote Sensing

Degree Requirements in Applied Physics

In general, a student in the Applied Physics program is required to complete at least 48 graduate credit hours for the M.S. degree with a cumulative grade point average of 3.0 or higher . The 48 credit hours include:

- 12 credit hours Independent Study
- 4 credit hours Applied Mathematics
- 8 credit hours Core Physics
- 12 credit hours Applied Physics

TDSI - AFIT Remote Sensing Program

The Department of Engineering Physics is pleased to propose a 12 month program of study satisfying degree requirements and leading to a Master of Science degree in physics with a specialization in remote sensing. This four quarter program is summarized in Figure 1.

Fall Quarter: October - December			
MATH 504 (Differential Equations of Mathematical Physics)	PHYS 601 (Electrodynamics) I	PHYS 640 (Optics)	PHYS 570 or PHYS 655 (Quantum Mechanics I)
Winter Quarter: January - March			
PHYS 635 (Thermal Physics)	OENG 644 (Linear Systems and Fourier Optics)	OENG 650 (Optical Radiometry and Detection)	Thesis Research
Spring Quarter: April - June			
OENG 620 (Laser Engineering) or PHYS 670 (Introduction to Solid State Physics)	OENG 780 (Infrared Technology)	SENG 699 (Integrated project)	Thesis Research
Summer Quarter: July - September			
OENG 647 (Hyperspectral Remote Sensing)	SENG 699 (Integrated project)	Thesis Research	Thesis Research

Figure 1
Remote Sensing Specialization in Applied Physics
TDSI - AFIT

There are two program tracks: The "a" track emphasizes engineering practice and the "b" track is more physics intensive. The associated course titles and descriptions are provided in the next section.

Course Descriptions

MATH-504 – Differential Equations of Mathematical Physics
This course builds proficiency with series solutions for ordinary differential equations with variable coefficients in the complex plane. It provides specific information on Bessel, Legendre functions, Lagurerre and Hermite polynomials. Other special functions of mathematics are introduced including gamma and beta functions. The course covers the needed topics in complex variables such as analytic function, singularities, power series expansions, contour integration and residue theory.
Prerequisites/Corequisites: None 4 credit hours

OENG 620 - Laser Engineering
Treats the basic operation and components of the laser with emphasis on the knowledge required to use the laser as an optical system component. Covers laser media, resonator, pump, and waste heat removal, as well as types of lasers available. Both CW and pulsed lasers will be treated. Stress will be placed on the laser output beam and the device parameters that affect that beam.
Prerequisites/Corequisites: PHYS 556 or PHYS 655, PHYS 640 4 credit hours

OENG 644 - Linear Systems and Fourier Optics
This course covers the linear systems approach to modeling optical wave front propagation, diffraction, and imaging. Introductory material includes analysis tools and two-dimensional Fourier transforms. The majority of the course is devoted to using these tools to solve problems in optics imaging, and optical information processing.
Prerequisites/Corequisites: PHYS 640 4 credit hours

OENG 647 – Hyperspectral Remote Sensing
This course provides a thorough treatment of the primary components of the field of hyperspectral remote sensing, including the underlying spectral signature characteristics of natural and man-made materials, the radiative transfer to remote sensors, the design of imaging spectrometers, and the data processing methods employed. The goal is to prepare the student to model the observed spectral radiance for several remote sensing scenarios, analyze the performance of hyperspectral imaging systems, and implement standard hyperspectral classification and detection algorithms.
Prerequisites/Corequisites: PHYS 640, OENG 650 4 credit hours

OENG 650 - Optical Radiometry and Detection
Radiation source characterization and the transport of that radiation through free space is considered in the first half of this course. In the second half, the principles of optical detection are considered along with specific application of various types of detectors.
Prerequisites/Corequisites: PHYS 640 4 credit hours

OENG 780 - Infrared Technology
This course presents the principles and technology required for the design and analysis of electro-optic systems, with emphasis on those systems operating in the infrared. Topics include sources of radiation, targets and backgrounds, atmospheric propagation, optics, detectors, detector performance criteria, scanning and tracking techniques. The course concludes with the design of a representative IR system such as an imaging system (FLIR) or a tracking system.

PHYS 601 - Electrodynamics I
A course in classical electromagnetic radiation. Treats wave propagation in space and in material media, reflection and refraction, and radiating systems.
Prerequisites/Corequisites: PHYS 531 4 credit hours

PHYS 635 - Thermal Physics
Treats statistical mechanics and thermodynamics. Topics include statistical methods, statistical thermodynamics with applications, ensemble theory, Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics with applications.
Prerequisites/Corequisites: PHYS 556 or PHYS 655 4 credit hours

PHYS 640 - Optics
Introduction to modern optics, with a treatment of both geometrical and physical optics. Geometrical topics include reflection and refraction, lenses, mirrors, stops, ray tracing, telescopes, and optical instruments. Wave phenomena treated will include interference, optical testing, polarization, and Fraunhofer and Fresnel diffraction.
Prerequisites/Corequisites: None 4 credit hours
Terms offered: Fall

PHYS 655 - Quantum Mechanics I
An introduction to the Schroedinger approach to quantum mechanics. Presentation and analysis of experimental background, postulatory basis, and perturbation methods. Application of theory to linear oscillator, free particle, hydrogen atom, hydrogen molecule, and tunnel effect is presented.
Prerequisites/Corequisites: PHYS 556 4 credit hours

PHYS 670 - Introduction to Solid State Physics
Study of fundamental concepts in solid state physics. Topics include crystal structure and binding, X-ray diffraction and reciprocal lattice, lattice vibrations and phonons, free electron Fermi gas, transport properties of metals, quantum theory of electrons and energy bands, semiconductors and semiconductor devices.
Prerequisites/Corequisites: PHYS 635, PHYS 655 4 credit hours

3	Department	Suggested Matrix
	Operational Sciences	• Operations Research • Logistics Management

Degree Requirements in Operations Research

To qualify for the Master of Science in Operations Research degree, all enrolled students must develop a foundation in fundamental operations research methods (decision analysis, optimization, simulation, statistical analysis, and stochastic modeling), and associated disciplines (economics and mathematics). This is accomplished through satisfaction of the course requirements shown below, representing 36 credit hours. Students must also perform a minimum of 12 credit hours of independent study, culminating in the submission and oral defense of a major research report (thesis).

TDSI - AFIT Operations Research Program

Specialization Program: foundation in fundamental operations research methods

Degree Awarded: Master of Science in Operations Research

Fall Quarter: October - December			
MATH 523 (Numerical Analysis & Linear Algebra)	STAT 587 (Applied Probability & Statistical Analysis)	OPER 543 (Decision Analysis)	Thesis Research
Winter Quarter: January - March			
OPER 510 (Deterministic Operations Research)	OPER 540 (Stochastic Modeling & Analysis)	OPER 561 (Discrete Event Simulation)	Thesis Research
Spring Quarter: April - June			
OPER 638 (Assessing Cost & Risk)	OPER 679 (Empirical Modeling)	SENG 699 (Integrated Project)	OPER 544 (Operational Decision Support Systems)
Summer Quarter: July - September			
Thesis Research	SENG 699 (Integrated Project)	Elective	Thesis Research

Notes:

1. OPER 561 may be waive-able for DTS - 5707. If so, this would create an elective opportunity in winter quarter.

Course Descriptions

MATH 523 - Numerical Analysis and Linear Algebra
This course presents the basic concepts necessary for the qualitative and quantitative analysis of mathematical systems. Topics covered include vector spaces, linear transformations, inner products, vector and matrix norms, orthogonality, linear systems, eigenvalue problems, least squares problems, convex sets and functions, unconstrained optimization theory, numerical root finding, iterative methods, polynomial interpolation, and numerical differentiation and integration.
Prerequisites/Corequisites: None 5 credit hours

STAT 587 - Applied Probability and Statistical Analysis
This course presents the basic concepts of probability and statistics. Emphasized topics are basic probability axioms and laws, discrete and continuous random variables, joint probability distributions, expectations, conditional probability and expectations, the central limit theorem, sampling theory, estimation, and hypothesis testing.
Prerequisites/Corequisites: None 5 credit hours

OPER 510 – Deterministic Operations Research
This course develops the theory of optimization, building on mathematical fundamentals introduced in the calculus. The emphasis of this course is on exposure to deterministic methods at an introductory graduate level. Topics include fundamentals of linear programming, application of Kuhn-Tucker conditions, integer programming, nonlinear programming, and dynamic programming. The emphasis is on problem solving and examples.
Pre/Corequisites: MATH 523 or Approval of Instructor 4 credit hours

OPER 540 - Stochastic Modeling and Analysis I
This course applies the fundamental probability theory to develop standard approaches to stochastic modeling in operations research. Specific topics include conditional probabilityand exception, the Poisson process and exponential distribution, discrete-time Markov chains, and continuous-time Markov chains. The various models are discussed in the context of military applications.
Prerequisites/Corequisites: STAT 587 or Approval of Instructor 4 credit hours

OPER 543 – Decision Analysis
This course is decision analysis theory and methodology. Decision analysis applies to complex problems involving sequential decisions, major uncertainties, single objectives, conflicting objectives, and multi-attribute value and utility functions. The course includes: decision structuring with influence diagrams, decision trees and value-focused thinking, modeling uncertainty with subjective probabilities, sensitivity analysis and the value of information, and modeling preferences with value and utility functions. Decision analysis for real word problems are discussed.
Prerequisites/Corequisites: STATS 543 or STAT 587 or Approval of Instructor 4 credit hours

OPER 544 – Operational Decision Support Systems
This course blends techniques from the fields of operations research, management sciences, artificial intelligence and information systems to create decision support systems primarily using Excel, including Excel VBA and specialized add-ins for analysis. This course will integrate the use of spreadsheets with operations research topics such as decision analysis, Monte-Carlo simulation and optimization models.
Prerequisites/Corequisites: OPER 510, OPER 543, and OPER 561, or Approval of Instructor. Corequisite: OPER 544L
3 credit hours

OPER 561 - Discrete-Event Simulation
This is an introductory course on the use of computer simulation modeling to analyze complex military systems. The focus of the course is on the development of discrete-event simulation models and the analysis of simulation model input and output. A modern simulation language is

taught to provide a modeling framework and the means for implementing a computerized model. Basic concepts important to simulation studies such as random number and random variate generation, model verification and validation, and output analysis are discussed. Examples and applications are oriented toward operational systems within the DoD.
Prerequisites/Corequisites: STAT 583 or STAT 587, or Approval of Instructor 4 credit hours

OPER 638 – Assessing Operational Coast and Risk
This course develops the theory of operational cost analysis, the evaluation of operational risk, and game theory. The effects of time on economic and monetary evaluation are studied, and risk and its impact on decision making is investigated. Specific topics covered include cost estimation, economic evaluation, risk assessment, value and utility functions, and multiattribute utility theory. A systems analysis perspective is used in the presentation of course material.

Prerequisites/Corequisites: OPER 510, OPER 540, OPER 543, and STAT 587 or Approval of Instructor 3 credit hours

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. Prerequisites/Corequisites: STAT 583 or STAT 587, or Approval of Instructor 3 credit hours

Degree Requirements in Logistics and Supply Chain Management

In general, a student in the Logistics and Supply Chain Management program is required to complete at least 49 graduate credit hours for the M.S. degree with a cumulative grade point average of 3.0 or higher. The 49 credit hours include:

- 15 credit hours — Logistics & Supply Chain
- 13 credit hours — Management Core
- 6 credit hours — Specialty Sequence
- 3 credit hours — Research Methods
- 12 credit hours — Independent Study

TDSI - AFIT Logistics and Supply Chain Management Program

Specialization Programs: Operational Logistics, Life Cycle Logistics, Operational Maintenance, or Petroleum Management

Degree Awarded: Master of Science in Logistics and Supply Chain Management.

Fall Quarter: October - December			
LOGM 520[1] (Economics)	LOGM 570 (Inventory Mgmt)	LOGM 601 (Research Methods)	Specialization Course (2 req'd)[3]
Winter Quarter: January - March			
ORSC 542[2] (Organizational Behavior)	LOGM 615 (Log Info Sys)	LOGM 617 (Transportation Sys & Strategic Mobility)	LOGM 627 (Supply Chain Mgmt)
Spring Quarter: April - June			
LOGM 565[4] (Strategic Sourcing) or CMGT 523 (Contracting)	LOGM 569 (Maint. & Production Management)	Specialization Course (2 req'd)[3]	SENG 699 (Integrated Project)
Summer Quarter: July - September			
LOGM 620 (Activity-Based Management & Costing)	SENG 699 (Integrated Project)	Thesis Research	Thesis Research

Notes:

1. Assumes OPER 501 (Quantitative Modeling) is waived for DTS 5703. LOGM 520 is a foundation course for AACSB conformance. LOGM 520 will require an added offering in fall term (is now taught winter only).
2. Assumes LOGM 590 (Simulation) is waived for DTS 5707. ORSC 542 is a foundation course for AACSB conformance.
3. Specialization Programs:
   a) Operational Logistics: Transportation Policy (LOGM 619) and Forecasting Management (LOGM 630)
   b) Life Cycle Logistics: Project Management (SMGT 546) and System Acquisition Management (SMGT 543)
   c) Operational Maintenance: Scheduling (LOGM 631) and Reliability & Maintainability (LOGM 634)
   d) Petroleum Management: Forecasting Management (LOGM 630) and Seminar in Petroleum Management (LOGM 651)
4. The Life Cycle Logistics specialization requires CMGT 523. The other three specializations require LOGM 565.

Course Descriptions

CMGT 523 - Contracting and Acquisition Management
This survey course introduces students to the DoD contracting and acquisition processes. Through classroom discussion and outside readings, the student is introduced to the overall weapon system acquisition environment, the acquisition process, the overall contracting process, and current ethical and reform issues. The objective of the course is to help students understand the role of contracting in the acquisition process as well as to assess their role and stake in these processes, whether it be as a user, developer, supporter, or manager of a weapon system.
Prerequisites/Corequisites: None 3 credit hours

LOGM 520 - Managerial Economics
Basic microeconomic principles such as supply and demand, elasticity, short-run and long-run shifts in resources allocation, diminishing returns, economies of scale, and pricing are covered. There is a general introduction to economics and economic reasoning, including the application of economic theory to the firm. Also covered are various tools of analysis helpful to decision makers, including demand, production, and cost estimation using regression analysis, forecasting, capital budgeting, and risk analysis. The nature of economic incentives concerning consumers, workers, and business are studied.
Prerequisites/Corequisites: None 4 credit hours

LOGM 565- Strategic Sourcing
This course provides an introduction to and an overview of the strategic sourcing process including topics such as supplier selection, supplier evaluation, negotiation, contract management, supplier development, e-procurement, buyer-supplier relationships, strategic cost management, and purchasing law and ethics.
Prerequisites/Corequisites: None 3 credit hours

LOGM 569 - Maintenance and Production Management
This course explores operations management functions as applied to an Air Force environment. The course familiarizes the student with a variety of operations management techniques which are being applied in maintenance as well as a variety of other operations management settings. Course topics include productivity, facility layout, location, capacity planning, quality control scheduling, project management, queuing theory, inventory management,, forecasting, and current operations management innovations.
Prerequisites/Corequisites: None 3 credit hours

LOGM 570 – Principles of Inventory Management
This course is designed for students who seek a fundamental understanding of the design and operation of inventory management systems. Specifically, this course will provide students with a broad survey of issues concerning managing inventory systems such as (1) the logistics pipeline with emphasis on the DOD, (2) demand data and forecasting methodologies, (3) consumable and reparable inventory models, (4) information theory and (5) management implications
Prerequisites/Corequisites: None 4 credit hours

LOGM 590 – Computer Simulation for Managers
The course concentrates on the concept of designing a model, and analyzing the results. The course's main emphasis is on the proper use of simulation techniques to model systems and answer logistics questions. Course work focuses on the use of the computer to enhance the decision-making capabilities of the logistics manager. This course provides the student with a working knowledge of discrete-event computer simulation as a decision-making tool.
Prerequisites/Corequisites: MATH 291, STAT 525, STAT 535 4 credit hours

LOGM 601 – Principles and Methods of Research
The course provides information on how to conduct an appropriate review of literature to identify gaps and opportunities surrounding the problem area, and to identify and evaluate approaches for data collection and analysis leading to valid inference about the topic into answerable research and investigation questions leading to a formal research proposal. The broadest scope of qualitative and quantitative research methods is discussed. Application of appropriate research designs and analysis tools are course outcomes.
Prerequisites/Corequisites: None 4 credit hours

LOGM 615- Logistics Information Systems
This course focuses on the application of information technologies to Logistics Management. As such, the students are expected to develop an understanding of the application of Information Systems to Logistics both in and outside military. Topics covered will include: Information Security Architecture, Warehouse Management Systems, and Transportation Management Systems. MRP/DRP, ERP systems, and E-logistics will be discussed. The application to USAF will be emphasized. The embedded OR/MS methodology in enterprise software will be discussed.
Prerequisites/Corequisites: None 3 credit hours

LOGM 617- Transportation and Strategic Mobility
Examines each transportation mode for similarities and differences. Ownership of the modes is also detailed, along with cost and service characteristics. Each mode is then examined for its particular contribution to the defense transportation system. The mission, organization, resources and financing arrangements of the three transportation operation agencies of the defense transportation system are examined. Problems associated with strategic mobility are emphasized.
Prerequisites/Corequisites: None 3 credit hours

LOGM 619- Transportation Policy and Strategic Mobility
Focuses on a study of the complex national and defense transportation policy frameworks that guide the constant development of our transportation systems. Examines how transportation policy impacts, and is, in turn impacted by policies formulated to address other national issues. Particular emphasis is placed on the study of the effects of national policies on the defense transportation system. Policy analysismodels are presented and discussed.
Prerequisites/Corequisites:None 3 credit hours

LOGM 620- Activity-Based Management and Costing
The course is designed to give the students knowledge of Activity Based Costing (ABC), why traditional accounting practices do not support managerial decision-making, and techniques to perform ABC. Activity Based Management will be introduced to enable the student to utilize the output from ABC. The development and application of non-financial metrics will be covered. Students will be introduced to the Theory of Constraints, and Balanced Scorecard will be covered. Examples from DoD and the commercial sector will be used to illustrate the application of ABC.
Prerequisites/Corequisites: None 4 credit hours

LOGM 627- Supply Chain Management
This course concentrates on the cross-functional integration of key business processes within the firm and across the network of firms that comprise the supply chain in both commercial and DoD organizations. Emphasis is on managing the complexity of the supply chain, developing supply chain strategies, selecting metrics, and mapping supply networks. The concept of business partnerships will also be explored. A capstone project provides students with hands-on experience in managing the integration of functional skills such as planning, forecasting, inventory management, and distribution.
Prerequisites/Corequisites: None 4 credit hours

LOGM 630- Forecasting Management
Since the DoD community collects much of its data as a natural time series, this course is concerned with the application of time series analysis theory in describing and forecasting logistics performance. This course covers analysis of time series data patterns, introduction of major forecasting techniques, measuring the effectiveness of these techniques, and implementing time series analysis theory in describing and forecasting logistics performance. Statistical development will be brief with intent to survey a wide variety of concepts. Forecasting methods covered include: moving average; exponential smoothing; regression; econometric; and Box-Jenkins.
Prerequisites/Corequisites: STAT 525, STAT 535 3 credit hours

LOGM 631- Scheduling Theory and Application
This course is an introduction to scheduling theory with applications in manufacturing and services. The course is of primary interest to officers in the maintenance career field who often encounter production scheduling problems in an industrial setting as well as workforce scheduling problems. Manufacturing applications include machine scheduling, job shop scheduling, scheduling of flexible assembly systems, and planning and scheduling in supply chains. Services

applications include reservations and timetabling, tournament scheduling, planning and scheduling in transportation, and workforce scheduling. The course is quantitative in nature but will also address management implications.
Prerequisites/Corequisites: MATH 291, STAT 525, and STAT 535 3 credit hours

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. 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.
Prerequisites/Corequisites: STAT 525, STAT 535 or equivalents. 3 credit hours

LOGM 651- Petroleum Management
This course provides an overview of the primary aspects of petroleum management within the Department of Defense. Major topics covered include product procurement, transportation modal selection, storage and inventory management, quality assurance, distribution, and joint operations. Additional areas include alternative fuels, environmental concerns, and interfaces with key Department of Defense organizations.
Prerequisites/Corequisites: None 3 credit hours

OPER 501- Quantitative Decision Making
This is an introductory course in management science applications for the logistics, systems, acquisition, and transportation manager. Emphasis is on understanding and applying the techniques to managerial problem solving and decision making. Major topics include linear programming, decision theory, networks, and queuing theory.
Prerequisites/Corequisites: None 3 credit hours

ORSC 542 - Management and Behavior in Organizations
This course will give the student an in-depth understanding of organizational behavior, organization theory, and management theory. Topics include, but are not limited to, classical and neoclassical organization and management theory, study of organizations, organizational culture, individual behavior, motivation, rewards, organizational behavior, politics, leadership, organizational structure and design, job and organizational design, communication and information in the postmodernist era, decision-making process, and organizational change.
Prerequisites/Corequisites: None 4 credit hours

SMGT 543- Systems Acquisition Management
This course provides the student with an understanding of the underlying concepts, fundamentals, and philosophies of the defense systems acquisition process and the practical application of program management methods within this process. It is designed to acquaint the student with the business, technical, and managerial aspects of managing a system acquisition program. The course examines management issues, control policies and techniques, and functional area concerns. Key topics include the system acquisition life cycle, acquisition management disciplines and activities, and the evolution and current state of systems acquisition management. Case studies are used to analyze various acquisition issues.
Prerequisites/Corequisites: None 3 credit hours

SMGT 546- Project Management
This course provides conceptual material on project management techniques appropriate in systems/subsystems management. The course introduces students to all areas of project management, from initiation to closing. Topics include project management functions; project management roles and responsibilities; effective teams; the project life cycle; conflict resolution; project planning, budgeting, scheduling, and control techniques; and cost estimating. Students get hands-on practice using the project management tool Microsoft Project. The goal of this course is to provide the student with the background knowledge and basic tools to handle a project or contribute effectively as a project team member.
Prerequisites/Corequisites: None 3 credit hours

4	Department	Suggested Matrix
	Systems and Engineering Management	• Systems Engineering

TDSI-AFIT Systems Engineering Program

The Department of Systems and Engineering Management is pleased to propose a 12 month program of study satisfying degree requirements and leading to a Master of Science degree with a concentration in Systems Engineering. This four quarter program is summarized below.

Specializations available: Avionics, Software Engineering, Controls and Optimization or others as appropriate for the thesis/capstone project

Degree Awarded: Master of Science (Systems Engineering)

Fall Quarter: October - December			
SENG 520[1] (Requirements Driven Design)	STAT 583 (Probability and Statistics)	Specialization[2] Course (3 req'd) or Analysis Course[3]	SENG 799[7] Thesis
Winter Quarter: January - March			
SENG 640 (System Architecture)	CSCE 590/CSCE 593[4] (Intro. To Software Engineering)	Specialization[2] Course (3 req'd) or Analysis Course[3]	SENG 799[7] Thesis
Spring Quarter: April - June			
SMGT 546[5,6] (Project Mgt or substitute)	Specialization[2] Course (3 req'd) or Analysis Course[3]	SENG 699 (Integrated project)	SENG 799[7] Thesis
Summer Quarter: July - September			
Free Elective	Specialization[2] Course (3 req'd) or Analysis Course[3]	SENG 699 (Integrated Project)	SENG 799[7] Thesis

Footnotes:

1. We note that TDSI students will likely take an introductory systems engineering course prior to arriving at AFIT, and it appears to offer enough of the curriculum elements contained in SENG 520. Particularly important is the coverage of definitional tools of architecture (e.g., SysML) required doing concept definition and establishing traceability of requirements through design elements. Where these curriculum elements are met by prior TDSI courses, a suitable substitute will be allowed in the student's AFIT SE program.
2. Students are required to take a specialization sequence composed of three or more courses, totaling 12 or more credit hours, with at least one course at the 600 level demonstrating depth in a

discipline or domain of application. Recommended tracks include avionics systems, software engineering, or control and optimization.

3. Students are required to take at least one course emphasizing quantitative analysis. Recommended courses include OPER543 (Decision Analysis), LOGM590 (Modeling and Simulation) and QMGT680 (Risk Analysis). Others are possible.

4. Either CSCE590 or 593 may be used to satisfy the software engineering requirement within the SE program. Students specializing in software development would be required to take CSCE593.

5. SENG610 (SE Management) is being phased out in favor of a consolidated Project Management course (SMGT546).

6. It is noted that TDSI students will likely have taken a Project Management course prior to arriving at AFIT. If most of the course objectives of SMGT546 are met prior to the student's arrival at AFIT, a substitute course from the management discipline would be recommended.

7. AFIT believes that, initially, a research project focused on design, build and test of small, multi-UAV systems would provide the best opportunities for a meaningful interdisciplinary group project. This allows for both analytic/computational and experimental efforts within a given group. These projects can also serve to integrate students across multiple programs (e.g., SE, Aero, EE, OR) based on the willingness of the faculty associated with those programs to participate in a collaborative effort. Non-SE students participating in these collaborative projects would still be required to write and defend an individual thesis based on current EN OIs.

CORE Course Descriptions

CSCE 590 Engineering Software-Intensive Systems 4 credit hours

This course explores the unique challenges faced by teams engineering large-scale software-intensive systems (i.e., systems which have a large software component). Techniques in software requirements elicitation, object-oriented design, and quality assurance are presented in the context of an iterative software development process. Particular attention is paid to object-oriented modeling using the Unified Modeling Language (UML) and real-world case studies of software development within commercial and government organizations. Techniques to facilitate the engineering of reliable and secure software systems are introduced. This course is an introduction to software engineering for experienced engineers whose area of expertise is outside computer science. This course will enable them to more effectively communicate with software users and developers and make sound management decisions with respect to software-intensive systems development. ***Prerequisites***: none

SENG 520 Systems Engineering Design 4 credit hours

This course provides a broad introduction to the structured approach necessary for the design of complex systems. The formulation of systems problems and the approach to their solution will be emphasized. Basic mathematical techniques available to the systems engineer are presented. The design process will be illustrated through the review of past design efforts, and the application to a problem of current interest. ***Prerequisites***: none

SENG 610 Systems Engineering Process and Management 4 credit hours

This is a graduate course primarily intended for the Master of Science program in Systems Engineering. It will provide an overview of the Systems Engineering process and selected topics from Systems Engineering Management. Topics include a model based-approach to key systems engineering design activities, process modeling, requirements analysis and functional allocation, trade-off analysis, and management of cost, schedule and risk. ***Prerequisites***: SENG 520

SENG 640 Systems Architecture 4 credit hours

This course provides the foundations for developing and evaluating architectures for systems of systems. The process for generating a functional, physical and operational architecture from a top level operations concept will be developed. Both structure and applied to DoD concept problems.

Generation of required DoD architecture products will be discussed. The course will also cover the generation of executable architecture models for evaluating the behavior system concepts. ***Prerequisites***: SENG 520 ***Corequisite***: SENG 590

STAT 583 Introduction to Probability and Statistics 4 credit hours

Basic concepts of probability and statistics with computer science applications are covered. Topics include: Permutations and combinations; random variables; probability distributions; estimation and confidence intervals; hypothesis testing. ***Prerequisites***: none

5	Department	Suggested Matrix
	Electrical & Computer Engineering	• Guidance, Navigation & Control • Electronic Warfare Technology • Synthetic aperture Radar • Computer Networks • Artificial Intelligence • Remote Sensing

TDSI-AFIT Guidance, Navigation, and Control Sequence

This sequence of courses covers four core topics that support research in autonomous systems: control theory, estimation theory, the Global Positioning System, and inertial navigation systems. The sequence satisfies the requirements for the Graduate Electrical Engineering program and leads to a Master of Science degree.

Fall Quarter: October - December			
STAT 586 (Probability Theory for Comm. & Control)	EENG 510 (Linear Systems)	EENG 534 (Fundamentals of Aerospace Instruments & Navigation System)	EENG 562 (Feedback Systems)
Winter Quarter: January - March			
EENG 765 (Stochastic Estimation and Control)	EENG 533 (Navigation Using the Global Positioning System)	EENG 635 (Inertial Navigation Systems)	Thesis Research
Spring Quarter: April - June			
Elective	EENG 799 (Independent Study)	SENG 699 (Integrated Project)	Thesis Research
Summer Quarter: July - September			
SENG 520 (Systems Engineering Design)	SENG 699 (Integrated Project)	Thesis Research	Thesis Research

CSCE 698 (Research Seminar) is required in the winter and spring quarters. Additional electives may be necessary to support the thesis research.

Based on research topic, the spring quarter elective can be selected from the following courses:

EENG 633 (Advanced GPS Theory and Applications)
EENG 735 (Inertial Navigation System Analysis and Integration)
EENG 766 (Stochastic Estimation and Control II)

TDSI-AFIT Electronic Warfare Technology Sequence

This sequence of courses exposes the student to some of the underlying technologies of electronic warfare with an emphasis on radar and communications. The sequence satisfies the requirements for the Graduate Electrical Engineering program and leads to a Master of Science degree.

Fall Quarter: October - December			
STAT 586 (Probability Theory for Comm. & Control)	MATH 521 (Applied Linear Algebra)	EENG 580 (Introduction to Signal Processing)	SENG 520 (Systems Engineering Design)
Winter Quarter: January - March			
EENG 535 (Radar Systems Analysis)	EENG 669 (Digital Communications I)	EENG 665 (Random Signal and Systems Analysis)	Elective
Spring Quarter: April - June			
EENG 668 (Advanced Radar Systems Analysis) or EENG 670 (Digital Communications II)	EENG 799 (Independent Study)	Thesis Research	Thesis Research
Summer Quarter: July - September			
SENG 699 (Integrated Project)	SENG 699 (Integrated Project)	Thesis Research	Thesis Research

CSCE 698 (Research Seminar) is required in the winter and spring quarters. Additional electives may be necessary to support the thesis research.

Based on research topic, the winter quarter elective can be selected from the following courses:

EENG 533 (Navigation Using GPS)
EENG 571 (Satellite Communications)
EENG 658 (LIDAR Systems)

TDSI-AFIT Synthetic Aperture Radar Sequence

This sequence of courses provides a background on all aspects of the radar problem with an emphasis on synthetic aperture radar and remote sensing. The sequence satisfies the requirements for the Graduate Electrical Engineering program and leads to a Master of Science degree.

Fall Quarter: October - December			
STAT 586 (Probability Theory for Comm. & Control)	MATH 521 (Applied Linear Algebra)	EENG 580 (Introduction to Signal Processing)	SENG 520 (Systems Engineering Design)
Winter Quarter: January - March			
EENG 535 (Radar Systems Analysis)	EENG 680 (Multidimensional Signal and Image Processing)	EENG 663 (Signal Detection and Estimation)	Thesis Research
Spring Quarter: April - June			
EENG 668 (Advanced Radar Systems Analysis)	EENG 799 (Independent Study)	SENG 699 (Integrated Project)	Thesis Research
Summer Quarter: July - September			
EENG 714 (Advanced Topics in Radar Applications)	SENG 699 (Integrated Project)	Thesis Research	Thesis Research

CSCE 698 (Research Seminar) is required in the winter and spring quarters. Additional electives may be necessary to support the thesis research.

TDSI-AFIT Computer Networks Sequence

This sequence of courses introduces the fundamental techniques and algorithms associated with the design and development of computer communication networks. A mixture of hardware and software techniques related to network design and analysis are presented. Design techniques presented in class are reinforced through simulation design projects. The sequence satisfies the requirements for the Graduate Computer Science program and leads to a Master of Science degree.

Fall Quarter: October - December			
STAT 583 (Probability & Statistics for Computer Science)	CSCE 586 (Design and Analysis of Algorithms)	CSCE 593 (Introduction to Software Engineering)	CSCE 531 (Discrete Mathematics)
Winter Quarter: January - March			
CSCE 689 (Distributed Software Systems)	CSCE 560 (Introduction to Computer Networks)	CSCE 544 (Data Security)	Thesis Research
Spring Quarter: April - June			
CSCE 686 (Advanced Algorithm Design)	CSCE 654 (Computer Communication Networks)	CSCE 799 (Independent Study)	Thesis Research
Summer Quarter: July - September			
CSCE 754 (Advanced Topics in Computer Networks)	SENG 699 (Integrated Project)	SENG 699 (Integrated Project)	Thesis Research

CSCE 698 (Research Seminar) is required in the winter and spring quarters. Additional electives may be necessary to support the thesis research.

TDSI-AFIT Artificial Intelligence Sequence

This sequence of courses fosters an understanding of the design and development of intelligent systems using artificial intelligence (AI) techniques. Emphasis will be on traditional single agent topics - such as intelligent search, knowledge based techniques, and planning - as well as distributed multi-agent systems. Techniques presented in class will be reinforced through several hands-on projects. The sequence satisfies the requirements for the Graduate Computer Science program and leads to a Master of Science degree.

Fall Quarter: October - December			
STAT 583 (Probability & Statistics for Computer Science)	CSCE 586 (Design and Analysis of Algorithms)	CSCE 593 (Introduction to Software Engineering)	CSCE 531 (Discrete Mathematics)
Winter Quarter: January - March			
CSCE 689 (Distributed Software Systems)	CSCE 523 (Artificial Intelligence)	CSCE 799 (Independent Study)	Thesis Research
Spring Quarter: April - June			
CSCE 686 (Advanced Algorithm Design)	CSCE 623 (Artificial Intelligence Systems Design)	SENG 699 (Integrated Project)	Thesis Research
Summer Quarter: July - September			
Elective	SENG 699 (Integrated Project)	Thesis Research	Thesis Research

CSCE 698 (Research Seminar) is required in the winter and spring quarters. Additional electives may be necessary to support the thesis research.

Students taking the Artificial Intelligence sequence must be proficient in an object-oriented programming language such as JAVA or C++.

Based on research topic and advisor input, the summer quarter elective can be selected from the following courses:

CSCE 723 (Advanced Topics in Artificial Intelligence)
CSCE 886 (Evolutionary Algorithms)

TDSI-AFIT Remote Sensing Sequence

This sequence of courses is designed to teach methods for extracting information from remotely sensed satellite imagery. It primarily focuses on methods of digital signal and image processing as well as optical system modeling. The sequence satisfies the requirements for the Graduate Electrical Engineering program and leads to a Master of Science degree.

Fall Quarter: October - December			
STAT 586 (Probability Theory for Comm. & Control)	PHY 640 (Optics)	EENG 580 (Introduction to Signal Processing)	SENG 520 (Systems Engineering Design)
Winter Quarter: January - March			
EENG 658 (Lidar Systems)	EENG 665 (Random Signal and Systems Analysis)	EENG 699 (Independent Study)	Thesis Research
Spring Quarter: April - June			
EENG 780 (Statistical Image Processing)	EENG 680 (Multidimensional Signal and Image Processing)	EENG 663 (Signal Detection and Estimation)	Thesis Research
Summer Quarter: July - September			
SENG 699 (Integrated Project)	SENG 699 (Integrated Project)	Thesis Research	Thesis Research

CSCE 698 (Research Seminar) is required in the winter and spring quarters. Additional electives may be necessary to support the thesis research.

Course Descriptions

CSCE 523 - Artificial Intelligence

This course presents the major principles and techniques of artificial intelligence. Specifically, in-depth studies of core issues, such as knowledge representation and problem identification, formulation, and solving are pursued. Topics include knowledge representation (models of logic, predicate calculus, production-rules, semantic networks, symbolic and sub-symbolic representations), problem solving (search thero-proving, reasoning), and knowledge-based systems (expert systems, natural language processing, vision, planning). Credit Hours 4 Prerequisites/Corequisites CSCE 531 and CSCE 586 Terms Offered Winter

CSCE 531 - Discrete Mathematics

This course provides more in-depth coverage, analysis, and application of set theory, binary relations, functions, and first-order predicate calculus from CSCE 431. Specifically, more emphasis is placed on applying predicate calculus and practice doing proofs, both deductive and inductive formal proofs, and informal proofs. New top areas include: set countability and resolution-based theorem proving. This course also provides detailed and varied examples of how discrete mathematics is applied in other graduate courses in computer science and engineering. Credit Hours 4 Prerequisites/Corequisites CSCE 431 Terms Offered Fall, Winter, Summer

CSCE 544 - Data Security

This course presents the rudiments of data security. The emphasis is on cryptography, beginning with simple ciphers, and extending to public key cryptography based on sophisticated number-theoretic considerations. Other topics include key management, access controls and inference controls. Remarks: Familiarize the student with standard cryptographic techniques. Introduce the student to the concept of public key cryptography, and the theoretical underpinnings of public key cryptography. Learn key management. Credit Hours 4 Prerequisites/Corequisites None Terms Offered Spring, Summer

CSCE 560 - Introduction to Computer Networking

This course provides an introduction to the fundamental concepts in the design and implementation of computer communication networks, their protocols, and applications. Students will understand and evaluate network protocols. The course discusses the basic performance and engineering tradeoffs in the design and implementation of computer networks. Topics include: overview of network architectures, network topology design applications network/programming interfaces (e.g., sockets), transport protocols, flow control, routing, network protocols, data link protocols, addressing, and local area networks. Examples are drawn primarily from the internet (e.g., TCP, UDP, and IP) protocol suite. Sockets programming and network simulations are used to emphasize topics. Credit Hours 4 Prerequisites/Corequisites None Terms Offered Fall, Winter

CSCE 586 - Design and Analysis of Algorithms

This course emphasizes the structure of data and the efficient and effective manipulation (algorithms) of such structures. Physical and logical organization of data is discussed along with data and algorithm abstraction using object-oriented design and abstract data types. Detailed procedures are developed for analyzing the time and space complexities of general algorithms as well as an introduction to NP completeness. Specific data structures discussed include generalized lists, trees, graphs, B-trees, and AVL-trees along with indexing, hashing, sorting, searching and recursive algorithms on specific structures. Well founded algorithm design techniques like divide-and-conquer, local searching, and global searching are also introduced. Course projects emphasize the analysis, reuse, and extension of existing designs and implementations. Credit Hours 4 Prerequisites/Corequisites CSCE 486 Terms Offered Fall, Winter

CSCE 593 - Introduction to Software Engineering

This course is concerned with the development of computer software. Techniques in software requirements elicitation, design, implementation, quality assurance, and project management are presented, along with discussion of the software development process. Emphasis is on object-oriented modeling using a subset of the Unified Modeling Language (UML). Hands-on experience is provided through individual homework problems and a group project. Credit Hours 4 Prerequisites/Corequisites Object-Oriented Programming (CSCE 093 or equivalent) Terms Offered Fall, Summer

CSCE 623 - Artificial Intelligence Systems Design
This course covers a selection of current state-of-the-art areas in artificial intelligence and intelligent systems design. In particular, emphasis is placed on the detailed development of complete systems. Areas include planning and scheduling, reasoning under uncertainty, vision, expert systems, natural language processing, machine learning, autonomous agents and distributed intelligence. Notes Required course in the artificial intelligence sequence in the graduate electrical engineering, graduate computer engineering, and graduate computer science programs. Credit Hours 4 Prerequisites/Corequisites CSCE 523 Terms Offered Spring

CSCE 654 - Computer Communication Networks
This is the intermediate course in networks and protocols. It examines the performance evaluation, design, and management of networks using analytical, simulation and experimental methods to evaluate design and manage networks and protocols. Topics include queuing theory, simulation methods, wireless networks, mobility issues, network security, performance of multiple access, TCP/IP, and Asynchronous Transfer Mode (ATM) technologies, protocols, design of backbone and access networks, and network management methods and protocols. Credit Hours 4 Prerequisites/Corequisites CSCE 560 and STAT 583, STAT 586 or STAT 601 Terms Offered Spring

CSCE 686 - Advanced Algorithm Design
This course provides a theoretical and practical foundation for understanding and analyzing the design, complexity and correctness of algorithms (control structure) along with data structure and implementation considerations. The emphasis on computational models relating to NP complete problems is extended. Use of search algorithms (tree/graph, linear programming, dynamic programming, probabilistic, etc.) to solve NP complete problems is related to the selection of various problem solving strategies including the incorporation of heuristics. Formal properties of the various approaches are studied using graph theory and computational models. Additional focus on logic programming, knowledge representation and automated reasoning in concert with the above topics provide a foundation in computational theory. In particular, applications in artificial intelligence, knowledge-based systems, software engineering, database management, signal processing, VLSI, and computer architecture are related through algorithm modeling and current literature. Credit Hours 4 Prerequisites/Corequisites CSCE 431 and CSCE 586 Terms Offered Spring

CSCE 689 - Distributed Software Systems
The objective of this course is to rigorously extend the fundamentals of computer operating systems into more advanced features. Topics include distributed operating systems, distributed file systems, distributed scheduling, fault tolerance, and multiprocessor operating systems. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties, as well as case study analysis of existing and proposed advanced operating systems. The objective of this course is to rigorously extend the fundamentals of computer operating systems into more advanced features. Topics include distributed operating systems, distributed file systems, distributed scheduling, fault tolerance, and multiprocessor operating systems. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties, as well as case study analysis of existing and proposed advanced operating systems. Credit Hours 4 Prerequisites/Corequisites CSCE 431, CSCE 489, and CSCE 492 Terms Offered Winter

CSCE 723 - Advanced Topics in Artificial Intelligence
This course treats topics selected to prepare students for research in artificial intelligence and for the application of artificial intelligence in the solution of commercial and military problems. Typical topics are knowledge-engineering, learning, constraint-satisfaction, neural networks, knowledge

acquisition, model and case-based reasoning, nonmonotonic reasoning, blackboard systems, and theorem proving. Credit Hours 4 Prerequisites/Corequisites CSCE 623 Terms Offered Summer

CSCE 754 - Advanced Topics in Computer Networks
This is the advanced course in networks and protocols. The objective of this course is to extend the fundamentals of computer communication systems into more advanced topics actively being researched. The course surveys current design and implementation techniques for development of high performance computer networks as well as to prepare students for doing research projects in this area. Topics are drawn from current papers in the field. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties. These types of analyses are reinforced through simulation projects. Credit Hours 4 Prerequisites/Corequisites CSCE 654 Terms Offered Summer

CSCE 799 - Independent Study
The thesis topic is normally selected during CSCE 698, Research Seminar, from a wide variety of subjects of current interest to various Air Force and DoD organizations. The thesis is performed under the supervision of a faculty member who serves as the student's thesis advisor and chairman of his thesis committee. The results of the research are presented in a formal written thesis. An oral presentation and defense or the research is also required. Notes A master's degree candidate must enroll in CSCE 799 for a total of 12 credit hours while working on the master's thesis. Ordinarily this course extends over the last four quarters of a student's program, with the student enrolling for 2 credit hours during the first two quarters of thesis work and for 4 credit hours the final two quarters. The letter grade for the entire 12 hours of thesis is awarded in the final thesis quarter. A grade of in-progress (IP) or unsatisfactory (U) is awarded for the other quarters. Credit Hours 1-12 Prerequisites/Corequisites Permission of Instructor Terms Offered All

CSCE 886 - Evolutionary Algorithms
This course provides a theoretical and practical foundation for continuing the understanding and analysis associated with the design, complexity and correctness of evolutionary algorithms. Evolutionary algorithms using genetic algorithms, evolutionary strategies and classifiers are discussed as probabilistic search algorithms. Evolutionary data representation and fitness function selection along with associated operators and population dynamics are thoroughly developed. Formal properties of various evolutionary approaches are addressed using graph theory, predicate calculus and computational models. Evolutionary algorithm implementations are associated with proper data and control structure selection, implementation and visualization considerations for serial, parallel and distributed computation. Application problems in artificial intelligence, knowledge-based systems, software engineering, database management, signal processing, VLSI, simulation, scheduling, planning and computer architecture design are related through similarity of domain structures. Credit Hours 4 Prerequisites/Corequisites CSCE 686 Terms Offered Summer

EENG 510 - Linear Systems
The objective of this course is to develop tools for the analysis and simulation of linear dynamic systems. Emphasis is placed on state space analysis for estimation and control theory applications. Topics covered include: linearization of a nonlinear system, derivation of linear time-invariant and time varying state equations, and the continuous time solution; relations between the state equations and the system transfer functions eigenvalue/eigenvector and singular value analysis of the state equations; transformations to canonical forms; and controllability and observability properties. Notes: (Equivalent to SENG 525) Credit Hours 4 Prerequisites/Corequisites None Terms Offered Fall

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

errors, GPS error courses, dilution of precision, GPS availability, differential GPS (DGPS), DGPS errors, GPS modernization, and other Global Navigation Satellite Systems (GNSS). Students will gain a thorough understanding of how GPS works, what errors exist, and how those errors can be mitigated. A number of hands-on laboratory experiments will familiarize students with a variety of GPS receivers and processing software. Credit Hours 4 Prerequisites/Corequisites None Terms Offered Winter

EENG 534 - Fundamentals of Aerospace Instruments and Navigation System
Basic references 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. Notes: Examples are taken from current and planned Air Force systems. Credit Hours 4 Prerequisites/Corequisites EENG 562 Terms Offered Fall

EENG 535 - Radar Systems Analysis
This course covers all aspects of radar from a systems point of view beginning with the definition and concluding with signal processing. After explaining the functions and characteristics of the transmitter, antenna, receiver, displays and the principles of microwave propagation and interaction with media, the Radar Range Equation is derived. Techniques of measurement and tracking of range, velocity, azimuth and bearing of a moving target are discussed. Recently introduced radars, such as the Over the Horizon, Synthetic Aperture, Terrain Following and Terrain Avoidance are briefly discussed. Credit Hours 4 Prerequisites/Corequisites EENG 530 and STAT 586 Terms Offered Winter

EENG 562 - Feedback Systems
This course covers the fundamental characteristics and design of linear feedback control systems. The interrelation between conventional and modern approaches is emphasized. Topics include: feedback system analysis; root locus, Bode, and Nyquist analysis; state feedback control and observers; control system compensation design. Notes: Course is now combined with SENG 565. Credit Hours 4 Prerequisites/Corequisites None/EENG 510 Terms Offered Fall

EENG 571 - Satellite Communications
The objective of this course is to provide a comprehensive introduction to modern communications principles with particular emphasis on applications to satellite and space communications systems. Topics include: modulation, signals, multiplexing, demodulation, multiple access, coding, orbits, look angles, satellite hardware, earth-station hardware, and link analysis. Credit Hours 4 Prerequisites/Corequisites None Terms Offered Winter

EENG 580 - Introduction to Signal Processing
This course presents an introduction to signal processing. Topics include I/O descriptions of discrete-time systems, Z-transforms, Discrete Fourier Transforms (DFT) and Fast Transforms (FFT), Finite Impulse Response (FIR) filter design, and Infinite Impulse Response (IIR) filter design. Notes: This course will be taught at the level of Roberts' and Mullis' Digital Signal Processing Credit Hours 4 Prerequisites/Corequisites None/MATH 521 Terms Offered Fall

EENG 633 - Advanced GPS Theory and Applications
Advanced topics in GPS are presented, building on the foundation laid in EENG 533. A precise description of each of the GPS observables is presented, with an emphasis on differential positioning. Real world error sources are analyzed, including satellite position, ionospheric, tropospheric, multipath, and receiver measurement noise errors. A major portion of the course describes receiver design and signal processing methods used by GPS receivers. Current literature and

laboratory projects provide enhanced insights into GPS receivers and systems. Credit Hours 4 Prerequisites/Corequisites EENG 622 and EENG 628 Terms Offered Summer

EENG 635 - Inertial Navigation Subsystems

The Inertial Navigation System (INS) concept is defined and analyzed in the context of space stabilized, local level and strap down configurations. Perturbation techniques are applied in the derivation of unified INS error models. The earth's gravitational field model is developed. Advantages and disadvantages of various configurations are presented within the context of the INS error dynamics. Methods of system alignment are examined. System response to inertial instrument errors, initial misalignments, and other sources are studied in frequency and time domains. System analysis tools, such as MATLAB are used throughout. Credit Hours 4 Prerequisites/Corequisites EENG 534 Terms Offered Winter

EENG 658 - LiDAR Systems

This course presents a systems approach to the analysis and design of both coherent and incoherent LiDAR systems. Topics covered include range equations and detection considerations, fundamentals of incoherent and coherent receivers, radar waveform types, imaging system fundamentals, effects of atmospheric propagation, methods for computing detection probabilities and false alarm rates, as well as an introduction to subsystems and components. Selected portions of the material will be implemented within discrete computer simulations. Credit Hours 4 Prerequisites/Corequisites EENG 580/STAT 586 Terms Offered Winter

EENG 663 - Signal Detection and Estimation

A Study of techniques of extracting information of signals corrupted by noise. Maximum Likelihood, Neyman Pearson, Ideal Observer, Bayes, and Mini-decision criteria. Binary and multiple decisions under single and multiple observations. Detailed consideration of signals in Gaussian noise. Karhunen-Loeve expansion and detection of signals in colored noise. Composite hypothesis. Sequential and non-parametric decision theories. Maximum. Likelihood, Least Squares, Minimum Variance, and Bayes estimators. Efficient estimators and Cramer-Rao bounds. Introduction to Kalman Filter. Credit Hours 4 Prerequisites/Corequisites EENG 665 Terms Offered Spring

EENG 665 - Random Signal and Systems Analysis

An introduction to the theory of random signals as it applies to communication. The concepts developed include: random signals, moments, correlation functions, stationary, ergodicity, power spectral density, joint processes and their cross-correlation, random signals in linear systems, and specific types of random processes. Credit Hours 4 Prerequisites/Corequisites STAT 586 Terms Offered Winter

EENG 668 - Advanced Radar System Analysis

This course investigates advanced radar waveforms, radar modeling and phenomenology, detection analysis, and prepares the student to conduct independent research. Topics include the following: detailed investigation of pulse compression waveforms; compressed waveform modeling, design and analysis using the ambiguity function; matched filter processing; range and Doppler resolution; introduction to statistical decision theory; modeling noise, clutter, and barrage noise jamming; and detection probability analysis. Credit Hours 4 Prerequisites/Corequisites EENG 535/EENG 663 is Highly Recommended Terms Offered Spring

EENG 669 - Digital Communications I

The objective of this course is to present the significant considerations necessary for the design and analysis of digital communication systems. The course develops a mathematical representation of baseband digital signals including signal space concepts. Signal detection in the presence of noise and matched filters are described. The use of source coding for efficient descriptions of information sources is motivated. Channel coding concepts are developed and shown to improve communication system performance. Block and convolution codes are described and their performance analyzed. Credit Hours 4 Prerequisites/Corequisites EENG 530 and STAT 586 Terms Offered Winter

EENG 670 - Digital Communications II

The objective of this course is to present the significant considerations necessary for the design and analysis of band-pass digital communication systems. This course examines coherent and noncoherent detection of digital band-pass signals in Gaussian noise and the corresponding error performance for binary and M-ary signaling. Modulation and coding tradeoffs are discussed. Methods of synchronization at the carrier, symbol, and frame rates are examined. Multiplexing and multiple access networking techniques are also explored, and a brief introduction to spread spectrum systems is provided. Credit Hours 4 Prerequisites/Corequisites EENG 665 and EENG 669 Terms Offered Spring

EENG 680 - Multidimensional Signal and Image Processing

This course covers multidimensional signal and image processing. Topics include multidimensional Fourier transform, discrete Fourier transform, multidimensional infinite impulse response filters, multidimensional finite impulse response filters, and an introduction to the basics of image processing, restoration, and coding. This course will be taught at the level of Jain's Fundamentals of Digital Image Processing. Credit Hours 4 Prerequisites/Corequisites EENG 580 and MATH 521/EENG 665 Terms Offered Spring

CSCE 698 - Research Seminar

This course provides a forum for students to gain an understanding of the graduate education process, department requirements and advice for preparing and writing the thesis, research milestones and deadlines, the scientific method, experiment design and analysis, and current DoD research interests in computer engineering, computer science, and computer systems. Notes This information will be provided as needed during the student's program in accordance with all programs; therefore, students are required to attend this course for two quarters (1 Winter, 1 Spring). This is a required course. This course will be graded Satisfactory or Unsatisfactory. Credit Hours 0 Prerequisites/Corequisites None Terms Offered Winter, Spring

EENG 714 - Advanced Topics in Radar Applications

This capstone radar course provides the student theoretical and practical exposure to advanced radar applications of continuing and/or emerging interest within the radar community. Instructor-led lectures develop the core mathematical, signal and image processing, modeling and simulation, and measurement methods as applicable to various radar applications. In addition, students conduct laboratory experiments and measurements, and/or modeling and simulation according to methods and techniques in the current literature. Credit Hours 4 Prerequisites/Corequisites EENG 535/EENG 668 Terms Offered Summer

EENG 735 - Inertial Navigation System Analysis and Integration

Optimal filtering theory is introduced and applied to the design of integrated navigation systems. The powerful properties of the Kalman filter are used to optimally combine the INS outputs with a variety of external measurements to extract superior navigation system performance. The Global Positioning System (GPS) mathematical and error models are derived and analyzed. Strap down INS computational algorithms are derived. Emphasis is placed on computational algorithms and their error performance. A substantial class project focuses on the benefits of INS integration (aiding) with external measurements, such as from the GPS. Credit Hours 4 Prerequisites/Corequisites EENG 635 and either EENG 712 or EENG 765 Terms Offered Spring

EENG 765 - Stochastic Estimation and Control I

Probability theory and stochastic process theory are investigated to develop practical system models in the form of linear dynamic systems driven by known inputs, disturbances, and uncertainty. Using this model, the optimal estimator (Kalman filter) is derived and studied. Design of practical on-line filters, including performance analyses and aspects of implementation on digital computers, is accomplished for various Air Force applications. Credit Hours 4 Prerequisites/Corequisites EENG 510 and STAT 586 or STAT 601 Terms Offered Winter

EENG 766 - Stochastic Estimation and Control II
Topics in linear estimation beyond those in EENG 765 are considered: frequency domain methods, square root filtering, optimal smoothing, and the extended Kalman filter as a means of applying linear estimation theory to nonlinear problems. Nonlinear filtering is then developed in detail, followed by stochastic digital controller design and performance analysis. The need for, and practical application of, these concepts in Air Force weapon systems are fully developed. Credit Hours 4 Prerequisites/Corequisites EENG 712 or EENG 765/SENG 562 Terms Offered Spring

EENG 799 - Independent Study
The thesis topic is normally selected during EENG 698, Research Seminar, from a wide variety of subjects of current interest to various Air Force and DoD organizations. The thesis is performed under the supervision of a faculty member who serves as the student's thesis advisor and chairman of his thesis committee. The results of the research are presented in a formal written thesis. Notes An oral presentation and defense of the research is also required. A master's degree candidate must enroll in EENG 799 for a total of 12 credit hours while working on his master's thesis. Ordinarily this course extends over the last three quarters of a student's program, with the student enrolling for 4 credit hours each quarter. The letter grade for the entire 12 hours of thesis is awarded in the final thesis quarter. A grade of in-progress (IP) or unsatisfactory (U) is awarded for the other quarters. Credit Hours 1-12 Prerequisites/Corequisites Permission of Instructor Terms Offered All

MATH 521 - Applied Linear Algebra
Algebra of matrices, the theory of finite dimensional vector spaces, and basic results concerning eigenvalues and eigenvectors with particular attention given to topics that arise in applications. Credit Hours 4 Prerequisites/Corequisites none Terms Offered Spring, Fall

PHYS 640 - Optics
Introduction to modern optics, with a treatment of both geometrical and physical optics. Geometrical topics include reflection and refraction, lenses, mirrors, stops, ray tracing, telescopes, and optical instruments. Wave phenomena treated will include interference, optical testing, polarization, and Fraunhofer and Fresnel diffraction. Credit Hours 4 Prerequisites/Corequisites None Terms Offered Fall

SENG 520 - Systems Engineering Design
This course provides a broad introduction to the structured approach necessary for the design of complex systems. The formulation of systems problems and the approach to their solution will be emphasized. Basic mathematical techniques available to the systems engineer are presented. The design process will be illustrated through the review of past design efforts, and the application to a problem of current interest. Credit Hours 4 Prerequisites/Corequisites None Terms Offered Summer, Fall

STAT 583 - Introduction to Probability and Statistics
Basic concepts of probability and statistics with computer science applications are covered. Topics include: Permutations and combinations; random variables; probability distributions; estimation and confidence intervals; hypothesis testing. Credit Hours 4 Prerequisites/Corequisites none Terms Offered Winter, Summer, Fall

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. Credit Hours 4 Prerequisites/Corequisites none Terms Offered Fall