Master of Science
in
Systems Engineering

December 2019
Version 14

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The Systems Engineering and Operations Research Department (SEOR)
is located in Room 2100, Nguyen Engineering Building
Systems Engineering

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Plan of Study (with Concentration)

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1. Introduction

Systems Engineering is concerned with analysis of needs and requirements, design, production, deployment, operation, maintenance, refinement, and retirement of reliable systems considering various system constraints. Systems Engineering comprises product, process, and resource management and focuses on architecture, human factors, decision support, performance and evaluation, and management.

System engineers are the visionaries who take a global perspective of the system. Whereas discipline-specific engineers deal with system components, the systems engineer is concerned with the integration of these components and the overall success of the system throughout its life cycle. Our educational and research program reflects the systems engineer's unique perspective on the system life cycle.

Mason's graduate program in Systems Engineering recognizes the importance of balancing an education in quantitative models and engineering tools with a proper understanding of the systems perspective. Concentration areas include Advanced Transportation Systems (ATS), Architecture-Based Systems Integration (ABSI), Command, Control, Communications, Computing, and Intelligence (C4I), Energy Systems (NRGS), Financial Systems Engineering (FNSE), Systems Engineering and Data Analytics (SEDA), Systems Engineering of Software-Intensive Systems (SESI) and Systems Management (SMG).

2. Program Description

The graduate program leading to the Master of Science in Systems Engineering (MSSE) emphasizes both analytical and practical aspects of engineering complex systems. Students are expected to demonstrate proficiency in using qualitative and quantitative tools relevant to systems engineering practice. The program also prepares students for careers in research and development and for pursuing advanced graduate study leading to the Ph.D. degree in Systems Engineering and Operations Research.

3. Foundation & Admission Requirements

Each applicant for the MS program should meet the following entrance requirements:

1. Have a baccalaureate degree from an accredited institution in engineering, mathematics, computer science, physical sciences, economics, or a related field.
2. Have completed courses in multivariate calculus, matrix algebra, differential equations, applied probability and statistics, and a computer language.
3. Provide evidence of satisfactory educational achievement in at least one of the following forms: a GPA of at least 3.00 as an undergraduate, or an acceptable GPA in graduate courses. International students must also achieve satisfactory scores on the Graduate Record Examination (GRE).
4. Have achieved a satisfactory score on the TOEFL examination for non-native English speakers.
5. Have two letters of recommendation submitted by former professors or supervisors.

Students who enter the program must have a working background in engineering mathematics and computer systems. A student lacking these foundations may apply for admission to the program, but may be required to take one or more foundation courses. The department offers SYST 500 as an intensive review of undergraduate engineering mathematics, including matrix algebra, calculus, differential equations, probability and statistics. Students who have not completed a two-semester calculus sequence and matrix algebra will be required to complete these courses prior to taking SYST 500.

Familiarity with analytical modeling software, such as spreadsheets or math packages, is also expected. Students should acquaint themselves with these software packages before beginning classes.
4. Degree Requirements
To obtain the Master of Science degree, students must complete a minimum of 30 semester hours of graduate level courses that consists of five core courses, three concentration courses, an elective, and a systems engineering project.

Candidates for the MS must have a minimum GPA of 3.00 in course work applied to the degree, which may include no more than 6 credits of C. The GPA calculation excludes all transfer courses and Mason nanodegree studies credits not formally approved for the degree. Candidates for Graduate Certificates must have a minimum GPA of 3.00 in course work applied to the certificate, which may include no more than 3 credits of C. The GPA calculation excludes transfer credits.

5. Advising
All entering systems engineering students must attend an orientation meeting. Each student is assigned a faculty advisor upon acceptance. Students must meet with their advisors during their first semester and design an approved plan of study. Students are encouraged to seek out their advisor when questions arise and when their plan of study needs to be revised. Any changes to the plan of study must be approved by the faculty advisor. A copy of the plan of study must remain on file with the department.

6. Accelerated BS/MS Program
Qualified undergraduate students may apply for a five-year accelerated BS/MS program leading to a Bachelor of Science in an engineering discipline and an MS degree in systems engineering. The accelerated BS/MS program can be completed in 144-150 credit hours.

Applicants to the accelerated BS/MS program must be Mason undergraduate students majoring in systems engineering, bioengineering, computer science, computer engineering, cyber security engineering, electrical engineering, civil and infrastructure engineering, mechanical engineering, or statistics. Students may apply for the accelerated BS/MS program during a semester after which they will have completed 90 or more credit hours applicable to their degree. Students must have an overall GPA of at least 3.30 on these courses and must have completed all their MATH and PHYS requirements, to apply for the program. Otherwise, criteria for admission into the accelerated BS/MS program are identical to criteria for admission into the MSSE program.

Students must complete all requirements for the BS degree in their chosen major. Students in the accelerated BS/MS program may apply to have the BS degree from the appropriate VSE program in the semester during which they expect to complete their BS requirements. The MSSE degree is granted upon completion of the remaining requirements.

Up to two courses (six credit hours) of masters level courses may be applied to both the undergraduate and graduate degrees. These two courses may be chosen from the list of graduate courses in the following table. For BSSE majors, these graduate courses replace the corresponding undergraduate courses listed in the table. The undergraduate version of these courses may not be applied toward the MSSE degree.

<table>
<thead>
<tr>
<th>Graduate course</th>
<th>Undergraduate course</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>SYST 521</td>
<td>SYST 420</td>
<td>Credit may not be received for both courses</td>
</tr>
<tr>
<td>SYST 573</td>
<td>SYST 473</td>
<td>Credit may not be received for both courses</td>
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<tr>
<td>OR 541</td>
<td>OR 441</td>
<td>Credit may not be received for both courses</td>
</tr>
<tr>
<td>OR 542</td>
<td>OR 442</td>
<td>Credit may not be received for both courses</td>
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</tbody>
</table>
These courses apply only to certain concentrations in the graduate program; credit may not be received for both courses.

Systems engineering majors in the BS/accelerated MS program do not receive credit for both SYST 371 and SYST 530. Students should take SYST 371 as part of the undergraduate BS program. Students should take a technical elective in lieu of SYST 530 as part of the MS program. The technical elective must be approved by the student’s advisor and the Department Chair.

7. Curriculum

Core Courses - Students must complete the following five core courses (15 credits):

- SYST 505: Systems Engineering Principles*
- SYST 510: Systems Definition and Cost Modeling
- SYST 520: System Engineering Design
- SYST 530: Systems Engineering Management I
- SYST 611: System Methodology and Modeling

* SYST 505 may be replaced by an approved elective for students who have work experience in systems engineering or who have been enrolled in the undergraduate BSSE program at Mason. SYST 505, if taken, must be taken in the first semester of enrollment in the MSSE program.

Basic Methods Courses - Students must complete one basic methods course (three credits). The choice of basic methods course may depend on the student’s concentration and must be selected from the following list:

- OR 531 Analytics and Decision Analysis
- OR 541 Operations Research: Deterministic Models
- OR 542 Operations Research: Stochastic Models
- SYST/OR 568 Applied Predictive Analytics
- ECE 528 Introduction to Random Processes in Electrical and Computer Engineering
- SYST 563 Evidence Based Systems Engineering
- SYST 573 Decision and Risk Analysis
- SYST 620 Discrete Event Systems
- SYST 664 Bayesian Inference and Decision Theory

Project - Students must complete three credit hours of SYST 699. Students in this course work in teams on an approved applied project. A project report is submitted at the end of the semester, and a final project presentation is made to the entire faculty of the SEOR Department.

Concentration Area Courses - Students must complete 3 courses (9 credits) from their area of emphasis. Students may select one of the following eight areas of concentration, or may create their own emphasis area with the approval of their advisor and the Department Chair (see Section 8 for details):

- Advanced Transportation Systems (ATS)
- Architecture-Based Systems Integration (ABSI)
- Command, Control, Communications, Computing, and Intelligence (C4I)
- Energy Systems (NRGS)
Certificate Programs. George Mason University offers a number of certificate programs to students who hold bachelor’s degrees in engineering or scientific disciplines or who are currently in graduate status in such programs (see Section 10 for details). Certificate programs that may be combined with the MSSE degree are:

- Certificate in Architecture-Based Systems Integration
- Certificate in Command, Control, Communications, Computing and Intelligence Systems
- Certificate in Engineering Resilient Enterprise Systems
- Certificate in Financial Systems Engineering

8. Specific Courses within each Emphasis Area

Approved basic methods and concentration courses for the eight concentration areas are listed below. Students are expected to select a set of concentration courses that constitute a clearly defined focus. These courses must be approved by the student's advisor. Each student is required to have a current plan of study on file with the Systems Engineering and Operations Research Department.

Advanced Transportation Systems (ATS)

The air transportation system is among the most complex networked systems. This concentration is designed to provide students with the skills to address the next generation of challenges of the air transportation system. Topics addressed include: congestion and safety of the national air space, economic and human factors, impact of technology innovation, and public policy. The program emphasizes design, modeling, and analysis to support decision making for the government and the aviation industry.

Basic methods course: One course from the list of basic methods courses (OR 531, OR 541, 542, 568 or SYST 568, ECE 528, SYST 563, 573, 620, 664).

Concentration-specific courses: Students must complete the two required courses listed and one graduate level elective course selected under advisement.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>SYST 560</td>
<td>Introduction to Air Traffic Control</td>
</tr>
<tr>
<td>SYST 660</td>
<td>Air Transportation Systems Modeling</td>
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Architecture-Based Systems Integration (ABSI)

There is much interest today in the engineering of systems that themselves are comprised of other component systems, and where each of the component systems serves organizational and human purposes. These systems families are often categorized as systems-of-systems, federations of systems, or coalition of systems. The design of architectures is a major ingredient in the design of systems families. Furthermore, it provides the conceptual basis for achieving system integration. This emphasis area covers the formulation of the system integration problem, the definition of architecture frameworks, the use of structured analysis and object oriented methodologies for the design of architectures, modeling and simulation for the evaluation of architectures and approaches to integration. Both defense and industrial applications are considered.

Basic methods course: Students must complete

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<tr>
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<tbody>
<tr>
<td>ECE 528</td>
<td>Introduction to Random Processes in Electrical and Computer Engineering</td>
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<tr>
<td>OR 531</td>
<td>Analytics and Decision Analysis</td>
</tr>
<tr>
<td>OR 541</td>
<td>Operations Research: Deterministic Models</td>
</tr>
<tr>
<td>OR 542</td>
<td>Operations Research: Stochastic Models</td>
</tr>
</tbody>
</table>
OR 568 or SYST 568  Applied Predictive Analytics
SYST 563  Evidence-Based Systems Engineering
SYST 573  Decision and Risk Analysis
SYST 620  Discrete Event Systems
SYST 664  Bayesian Inference and Decision Theory

Concentration-specific courses: Students must complete the two required courses listed below and one graduate level elective course selected under advisement.

- SYST 618  Model-based Systems Engineering
- SYST 621  System Architecture Design and Evaluation

Command, Control, Communications, Computing, and Intelligence Systems (C4I)

C4I systems are concerned with gathering, retrieval, analysis, and dissemination of time-sensitive information to achieve mission-critical objectives. These systems support military operations across the spectrum of conflict, intelligence operations, transportation monitoring, emergency response, drug interdiction, and law enforcement, among others. C4I systems include the equipment, people, and procedures necessary to accomplish the mission. The equipment may include a variety of sensors, communications systems, and information processing and decision-support systems.

The program focuses on the analysis, design, development, and management of C4I systems. Topics addressed include: C4I architectures and software, communications, decision support, modeling and simulation, and sensor data fusion.

Basic Methods Course: One of the following:

- OR 542  Stochastic Models in Operations Research
- OR 541  or ECE 528  Introduction to Random Processes in Electrical and Computer Engineering

Concentration-specific courses: Students must complete the two required courses listed below and one graduate level elective course selected under advisement.

- SYST 680  Principles of Command, Control, Communications, Computing, and Intelligence (C4I)
- SYST 620  or ECE 670  Principles of Command, Control, Communications, Computing, and Intelligence (C4I)
- SYST 584  Heterogeneous Data Fusion

Energy Systems (NRGS)

With the rising economic and environmental costs to power homes, businesses and the transportation systems that move people and goods from place to place, innovative solutions are required to meet the world’s expanding energy needs. Students completing the energy systems concentration will build upon a foundation in systems engineering design by incorporating physical principles of thermal fluid energy transfer into system models. Students will develop the tools to model and analyze generation, transmission, and utilization systems in steady and dynamic operation. Students will optimize these systems by considering physical principles, economics, local policy and security concerns. Graduates will be able to apply their expertise to work with: traditional power generation facilities; renewable energy integration; national, local, and smart grids; mechanical and electrical energy storage systems; utilization of energy in building and transportation systems.

Basic Methods Courses: One course from the list of basic methods course (OR 531, OR 541, 542, 568 or SYST 568, ECE 528, SYST 563, 573, 620, 664).
Concentration-specific courses: Students must complete the three required courses listed below and one graduate level elective course selected under advisement.

- ME 521 Energy Transfer
- ME 531 Energy Transmission
- ME 541 Power Generation

Financial Systems Engineering (FNSE)

Financial engineering is a cross-disciplinary field that relies on mathematical finance, numerical methods, and computer simulations to make trading, hedging, and investment decisions, as well as facilitating the risk management of those decisions. While mathematics is indispensable in financial engineering, the concentration will try best to focus on the concepts and ideas of finance, while limiting the math within a scope acceptable to most students in engineering.

Basic methods course: Students must complete

- SYST 538 Analytics for Financial Engineering and Econometrics

Concentration-specific courses: Students must complete the two required courses listed below and one graduate level elective course selected under advisement.

- SYST 588 Financial Systems Engineering I: Introduction to Options, Futures, and Derivatives
- SYST 688 Financial Systems Engineering II: Derivative Products and Risk Management

Systems Engineering and Data Analytics (SEDA)

Systems engineers must address a broad range of issues relevant to the design, implementation, analysis and management of systems. This concentration provides the student with methodological tools that can be applied to the systems engineering process. Areas of focus include decision support systems, distributed intelligent systems, knowledge-based planning systems, network systems, probabilistic reasoning systems, sensor fusion systems, and optimization methods.

Basic methods course: Students must complete

- OR 531 Analytics and Decision Analysis

Concentration-specific courses: Students must complete the two required courses listed below and one graduate level elective course selected under advisement.

- SYST 568 Applied Predictive Analytics
- SYST 573 Decision and Risk Analysis

Systems Engineering of Software Intensive Systems (SESI)

This concentration addresses the software component of the systems engineering life cycle. It specifically covers the allocation of system requirements to software. Practitioners are concerned with the theoretical and practical aspects of technology, cost, and the social impact of computer systems that are reliable, maintainable, secure, efficient, and cost effective. The program emphasizes the integration of hardware, software, and firmware, the management of these complex computer systems over their life cycle through systems engineering methods, tools, and processes.

Basic Methods Courses: One course from the list of basic methods course (OR 531, 541, 542, 568 or SYST 568, SYST 563, 573, 620, 664, ECE 528).
Concentration-specific courses: Students must complete the two required courses listed below and one graduate level elective course selected under advisement.

- SYST 542 Decision Support Systems Engineering
- SYST 618 Model-based Systems Engineering

Systems Management (SMG)
The management aspect of systems engineering involves tracking and control of system development through the major phases of the system lifecycle, identifying and resolving problems to minimize impacts on cost, schedule or performance, and iteratively improving both product and process. This concentration area emphasizes the theory and practice of systems management and prepares students for careers in managing the development of complex systems.

Concentration-specific courses: Students must complete the three required courses listed below and one graduate level elective course selected under advisement:

- SYST 514 Systems Thinking
- SYST 618 Model-based Systems Engineering
- SYST 630 Systems Engineering Management II

9. Online MS in Systems Engineering
The graduate program leading to the Master of Science in Systems Engineering can be completed entirely online. The delivery mode for the online program is asynchronous, but many courses are also offered in synchronous mode. Students may also plan a program with some courses taken online and some in the classroom. The following courses are offered online at least once a year:
SYST 500, 505, 510, 520, 530, 542, 573, 611, 618, 620, 621, 630, 699
OR 531, 541, 542.

10. Certificate Programs
Certificate in Architecture-Based Systems Integration (ABSI)
A certificate program in ABSI is available to those who satisfy the admission requirements for the master's degree in systems engineering. Students who are already enrolled in the master's program can submit a second Certificate application form (available from the Registrar’s website) to enroll in this certificate program; all others must apply for graduate admission to this certificate program. To be eligible for a certificate, students must complete:

Required courses: Students must complete the required courses listed below
- SYST 520 System Engineering Design
- SYST 618 Model-based Systems Engineering
- SYST 620 Discrete Event Systems
- SYST 621 Systems Architecture Design

The following is a suggested program of study for obtaining the certificate while studying for the MS in Systems Engineering degree (certificate required courses indicated in bold italics):

- Core courses: SYST 505, 510, 520, 530, 611
- Methods course: SYST 620
• Concentration-specific courses: SYST 618, 621, and one additional approved ABSI elective course
• Project: SYST 699

Concentration in Communications and networking (CONE)

The certificate with a concentration in Communications and Networking is awarded on completion of five graduate courses (15 credits) in communications and networking. A cumulative GPA of 3.00 is required and one course with a grade of C at most may be applied toward the certificate. The certificate courses comprise two required foundation courses and three electives.

Required courses: Students must complete three required courses listed below
- ECE 528 Introduction to Random Processes in Electrical and Computer Engineering
- ECE 542 Computer Network Architectures and Protocols

Electives: Students choose electives by taking three courses from the following:
- Select three courses from the following:
  - ECE 535 Digital Signal Processing
  - ECE 565 Introduction to Optical Electronics
  - ECE 567 Optical Fiber Communications
  - ECE 630 Statistical Communication Theory
  - ECE 633 Error Control Coding
  - ECE 635 Adaptive Signal Processing
  - ECE 642 Design and Analysis of Computer Communication Networks
  - ECE 643 Network Switching and Routing
  - ECE 646 Applied Cryptography
  - ECE 731 Digital Communications
  - ECE 732 Mobile Communication Systems
  - ECE 734 Detection and Estimation Theory
  - ECE 738 Advanced Digital Signal Processing
  - ECE 741 Wireless Networks
  - ECE 742 High-Speed Networks
  - OR 635 Discrete System Simulation
  - OR 643 Network Modeling
  - OR 647 Queuing Theory

Concentration in Tactical Computer Operations (TCO)

Required courses:
- CS 571 Operating Systems
- ECE 511 Computer Architecture

Electives: Students choose electives by taking two courses from the following:
- CFRS 761 Malware Reverse Engineering
- CFRS 767 Penetration Testing in Computer Forensics
- CFRS 769 Anti-Forensics
- CFRS 773 Mobile Application Forensics and Analysis
- CFRS 775 Kernel Forensics and Analysis
Certificate in Financial Engineering

A certificate program in FSE is available to those who satisfy the admission requirements for the master's degree in systems engineering. Students who are already enrolled in the master's program can submit a second Certificate application form (available from the Registrar’s website) to enroll in this certificate program; all others must apply for graduate admission to this certificate program. To be eligible for a certificate, students must complete:

**Required courses:** Students must complete three required courses listed below

- SYST/OR 538 Analytics for Financial Engineering and Econometrics
- SYST/OR 588 Financial Systems Engineering I: Introduction to Options, Futures, and Derivatives
- SYST/OR 688 Financial Systems Engineering II: Derivative Products and Risk Management

**Electives:** Select one of the following:

- OR 645 Stochastic Processes
- OR 682 Computational Methods in Engineering and Statistics
- SYST 584 Heterogeneous Data Fusion
- SYST 671 Judgement and Choice Processing and Decision Making

Certificate in C4I Systems Engineering

A certificate program in C4I is available to those who satisfy the admission requirements for the master's degree in systems engineering. Students who are already enrolled in the master's program can submit a second Certificate application form (available from the Registrar’s website) to enroll in this certificate program; all others must apply for graduate admission to this certificate program. To be eligible for a certificate, students must complete (1) SYST 680 or ECE 670; (2) OR 542 or ECE 528; and two courses from SYST 584, 664, 683 OR 635, ECE 542, 630, 642.

The following is a suggested program of study for obtaining the certificate while studying for the MSSE degree (certificate required courses indicated in bold italics):

- **Core courses:** SYST 505, SYST 510, SYST 520, SYST 530, SYST 611
- **Methods courses:** ECE 528 or OR 542
- **Concentration courses:** SYST 680 and two C4I approved elective courses
- **Project:** SYST 699

Certificate in Engineering Resilient Enterprise Systems

This certificate is available to any student who holds a bachelor's degree in an engineering or scientific discipline or has graduate status in such a program. Admission requirements are identical to those for the master’s program in Systems Engineering except that the math requirements include only calculus I, calculus II, and a probability and statistics course. Students who are already enrolled in the master's program can submit a second Certificate application form (available from the Registrar’s website) to enroll in this certificate program; all others must apply for graduate admission to this certificate program. To be eligible for a certificate, students must complete:
**Required courses:** Students must complete the two required courses listed below

- SYST 523  Engineering Resilient and Agile Enterprise Systems
- SYST 618  Model-based Systems Engineering

**Electives:** Select at least one of the following:

- SYST 514  Systems Thinking
- SYST 542  Decision Support Systems Engineering
- SYST 584  Heterogeneous Data Fusion
- SYST 630  Systems Engineering Management II
- INFS 622  Information Systems Analysis and Design
- SWE 619  Object-Oriented Software Specification and Construction

Select a second elective course from the courses listed above or from the following:

- CS 555  Computer Communications and Networking
- ECE 542  Computer Network Architectures and Protocols
- INFS 612  Principles and Practices of Communications Networks

The following is a suggested program of study for obtaining the certificate while studying for the MSSE degree (certificate required courses indicated in bold italics):

- **Core courses:** SYST 505, SYST 510, SYST 520, SYST 530, SYST 611
- **Methods course:** One approved method course
- **Elective courses:** SYST 523, 618 and one elective approved for the master’s degree emphasis
- **Project:** SYST 699

11. **Ph.D. in Systems Engineering and Operations Research.**

The SEOR Department offers a program leading to the PhD in Systems Engineering and Operations Research. A brochure describing this program may be obtained from the Department.

12. **Course Descriptions**

Descriptions of SYST and mostly related OR graduate courses offered by the Department of Systems Engineering and Operations Research follow.

**Systems Courses:**

**500/CSI 600: Quantitative Foundations for Systems Engineering (3:3:0)**

Prerequisite: Math 203, 213

Provides quantitative foundations necessary for core courses in systems engineering and operations research master’s program, and certificate program in C4I. Topics include vectors and matrices, infinite series, partial differentiation, multiple integrals, differential and difference equations; linear systems; Laplace and Z-transforms, and probability theory. Students receive graduate credit for this course, which, when used on plan of study, extends minimum credit requirements for degree.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

**505 Systems Engineering Principles (3:3:0)**

Prerequisite: graduate standing.

This course serves as a foundation for the other courses in the MS/SE curriculum. Different components of the systems life cycle will be explored. Basic principles including requirements, design frameworks, functional systems, models,
qualification strategy, maintenance and disposal will be covered as well as systems thinking. Students will gain practical knowledge concerning this subject by modeling functional, state, and object primitives. Students who have work experience in systems engineering should consult with their advisor on replacing SYST 505 with a higher-level SYST course.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

508 Complex Systems Engineering Management (3:3:0)
Prerequisite: graduate standing.
Introduces the organizational, economic, technological and societal factors (POETS) that apply to the development of large-scale, complex mega-systems, and shows that "one size does not fit all" when it comes to the project management of mega-systems. Notes: Course cannot be applied for credit towards the MS in Systems Engineering degree.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

510 Systems Definition and Cost Modeling (3:3:0)
Prerequisite: graduate standing.
Comprehensive examination of methods and processes for the identification and representation of system requirements. Investigation of the systems acquisition life cycle with emphasis on requirements definition, including functional problem analysis. Examination of the systems engineering definition phase including requirements, problem analysis, definition, and functional economics. Specification of functional and nonfunctional requirements, and associated requirements prototyping. Functional economic analysis, including the use of prevailing cost estimation models and planning and control of common operating environments. Lecture and group project including creation of requirements and use of cost estimation model.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

523 Engineering Resilient and Agile Enterprise Systems(3:3:0)
Large-scale enterprise systems have ill-defined boundaries, complex behaviors, and evolve in unplanned ways. Enterprise systems need to be resilient and agile. This course introduces several tools and frameworks that can be used to understand resilience and agility, design resilience and agility into enterprises, and measure the degree of enterprise resilience and agility. Case studies are used to explore these concepts.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

514 Systems Thinking (3:3:0)
Recommended Corequisite: SYST 505
Enables students to understand and use systems thinking concepts, tools and techniques that can apply across all system types, especially those which exhibit a fusion of technology and human activities. Additionally, the course extends the understanding of systems beyond technology, to systems with significant human activity components, such as organizations and enterprises. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

520/ECE 550: System Engineering Design (3:3:0)
Recommended Corequisite: SYST 505
System engineering design methods are studied and practiced, including object-oriented and structured analysis based techniques. Design Description languages such as UML, SysML, IDEF0 and IDEF1x are introduced and used in carrying out complete system designs. Teams make presentations of their designs. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

521 Network Analysis (3:3:0)
Recommended Prerequisites: MATH 203 and 213, OR 441 or 541.
Network nomenclature. Elementary graph theory. Linear and nonlinear network models: multi-commodity flow, mathematical games and equilibria on networks, network design and control. Dynamic network models. Applications to transportation, telecommunications, data communications, and water resource systems. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

523 Engineering Resilient and Agile Enterprise Systems (3:3:0)
Large-scale enterprise systems have ill-defined boundaries, complex behaviors, and evolve in unplanned ways. Enterprise systems need to be resilient and agile. This course introduces several tools and frameworks that can be used to understand resilience and agility, design resilience and agility into enterprises, and measure the degree of enterprise resilience and agility. Case studies are used to explore these concepts. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

530 System Engineering Management I (3:3:0)
Recommended Prerequisite: SYST 510.
Provides techniques for evaluating cost and operational effectiveness of system designs and systems management strategies. Discusses performance measurement, work breakdown structures, cost estimating, quality management, configuration management, standards, and case studies of systems from different application areas. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

538/OR 538 Analytics for Financial Engineering and Econometrics (3:3:0)
Prerequisite: STAT 515 or STAT 544
This course introduces the basic analytics for financial engineering and econometrics, topics include financial transactions and econometric data management, correlation, linear and multiple regressions for financial and economic predictions, financial time series analysis, portfolio theory and risk analysis. It will provide a foundation of basic theory and methodology as well as applied examples with techniques to analyzing large financial and econometric data. Hand-on experiments with R will be emphasized throughout the course. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

542 Decision Support Systems Engineering (3:3:0)
Studies design of computerized systems to support individual or organizational decisions. Teaches systems engineering approach to decision support system (DSS) development. DSS is end product of development process, and process is key to successfully integrating DSS into organization. Any DSS is built on a theory
(usually implicit) of what makes for successful decision support in given context. Empirical evaluation of specific DSS and the underlying theory should be carried on throughout development process. Course examines prevailing theories of decision support, considers issues in obtaining empirical validation for theory, and discusses empirical support that exists for theories considered. Students design decision support system for semester project. f

Prerequisite: Requires minimum grade of B- in SYST 573, 473 or OR 681.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

560 Introduction to Air Traffic Control (3:3:0)
Introduction for those who plan professions in aviation industry. Surveys entire field, presenting history of ATC and how it came to be, technology on which system is based, procedures used by controllers to meet safety and efficiency goals, organizational structure of the FAA, challenges facing system, and means under investigation to meet these challenges. Involves some field work for data collection and analysis. Class project requiring system simulation required.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

563 Evidence-Based Systems Engineering (3:3:0)
Recommended Prerequisite: STAT 344 and STAT 354 or equivalent.
One of the most common causes of failure and risk in system development is making decisions when lacking clear evidence to support them; e.g., when deciding whether a proposed system architecture is mature enough to meet required safety, availability, or other critical quality targets. This course presents frameworks and methods to make sound, evidence-based decisions throughout the system lifecycle. Students learn what information to gather, how to analyze it, and how to present those analyses when deciding on the adequacy of design options, process improvements, and other programmatic decisions. The course covers different sources of scientific and expert evidence, including designed experiments, quasi-experiments, field studies, surveys, case studies, and informed engineering judgment. Methods of measurement are discussed, including approaches to measuring soft, difficult-to-quantify factors. Case studies of enterprise systems are presented.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

568/OR 568 Applied Predictive Analytics (3:3:0)
Prerequisite: STAT 515 or enrollment in the MSOR or MSSE programs.
Introduces predictive analytics with applications in engineering, business, and econometrics. Topics include time series and cross-sectional data processing, correlation, linear and multiple regressions, time series decomposition, predictive modeling and case study. Provides a foundation of basic theory and methodology with applied examples to analyze large engineering and econometric data for predictive decision making. Hand-on experiments with R will be emphasized.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

573/OR 681 Decision and Risk Analysis (3:3:0)
Recommended Prerequisite: STAT 344 or equivalent
Study of analytic techniques for rational decision making that address uncertainty, conflicting objectives, and risk attitudes. Covers modeling uncertainty; rational decision-making principles; representing decision
problems with value trees, decision trees, and influence diagrams; solving value hierarchies, decision trees, and influence diagrams; defining and calculating the value of information; incorporating risk attitudes into the analysis; and conducting sensitivity analysis. Note: Students may not receive credit for both SYST 473 and 573 Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

574/OR 574 Quality Control and Process Management (3:3:0)
Provides fundamentals of quality control and process management methodologies that are applicable in manufacturing industries. Introduces the basic concepts of engineering process and product quality management techniques. Provides exposition of fundamentals of lean Six Sigma and total quality management and maintainability Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

576/OR 576 Manufacturing Systems Analysis (3:3:0)
Provides fundamentals of modeling and analysis of general manufacturing systems that are also applicable to semiconductor manufacturing. Introduces the basic concepts of scheduling, inventory control, and enterprise resource management. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

584 Heterogeneous Data Fusion (3:3:0)
Introduces the theory, design and implementation of multi-source information fusion systems in various domains. The course covers distinct technologies for combining data from multiple, heterogeneous sources and performing inferences in support to applications such as cyber security, Semantic Web, decision support systems, situational awareness, intrusion detection, crisis management, and others. The technical content is largely multi-disciplinary, encompassing disciplines such as knowledge engineering, ontologies, statistical learning, artificial intelligence, and data mining. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

588/OR 588 Financial Systems Engineering I: Introduction to Options, Futures, and Derivatives (3:3:0)
Prerequisite: Engineering or math graduate standing, or permission of instructor. This course is an introduction to financial engineering. Financial engineering is a cross-disciplinary field that relies on mathematical finance, numerical methods, and computer simulations to make trading, hedging, and investment decisions. This course will introduce basic types of derivatives, such as forward, futures, swaps, and options; as well as financial models such as Brownian motion; Ito’s formula, and Black-Scholes model. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

611 System Methodology and Modeling (3:3:0)
Recommended Prerequisite: SYST 500 or equivalent. Provides broad yet rigorous foundations and applications of dynamic modeling. Emphasizes methodologies used across various disciplines. Topics include modeling and analysis of time-driven and event-driven, linear and
nonlinear systems. The applications are presented with real-world example systems. Methodologies address
dynamic systems using the concepts of composition, abstraction, execution, and performance. The issues of
stochastic modeling and decision analysis are also covered.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

618 Model-based Systems Engineering (3:3:0)
Recommended Prerequisite: SYST 520
Model-based Systems Engineering (MBSE) provides a formalized application of modeling to support the
engineering of systems. The purpose of the course to study and practice the leading methodologies for MBSE
and illustrate the MBSE approaches in systems engineering and management. The advanced object-oriented
systems engineering methodology and model transformation techniques are addressed. Software tools are
introduced and used for supporting systems engineering design. Students are expected to develop a system design
of their choice using MBSE approaches presented in class and they will make presentations on these designs.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

620/ECE 673 Discrete Event Systems (3:3:0)
Recommended Prerequisites: SYST 611 or ECE 521, or permission of instructor.
Introduces modeling and analysis of discrete event dynamical systems. Course covers elements of discrete
mathematics and then focuses on Petri Net models and their basic properties. Relation to other discrete event
models of dynamical systems.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

621/ECE 674 Systems Architecture Design(3:3:0)
Recommended Prerequisite: SYST 520/ECE 550
Architecture design and representation and the methodologies used to obtain them. Approaches based on
system engineering constructs such as object orientation and service oriented architectures are used to design
architectures and then represent them in conformance with an architecture framework such as DoDAF.
Executable models of the architecture are derived to be used for architecture evaluation Enrollment limited to
students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

630 Systems Engineering Management II (3:3:0)
Recommended Prerequisites: SYST 470 or SYST 530
Study of more advanced topics in systems engineering management. Students expected to read selections from
current literature as well as make presentations and produce papers on engineering management topics. Work in
groups to create SEMP, RMP and PAP. Focuses strongly on the practical impacts of various system engineering
management techniques and practices on projects, organizations, and personnel.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

659 Topics in Systems Engineering (3:3:0)
Topics not covered in department’s regular systems engineering offerings. Course content may vary each semester depending on instructor and the perception of students’ needs. May be repeated within the term for a maximum 6 credit.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

660/OR 660 Air Transportation Systems Modeling (3:3:0).
Recommended Prerequisite: SYST 460/560 or permission of instructor.
Introduces wide range of current issues in air transportation. Issues include public policy toward industry, industry economics, system capacity, current system modeling capability, human factors considerations, safety analysis and surveillance systems, and new technological developments. Develops broad understanding of contemporary and future issues. Knowledge evaluated through class discussions, take-home midterm exam, and term project to be completed by end of semester.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

664/CSI 674/OR 664 Bayesian Inference and Decision Theory (3:3:0)
Recommended Prerequisite: STAT 544 or 554, or equivalent.
Introduces decision theory and relationship to Bayesian statistical inference. Teaches commonalities, differences between Bayesian and frequentist approaches to statistical inference, how to approach statistics problem from Bayesian perspective, and how to combine data with informed expert judgment in a sound way to derive useful and policy relevant conclusions. Teaches necessary theory to develop firm understanding of when and how to apply Bayesian and frequentist methods; and practical procedures for inference, hypothesis testing, and developing statistical models for phenomena. Teaches fundamentals of Bayesian theory of inference, including probability as a representation for degrees of belief, likelihood principle, use of Bayes Rule to revise beliefs based on evidence, conjugate prior distributions for common statistical models, and methods for approximating the posterior distribution. Introduces graphical models for constructing complex probability and decision models from modular components.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

670/OR 670 Metaheuristics for Optimization
Recommended Prerequisite: OR 441/541 or permission of instructor.
Course on the theory and practice of metaheuristics, i.e. solution search techniques for solving combinatorial optimization problems. It will introduce the theory, applications (scheduling in manufacturing, transportation, and in other engineering and service industries), and computational aspects of directly searching for solutions to solve computationally complex optimization problems without a well-defined analytical model.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Enrollment is limited to Graduate, Non-Degree or Undergraduate level students. Students in a Non-Degree Undergraduate degree may not enroll. Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

671/OR 671 Judgment and Choice Processing and Decision Making (3:3:0)
Recommended Prerequisite: STAT 344, STAT 354, OR 542 or permission of instructor.
How do people make judgments and decisions? Course presents initial review of scientific literature directed toward answering this question, and emphasizes importance when performing decision analysis and designing systems to support judgment and decision processes.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

**674/OR 674 Dynamic Programming (3:3:0)**
Recommended Prerequisites: OR442 or OR542 or permission of instructor
Theory and practice of dynamic programming, i.e., optimal sequential decision making over time in the presence of uncertainties is covered. Stresses intuition, the mathematical foundations being for the most part elementary. It will introduce the theory, applications (finance, engineering, and biology), and computational aspects of dynamic programming for deterministic and stochastic problems.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

**675 Reliability Analysis (3:3:0)**
Recommended Prerequisites: STAT 544, STAT 554, OR 542 or permission of instructor
Introduction to component and system reliability, their relationship, and problems of inference. Topics include component lifetime distributions and hazard functions, parameter estimation and hypothesis testing, life testing, accelerated life testing, system structural functions, and system maintainability.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

**680/ECE 670/OR 683 Principles of Command, Control, Communications, Computing, and Intelligence (C4I) (3:3:0)**
Recommended Prerequisite: ECE 528 or SYST 611 or OR 542 or equivalent.
Broad introduction to fundamental principles of command, control, communications, computing, and intelligence (C4I). Principles and techniques applicable to wide range of civilian and military situations. Discusses modeling and simulation of combat operations. Studies in detail sensing, fusion, and situation assessment processes. Derives optimal decision-making rules; discusses concepts of C4 architectures; and develops tools to evaluate and design C4 systems such as queuing theory.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

**683 Modeling, Simulation, and Gaming (3:3:0)**
Recommended Prerequisites: MATH 213, SYST 500 or equivalent, and graduate standing.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

**688/OR 688 Financial Systems Engineering II: Derivative Products and Risk Management (3:3:0)**
Recommended Prerequisite: OR588 or SYST 588 or permission of instructor
Financial engineering is a cross-disciplinary field that relies on mathematical finance, numerical methods, and computer simulations to make trading, hedging, and investment decisions, as well as facilitating the risk management of those decisions. This course will focus on risk management for market risk, credit risk, and operational risk. It will cover a broad range of derivatives products and hedging strategies with emphasis on
how risks are managed in financial institutions.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

698 Independent Study and Research (3:3:0)
Recommended Prerequisites: Completion of at least two core courses, permission of instructor.
Study of a selected area in systems engineering or C4I under the supervision of a faculty member. Written report required. May be repeated within the degree for a maximum 12 credits.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

699 Masters Project (3:0:0)
Recommended Prerequisite: 21 graduate credits in OR or SYST
Capstone project course for MS/SE program. Key activity is completion of major applied team project resulting in an acceptable technical report, and oral briefing. Students should plan to take course in last semester of studies.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

735/ OR 735 Advanced Stochastic Simulation (3:3:0)
Recommended Prerequisite: OR 635, or permission of instructor.
Special topics and recent developments in Monte Carlo simulation methodology for discrete-event stochastic systems. Contents vary; possible topics include statistical analysis of simulation output data, random number and random variate generation, variance reduction techniques, sensitivity analysis and optimization of simulation models, distributed and parallel simulation, object-oriented simulation, and specialized applications.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

740 Advances in Multi-Modeling (3:3:0)
Recommended Prerequisite: SYST 620 or ECE 673 or permission of instructor
Focuses on the inter-operation of multiple models expressed in different modeling languages but which draw from the same data set: i.e., multi-modeling. Socio-technical systems often require a variety of modeling tools to define their operation accurately. An ontology based approach is used to analyze the validity of a proposed modeling architecture and workflow to address a specific issue.
Enrollment is limited to Graduate or Non-Degree level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

750 Advanced Topics in Systems Engineering (3:3:0)
Recommended Prerequisite: 600 level course that varies with content of course
Advanced topics not covered in department’s regular systems engineering offerings. Course content may vary each semester depending on instructor and the perception of students’ needs. May be repeated for credit when topics are distinctly different. May be repeated within the degree for a maximum 12 credits.
Enrollment is limited to Graduate or Non-Degree level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.
763/OR 763 Research Methods in Systems Engineering and Information Technology (3:3:0)
Recommended Prerequisite: STAT 554, OR 542 or permission of instructor.
Examines alternative paradigms of scientific research and their applicability to research in information technology. Topics include fundamental elements of scientific investigation, basic principles of experimental design and statistical induction, philosophy of science and its relation to the information technology sciences, and case studies of information technology research.
Enrollment is limited to Graduate or Non-Degree level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

781: Data Mining and Knowledge Discovery (3:3:0)
Recommended Prerequisite: One of the following courses: CS 687, CS 650, INFS 614, STAT 663, SYST 664, or permission of the instructor.
Statistical and computational methods and systems for deriving user-oriented knowledge from large databases and other information sources, and applying knowledge to support decision making. Information sources can be in numerical, textual, visual, or multimedia forms. Covers theoretical and practical aspects of current methods and selected systems for data mining, knowledge discovery, and knowledge management, including those for text mining, multimedia mining, and web mining.
Enrollment is limited to Graduate or Non-Degree level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

799 Master’s Thesis (1-6:0:0)
Recommended Prerequisites: 21 graduate credits and permission of instructor.
Research project chosen and completed under the guidance of a graduate faculty member, which results in a technical report acceptable to a three-member faculty committee, and an oral defense.
Enrollment is limited to Graduate or Non-Degree level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

842 Models of Probabilistic Reasoning (3:3:0)
Recommended Prerequisites: STAT 544, OR 542, OR 681, or permission of instructor
Survey of alternative views about how incomplete, inconclusive, and possibly unreliable evidence might be evaluated and combined. Discusses Bayesian, Baconian, Shafer-Dempster, and Fuzzy systems for probabilistic reasoning.
Enrollment is limited to Graduate level students.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

850 Topics in Systems Integration Engineering (3:3:0)
Recommended Prerequisite SYST 510 or 520.
Covers lifecycles; large systems comprised of heterogeneous components; human, organizational, and technological basis for integration; societal and cultural basis; conceptual frameworks; structure, function, and purpose of industry; risk management; user requirements and functional specifications; bid and proposal process; systems integration and federal government; standards; integration of systems and federations of systems; integrated process and product development; architectures; systems management and cost estimation; reengineering; quality management; increasing returns to scale, network effects, and path dependency issues; and systems integration ecology and evolutionary systems integration.
Enrollment is limited to Graduate level students.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

888/OR 888 Distributed Estimation and Multisensor Tracking and Fusion (3:3:0)
Recommended Prerequisite: ECE 734 or SYST 611.
Centralized and distributed estimation theory, hierarchical estimation, tracking and data association, multisensor multitarget tracking and fusion, distributed tracking in distributed sensor networks, track-to-track association and fusion, and Bayesian networks for fusion. Enrollment is limited to Graduate level students.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

944/OR 944 The Process of Discovery and Its Enhancement in Engineering Applications (3:3:0)
Recommended Prerequisite: IT 842 or permission of instructor.
Studies ingredients of imaginative reasoning as it concerns efficient discovery of new ideas and valid evidential test of them. Topics include different interpretations of Peirce’s theory of abductive reasoning and other forms of reasoning, Hintikka’s analysis of process of inquiry, and current attempts to design systems that provide assistance in discovery-related or investigative activities.
Enrollment is limited to Graduate level students.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

Related Operations Research Courses:

541 Operations Research: Deterministic Models (3:3:0)
Recommended Prerequisite: MATH 203 or equivalent.
Survey of deterministic methods of solving real world decision problems. Covers linear programming model and simplex method of solution, duality, and sensitivity analysis, transportation and assignment problems; shortest path, minimal spanning tree, and maximal flow problems; and an introduction to integer and nonlinear programming. Emphasis on modeling and problem solving. Students who have taken OR 441/MATH 441 will not receive credit. Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

542 Operations Research: Stochastic Models (3:3:0)
Recommended Prerequisite: STAT 344 or MATH 351, or equivalent.
A survey of probabilistic methods for solving decision problems under uncertainty, probability theory review, reliability, queuing theory, inventory systems, Markov chain models, and simulation. Emphasis on modeling and problem solving. Students who have taken OR 442/MATH 442 do not receive credit.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

635 Discrete System Simulation (3:3:0)
Recommended Prerequisite: OR 542 or STAT 354 or STAT 344, or equivalent, and knowledge of a scientific programming language.
Computer simulation as a scientific methodology in operations analysis, with emphasis on model development, implementation, and analysis of results. Discrete-event models, specialized software, input modeling and output statistics are covered. Extensive computational work is required.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.
13. Systems Engineering and Operations Research Faculty

Adelman, Leonard, Ph.D., University of Colorado; Professor

Brouse, S. Peggy, Ph.D., George Mason University, Associate Professor

Chang, Kuo-Chu, Ph.D., University of Connecticut, Professor

Chen, Chun-Hung, Ph.D., Harvard University, Professor

Clemons, Thomas, Ph.D., George Mason University, Associate Professor

Costa, Paulo, Ph.D., George Mason University, Associate Professor

Donohue, George, Ph.D., Oklahoma State University, Professor Emeritus

El-Amine, Hadi, Ph.D., Virginia Tech, Assistant Professor

Ganesan, Rajesh, Ph.D., University of South Florida, Associate Professor

Hoffman, Karla L., Sc.D., The George Washington University; Professor

Huang, Chien-Chung, Ph.D., Georgia Institute of Technology, Assistant Professor

Ji, Ran, Ph.D., The George Washington University, Assistant Professor

Jones, Rochelle, Ph.D., University of Central Florida, Associate Professor

Laskey, Kathryn B., Ph.D., Carnegie Mellon University, Professor

Loerch, Andrew, Ph.D., Cornell University, Associate Professor

Nash, Stephen G., Ph.D., Stanford University, Professor

Pyster, Art, Ph.D., The Ohio State University, Professor

Sherry, Lance A., Ph.D., Arizona State University, Associate Professor

Shortle, John, Ph.D., University of California, Berkeley, Professor and Chair

Sokolov, Vadim, Ph.D., Northern Illinois University, Assistant Professor

Xu, Jie, Ph.D., Northwestern University, Associate Professor

Zaidi, Abbas, Ph.D., George Mason University, Professor

Adjunct Professors: Arab Ali; Michael Bailey; Philip Barry; Brian Burke; Steven Charbonneau; Kenneth Comer; Robert Edson; Larrie Ferreiro; Joshua Icore; Sabyasachi Guharay; Raza Hashim; Ilean Keltz; Howard Killam; Jack Laveson; Michael Mulhearn; Paul Nicholas; Jeffrey Ray; Martin Rothwell; Daniel Stimpson; Kathleen Warren; Fred Wieland; Ronald Woodaman; Yue (Richard) Xie
Plan of Study (with Concentration)

**Master of Science in Systems Engineering**

Name: ___________________________ G# __________________

Address: ___________________________ Phone: ______________

City, State, Zip: ___________________ Email: __________________

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<tr>
<th>Degree Requirements (30)</th>
<th>Semester/Yr</th>
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<tbody>
<tr>
<td><strong>Foundation Course (if needed)</strong></td>
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<tr>
<td>SYST 500: Quantitative Foundations for Systems Engineering (3)</td>
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<tr>
<td><strong>Systems Engineering Core Courses (12/15)</strong></td>
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<tr>
<td>SYST 505: Systems Engineering Principles (3)*</td>
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<td>SYST 510: Systems Definition and Cost Modeling (3)</td>
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<tr>
<td>SYST 520: Systems Design &amp; Integration (3)</td>
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<tr>
<td>SYST 530: Systems Engineering Management I (3)</td>
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<tr>
<td>SYST 611: System Methodology and Modeling (3)</td>
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<tr>
<td><strong>Project (3)</strong></td>
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<tr>
<td>SYST 699: Master’s Project (3)</td>
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<tr>
<td><strong>Basic Methods Courses (3)</strong></td>
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<td>– Students must complete the required basic methods course in the concentration area or choose from the list of approved basic methods courses if no required methods course is listed.</td>
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<tr>
<td>Concentration: ___________________________</td>
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<tr>
<td>Methods course: ___________________________</td>
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<tr>
<td><strong>Concentration-Specific Courses (9/12)</strong> - Students must complete the required courses and an elective courses(s) as required for the concentration.</td>
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<td>Course 1: ___________________________</td>
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<td>Course 2: ___________________________</td>
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<td>Course 3: ___________________________</td>
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<tr>
<td>Course 4: (in lieu of SYST 505) ___________________________</td>
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</tbody>
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Student Signature: ___________________________ Date: ____________

Faculty Advisor Signature: ___________________________ Date: ____________

* SYST 505 may be replaced by an approved elective for students who have work experience in systems engineering or who have been enrolled in the undergraduate BSSE program at Mason. SYST 505, if taken, must be taken in the first semester of enrollment in the MSSE program.
Plan of Study (with No Concentration)

Master of Science in Systems Engineering

Name: ________________________________  G# __________________

Address: ________________________________  Phone: __________________

City, State, Zip: _________________________  Email: ___________________

**Degree Requirements (30)**

<table>
<thead>
<tr>
<th>Semester/Yr</th>
<th>Foundation Course (if needed)</th>
<th>Systems Engineering Core Courses (12/15)</th>
<th>Project (3)</th>
<th>Basic Methods Courses (3)</th>
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<td><strong>Elective Courses (9/12)</strong></td>
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<td>Course 4: (in lieu of SYST 505)</td>
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</table>

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Faculty Advisor Signature: ________________________________  Date: ____________

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