Department of Engineering Management and Systems Engineering

Web Site: http://www.odu.edu/emse
2101 Engineering Systems Building
Norfolk, VA 23529
(757) 683-4558

Andres Sousa-Poza, Chair
Andres Sousa-Poza, Graduate Program Director, Master's Programs
M. Pilar Pazos-Lago, Graduate Program Director, Doctoral Programs

General Description

The Engineering Management and Systems Engineering (EMSE) Department at Old Dominion University is dedicated to excellence in teaching and research in critical areas related to the management of complex, technology-intensive organizations and systems. Our award-winning programs are directed at working professionals and traditional full-time students with technical undergraduate degrees. The degree is available on campus in a traditional classroom setting as well as online. Courses are scheduled in the evenings and they could be attended from off-campus sites, including the Peninsula Higher Education Center in Hampton and the Virginia Beach Higher Education Center. The complete M.E.M. program is available through Old Dominion University’s distance learning program and through the Commonwealth Graduate Engineering Program. Both programs transmit courses to educational, industrial, and government locations throughout Virginia and via web-based platform.

Admission Requirements

Admission to the master of Engineering Management program is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for master’s programs as specified in this catalog.

Admission requirements specific to this program include the following:

1. Undergraduate degree from an ABET-accredited program in engineering or engineering technology from an accredited program in applied science with a GPA of 3.00 (out of 4.00) or better.
2. GRE Exam (GRE requirement may be waived at GPD discretion based on academic preparation and related work experience).
3. Students with an undergraduate GPA between 2.70 and 3.00 on the required undergraduate degrees may be admitted provisionally based on their academic preparation and GRE scores. GRE scores should be in the 60th percentile or higher.
4. A minimum score of 550 on university-level TOEFL scores for all international students when English is not their first language.

Degree Requirements

General Requirements

The master of Engineering Management is in accordance with the general requirements for master’s degrees as specified in this Catalog. All students must have mathematics course work through the level of integral calculus, matrix algebra or differential equations, and ENMA 420 or equivalent, as part of their plan of study. Students with an undergraduate GPA between 2.70 and 3.00 on the required undergraduate degrees may be admitted provisionally based on their academic preparation and GRE scores. GRE scores should be in the 60th percentile or higher. A minimum score of 550 on university-level TOEFL scores for all international students when English is not their first language.

Curricular Requirements

All students admitted to the MEM program must earn a grade of “C” or better in all courses required for the degree and in all Engineering Management prerequisite courses. A student may be removed from the program if he/she receives 2 (two) grades of “C” or lower. The master of engineering management requires 31 credit hours of course work (10 three-credit courses plus a one-credit capstone course). The program requires 6 core courses and 4 electives. At least three-fifths (3/5) of course work must be at the 600 or 700 level for the M.S. degrees. The electives may be selected from the ENMA approved courses (and/or from courses in other
departments with the approval of the Graduate Program Director). All electives must be at the graduate level. The following table delineates the specific course requirements for this program.

### M.E.M. Courses:

#### Prerequisite *

<table>
<thead>
<tr>
<th>Core</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENMA 600</td>
<td>Cost Estimating and Financial Analysis</td>
</tr>
<tr>
<td>ENMA 601</td>
<td>Analysis of Organizational Systems</td>
</tr>
<tr>
<td>ENMA 603</td>
<td>Operations Research</td>
</tr>
<tr>
<td>ENMA 604</td>
<td>Project Management</td>
</tr>
<tr>
<td>ENMA 614</td>
<td>Quality Systems Design</td>
</tr>
</tbody>
</table>

Select one of the following: 3

| ENMA 640 | Integrated Systems Engineering I |
| ENMA 715 | Systems Analysis |
| ENMA 724 | Risk Analysis |

**Electives ** 12

| ENMA 605 | Program Capstone (required final semester) |

### Capstone 1

#### Total Hours 31

* All students are required to have mathematics course work through the level of integral calculus; matrix algebra or differential equations; and a course in calculus-based statistics (ENMA 420). Exceptions to these requirements must be approved by the Graduate Program Director.

** Students must select twelve credit hours of elective coursework for the M.E.M. These electives may be selected from the available level ENMA courses (and/or from courses in other departments with the approval of the Graduate Program Director). Electives must be at the graduate level.

### Requirements for Graduation

In addition to completing all the required courses, all graduate students must complete the Collaborative Institutional Training Initiative (CITI) basic course. The basic course includes the following modules: Misconduct (falsification, fabrication, and plagiarism); Data acquisition, management, sharing and ownership; Mentor/trainee relationships; Publication practice and responsible authorship; Peer review; Conflicts of interest; and Collaborative research. The RCR modules must be completed prior to completion of 12 semester hours. Students who fail to complete this requirement will have a registration hold placed on their records.

### Master of Science, Engineering – Engineering Management

#### Degree Description

The Master of Science in Engineering Management (MSEM) provides a foundation and the necessary skills, knowledge, and abilities required to design and manage the technology-based, project-driven enterprise. The Master of Science (M.S.) program requires thesis research, and the student is expected to identify an advisor and work with him/her starting from the first semester. Fundamentally, the engineering management program focuses on problems, design, and management of projects and complex operations. The program is grounded in solid principles of systems science while exploiting the tools of management science and project management. The course work is designed to produce graduates capable of addressing issues related to the design, operation, analysis, and transformation of complex problems. Core course work in the Master of Science in Engineering Management program concentrate on developing the knowledge and skills required by graduates to provide the project and program leadership and management necessary for an organization to develop and manage technologies.

The degree is directed at working professionals and traditional full-time students. The degree is available on campus in a live setting as well as online. Courses are scheduled in the evenings and they could be attended from off-campus sites, including the Peninsula Higher Education Center in Hampton and the Virginia Beach Higher Education Center. The complete MSEM program is available through Old Dominion University’s distance learning program and through the Commonwealth Graduate Engineering Program. Both programs transmit courses to educational, industrial, and government locations throughout Virginia and via web-based platform.

### Admission Requirements

Admission to the Master of Science in Engineering Management program is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for master’s programs as specified in this catalog.

Admission requirements specific to this program include the following:

1. Undergraduate degree from an ABET-accredited program in engineering or engineering technology or from an accredited program in applied science with a GPA of 3.00 (out of 4.00) or better.
2. GRE Exam (GRE requirement may be waived at GPD discretion based on academic preparation and related work experience).
3. Students with an undergraduate GPA between 2.70 and 3.00 on the required undergraduate degrees may be admitted provisionally based on their academic preparation and GRE scores. In order to be admitted provisionally, GRE scores should be in the 60th percentile or higher.
4. A minimum score of 550 on university-level TOEFL scores for all international students when English is not their first language.

### Degree Requirements

#### General Requirements

The Master of Science in Engineering Management (MSEM) is in accordance with the general requirements for master’s degrees as specified in this Catalog. Students are required to identify an advisor as part of the program requirements. All students are expected to communicate effectively both orally and in written documents, that are correct in grammar, style, and mechanics. Those deemed insufficient may be required to take remedial speech or writing courses. All students must have mathematics course work through the level of integral calculus, matrix algebra or differential equations, and ENMA 420 or equivalent calculus-based probability and statistics. Students who have not had a calculus-based probability and statistics course will be required to include ENMA 420, or equivalent, as part of their plan of study in addition to the required 30 credits.

#### Curricular Requirements

All students admitted to Engineering program must earn a grade of “C” or better in all courses required for the degree and in all Engineering Management prerequisite courses. A student may be removed from the program if he/she receives 2 (two) grades of “C” or lower. The master of engineering management requires 30 credit hours of course work (8 three-credit courses plus 2 three-credit thesis research courses). At least three-fifths (3/5) of course work must be at the 600 or 700 level for the M.S. degrees.

The following table delineates the specific course requirements for this program.

### M.S. Courses:

#### Prerequisite *

<table>
<thead>
<tr>
<th>Core</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENMA 600</td>
<td>Cost Estimating and Financial Analysis</td>
</tr>
<tr>
<td>ENMA 601</td>
<td>Analysis of Organizational Systems</td>
</tr>
<tr>
<td>ENMA 603</td>
<td>Operations Research</td>
</tr>
<tr>
<td>ENMA 604</td>
<td>Project Management</td>
</tr>
<tr>
<td>ENMA 614</td>
<td>Quality Systems Design</td>
</tr>
<tr>
<td>ENMA 715</td>
<td>Systems Analysis</td>
</tr>
<tr>
<td>ENMA 721</td>
<td>Foundations of Research</td>
</tr>
</tbody>
</table>

**Electives 6**

| ENMA 605 | Program Capstone (required final semester) |

---

Department of Engineering Management and Systems Engineering 2
Admission requirements specific to this program include the following:

- Technology requirements for master’s programs as specified in this catalog.

### Curricular Requirements

**Prerequisite/Corequisite**

<table>
<thead>
<tr>
<th>Core</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENMA 602</td>
<td>Systems Engineering Management</td>
</tr>
<tr>
<td>ENMA 640</td>
<td>Integrated Systems Engineering I</td>
</tr>
<tr>
<td>ENMA 641</td>
<td>Requirements Management, Verification and Validation</td>
</tr>
<tr>
<td>ENMA 660</td>
<td>Systems Architecture and Modeling</td>
</tr>
<tr>
<td>ENMA 715</td>
<td>Systems Analysis</td>
</tr>
<tr>
<td>ENMA 771</td>
<td>Risk and Vulnerability Management of Complex Interdependent Systems</td>
</tr>
</tbody>
</table>

**Capstone**

- ENMA 605 | Program Capstone
- or ENMA 690 | Systems Engineering Capstone

**Electives**

- Select four of the following:
  - ENMA 603 | Operations Research
  - ENMA 645 | Preparation for Systems Engineering Professional Certification
  - ENMA 702 | Systemic Decision Making
  - ENMA 703 | Optimization Methods
  - ENMA 710 | Modeling and Analysis of Systems
  - ENMA 712 | Multi-Criteria Decision Analysis and Decision Support Systems
  - ENMA 716 | Complex Adaptive Situations Environment
  - ENMA 717 | Cost Engineering
  - ENMA 723 | Enterprise and Complex System Dynamics
  - ENMA 743 | Reliability and Maintainability
  - ENMA 750 | System of Systems Engineering

**Exceptions to these requirements must be approved by the Graduate Program Director.**

### Requirements for Graduation

In addition to completing all the required courses, all graduate students must complete the Collaborative Institutional Training Initiative (CITI) basic course. The basic course includes the following modules: Misconduct (falsification, fabrication, and plagiarism); Data acquisition, management, sharing and ownership; Mentor/trainee relationships; Publication practice and responsible authorship; Peer review; Conflicts of interest; and Collaborative research. The RCR modules must be completed prior to completion of 12 semester hours. Students who fail to complete this requirement will have a registration hold placed on their records. Master of Science students must also pass a final examination front of a thesis committee approved by the graduate program director.

### Master of Engineering – Systems Engineering

**Degree Description**

The Master of Engineering – Systems Engineering provides an interdisciplinary approach to support the realization, deployment, and maintenance of successful system solutions to complex problems. ODU’s Systems Engineering Master’s program builds upon your technical background as an engineer. It is designed to provide in-depth, real-world practitioner expertise in engineering complex system solutions. In addition, this rigorous educational experience will help develop your skills in effectively addressing complex problems for both government and commercial organizations. Students in the program are introduced to core competencies for systems engineering, complex systems, modeling, systems analysis, complex problem solving needed for successful delivery of system solutions.

### Admission Requirements

Admission to the Master in Systems Engineering program is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for master’s programs as specified in this catalog.

Admission requirements specific to this program include the following:

1. Undergraduate degree from an ABET-accredited program in engineering or engineering technology or from an accredited program in applied science with a GPA of 3.00 (out of 4.00) or better.
2. GRE Exam (GRE requirement may be waived at GPD discretion based on academic preparation and related work experience).
3. Students with an undergraduate GPA between 2.70 and 3.00 on the required undergraduate degrees may be admitted provisionally based on their academic preparation and GRE scores. GRE score should be in the 60th percentile or higher.
4. A minimum score of 550 on university-level TOEFL scores for all international students when English is not their first language.

### Degree Requirements

**General Requirements**

The Master of Engineering with a concentration on Systems Engineering is in accordance with the general requirements for master’s degrees as specified in this Catalog. In addition, all students must have mathematics course work through the level of integral calculus, matrix algebra or differential equations, and ENMA 420 or equivalent calculus-based probability and statistics. Students who have not had a calculus-based probability and statistics course will be required to include ENMA 420, or equivalent, as part of their plan of study as an additional requirement to the 31 credit hours. All students are expected to communicate effectively both orally and in written documents, that are correct in grammar, style, and mechanics. Those deemed insufficient may be required to take remedial speech or writing courses.

### Curriculum Requirements

All students admitted to Engineering program must earn a grade of “C” or better in all courses required for the degree and in all Engineering Management prerequisite courses. A student may be removed from the program if he/she receives 2 (two) grades of “C” or lower. Specific requirements for the Master in Engineering with a concentration in systems engineering include the following: The M.E. with a concentration in systems engineering requires 31 graduate credit hours of course work (10 courses plus a one-credit capstone course) for the. At least three-fifths (3/5) of course work must be at the 600 or 700 level for the M.S. degrees. The capstone course should be taken within the last two semesters of study. The following table delineates the specific course requirements for this program.
Each applicant is required to submit the following documentation when initially applying: (1) Transcripts from all institutions that the applicant has attended; (2) Graduate Record Examination general aptitude scores; (3) A curriculum vitae that highlights professional and research related activities; and (4) an essay of 500 words or less describing personal and academic goals, professional objectives, preparation for graduate study, and how the chosen program will help the applicant achieve these goals and objectives. The essay should clearly state the specific area in which the applicant intends to specialize.

Applicants whose interests can be supported by a faculty's specialization and demonstrate adequate preparation to meet the demands of doctoral studies will be contacted by the Graduate Program Director. The GPD may request additional information that will assist in the selection process. Additional information may include, but is not restricted to: Publications, samples of research reports, and documents or materials that support proficiency claims of specialized skills. If warranted, the GPD will organize an interview of the applicant by faculty that have specializations in areas that may overlap with the applicant's intended area of research.

Admission is contingent on having the support of a faculty that is willing to commit to acting as an advisor should the applicant be admitted. Students lacking adequate academic preparation may be required to complete coursework in addition to the graduate admission requirements. Students may be admitted to the Ph.D. program deficient in these leveling courses, but as part of their plan of study, the student must take and successfully complete these courses at the earliest possible opportunity. All students must have mathematics coursework through the level of integral calculus; matrix algebra or differential equations; and a course in calculus-based statistics (ENMA 420 or equivalent). As part of master's-level coursework, all students must have completed the following engineering management leveling courses or their equivalent: ENMA 600, ENMA 603, and ENMA 604.

**Degree Requirements**

*General Requirements*

The Ph.D. program is intended to develop scholarship and research capabilities in the student. Graduates will be experts within their chosen field, highly skilled researchers, critical thinkers, and competent communicators and debaters. Graduates will demonstrate this in a variety of ways that will include, but is not limited to, their performance in coursework, written and oral examinations, closed and public debates and defenses, and contribution to their field's body of knowledge. The development and assessment of such expertise and scholarship takes place under the guidance, advising, and mentorship of a faculty that is an expert in the field, and appropriate guidance, dissertation and examination committees.

*Curricular Requirements*

Curriculum requirements in engineering management are in accordance with the general requirements for Ph.D. degrees as specified in the Requirements for Graduate Degrees section of this catalog. The Ph.D. program is governed by a Plan of Study that is established by the student in conjunction with his/her advisor and guidance committee within the first nine credit hours of course work and will follow the established course requirements (below) unless a substitution to one or more courses is agreed upon between the advisor and student and approved by the Graduate Program Director. The plan of study is designed to prepare the student to undertake scholarly research in the particular field and specialization of their dissertation. The coursework selected will provide the student with (1) the requisite foundational knowledge of the selected field, and (2) the necessary research skills. A high degree of flexibility is provided to customize the plan of study, taking into account the diversity in the fields of study, the multidisciplinary nature and variety of research that is undertaken, as well as the different levels of preparation that individual students have.
At least three-fifths (3/5) of formal coursework must be at the 800 level for all doctoral programs.

**Subject Area Specialization**

Subject Area Electives (minimum) 9+

**Research Skills**

ENMA 821 Foundations of Research 3
Research Skills Electives (minimum) 6+

**Total Coursework Required (minimum)** 24

**Dissertation Research** 24

**Total Hours (minimum)** 48

* Up to 6 dissertation research hours may be replaced by coursework with the approval of the advisor and GPD.

### Requirements for Graduation

In addition to any University and College requirements presented in this catalog, the Ph.D. program in engineering management requires:

1. Satisfactory completion of a minimum of 48 credit hours of postmaster’s degree credit or equivalent level of performance course work. This shall include a minimum of 24 credit hours of coursework that complies with the student’s plan of study, and a minimum of 18 credit hours of dissertation research hours.
2. Passing a written and oral candidacy examination at the completion of formal course work.
3. The completion of research representing independent original research and its formal documentation as a dissertation.
4. The successful defense of a written dissertation proposal.
5. The successful public defense of the dissertation before an audience, which includes an appropriately selected committee of faculty knowledgeable in the field of the research.

### Continuance Requirements

Students may be separated for failure to comply with any policies, procedures or requirements that pertain to this Ph.D. program or student behavior. In addition to the requirements for graduation, separation from the program may be warranted for the following reasons, among others:

**Coursework:**

1. All students admitted to Engineering Management and Systems Engineering programs must earn a grade of "C" or better in all courses required for the degree and in all Engineering Management prerequisite courses. A student may be separated from the program if he/she receives a grade lower than a "C". Additionally, a student may be separated from the program if he/she receives 2 (two) grades lower than a "B".

**Adherence to programmatic expectations:**

1. Students are expected to complete their coursework according to an agreed upon plan of study. Failure to adhere to the plan of study may result in separation from the program.
2. Students are expected to make timely progress on their coursework and research. Persistent failure to meet deadlines and milestones, or other indicators that demonstrate progress, as assessed and documented by the guidance or advisory committee may lead to separation from the program.
3. Students are expected to remain within the specialization area of their advisor and committee members. Students that deviate outside of the agreed upon research area will be notified of this deviation. The student may lose the support of their advisor and committee if the deviation persists. A student will be given a limited period of time (generally one semester) to acquire an advisor that is capable of supporting their new research direction. Separation from the program will result if the student cannot obtain a new advisor, whether this is due to the lack of a specialization in the new field, or if a faculty with a suitable specialization cannot take on additional advising responsibilities.

4. Similarly, if a student is left without an advisor for any other reason (e.g. departure of a faculty advisor from the program), it is contingent upon the student to obtain a new advisor in a timely manner. This may require flexibility and willingness by the student to adjust their area of specialization. The department will assist the student and take their particular situation into consideration when the loss of an advisor is due to factors outside of the student’s control. Separation from the program will, however, result if no advisor is obtained after a limited period of time (generally one semester).

### Quality of Research

1. A student that persistently submits work of low quality whether it be in documented or in oral form, may be required to submit for special reviews by the committee. Records taken by the advisor, and the guidance or advisory committees, which document the quality problems and present remedial actions where appropriate will be used to help ascertain whether the problems can reasonably be expected to be resolved, or if separation from the program is warranted.

### Ethical Behavior

1. Any student partaking or demonstrating behaviors that might be considered to go against the policies and conditions expected for responsible conduct in research, Old Dominion University expected codes of conduct, or ethical considerations that might be specific to an area of research, may result in separation from the program.

### Doctor of Engineering – Engineering Management and Systems Engineering

**Degree Description**

The Department offers a Doctor of Engineering (D.Eng.) program with concentration in Engineering Management and Systems Engineering in accordance with the D.Eng. program requirements specified for the Batten College of Engineering and Technology in this catalog. Additional information on the admission procedure and criteria can be found at https://www.odu.edu/academics/programs/doctoral/engineering-management.

**Graduate Certificates**

The Department of Engineering Management and Systems Engineering administers or participates in a variety of graduate certificates. These include graduate certificates, or advanced engineering certificates with concentrations in:

- Advanced Engineering Certificate in
  - Engineering Management
  - Cyber Systems Security
  - Energy Systems
- Graduate Certificate in
  - Project Management
  - Homeland Security
  - Entrepreneurship and Innovation in Engineering

Please refer to Frank Batten College of Engineering and Technology (http://catalog.odu.edu/graduate/frankbattencollegeofengineeringandtechnology) for more information.

### ENGINEERING MANAGEMENT Courses

**ENMA 510. Agile Project Management. 3 Credits.**

This course focuses the management of projects using an agile approach to respond to the continuous changes that affect project capabilities and performance. Although any project can be manage using agile project management, projects with high degree of uncertainty obtain the most benefits from this approach (e.g., R&D projects). The course covers Scrum and expands it by articulating the human and business factors that make successful agile project management. Case studies and/or short-projects are required. Prerequisites: ENMA 401 or equivalent.
ENMA 511. Networked System Security. 3 Credits.
Course presents an overview of theory, techniques and protocols that are used to ensure that networks are able to defend themselves and the end-systems that use networks for data and information communication. Course will also discuss industry-standard network security protocols at application, socket, transport, network, VPN, and link layers, popular network security tools, security, performance modeling and quantification and network penetration testing. Discussion will be based on development of system level models and simulations of networked systems. (Cross-listed with ECE 511/MSIM 511).

ENMA 515. Introduction to Systems Engineering. 3 Credits.
Introduces the principles, concepts and process of systems engineering. Examination of problem formulation, analysis, and interpretation as they apply to the study of complex systems. Emphasizes the design nature of systems engineering problem solving, and includes case studies stressing realistic problems. Development of system requirements, system objectives, and the evaluation of system alternatives.

ENMA 516. Cyber Defense Fundamentals. 3 Credits.
The objective of this course is to give an introduction of cyber hacking techniques, and defense mechanisms to detect and thwart cybercrime. Cyber attacks aim at compromising cyber systems to disclose information, alter data or operation, cause denial of service, etc. The course first reviews the attacks to wireless networks, such as WiFi and MANET, and the defense strategies and technologies developing system level models. Next, it reviews the attacks to general wired networks and information systems, and introduces the corresponding defense mechanisms. Last it discusses cyber defense security policies and architectures. (Cross-listed with ECE 516 and MSIM 516).

ENMA 517. Secure and Trusted Operating Systems. 3 Credits.
Course will review typical operating systems developing system models and identifying potential vulnerabilities. Course will discuss policies and their implementation required to fix such vulnerabilities to arrive at a secure and Trusted Computing Base. Course examines the security architecture Security Enhanced Linux (SELinux) Windows and Android OS. (Cross-listed with ECE 517/MSIM 517).

ENMA 518. Applied Cryptography. 3 Credits.
This course will discuss cryptography requirements, techniques and protocols used for ensuring confidentiality and integrity of data. The topics will include mathematical fundamentals of cryptography, hash functions, generation and exchange cryptographic keys, secure hash, message authentication codes, private and public key cryptography, DES, AES, RSA and ECC, Block and Stream encryption, SHA, digital signatures and digital certificates, and crypto-analysis. The course will teach students to develop code in Python, C/C++ and Java for common cryptography functions, hash, secure hash, MAC, digital signature, symmetric key crypto (AES) and public key crypto (RSA).

ENMA 519. Cyber Physical Systems Security. 3 Credits.
Cyber Physical Systems (CPSs) integrate computing, networking, and physical processes. CPSs are known for their ability to monitor the physical environment; use the monitored data in detecting the state of the physical environment; control the physical environment; and use cyber communications to perform its monitoring, detection, and control operations. One of the biggest challenges to these systems is the security of its cyber space. This course will cover topics in CPS applications, design issues, and security based on development of a system level model. (Cross-listed with ECE 519 and MSIM 519).

ENMA 570. Foundations of Cybersecurity. 3 Credits.
This course provides an overview of the theory, tools and practice of cyber security and information assurance through the prevention and detection of cyber attacks and the recovery from such attacks. Techniques for security modeling, attack graph and attack tree modeling, risk analysis and cost-benefit analysis to manage the security of cyber systems will be discussed. The course will also cover cryptography constructs, as well as the fundamental principles of cyber security and their applications for protecting software and information assets of individual computers and networks.
ENMA 616. The Entrepreneurial Engineering Manager. 3 Credits.
Globalization has increased competition among the planet’s enterprises.
The quality of products and services has dramatically improved while prices have plummeted. Consumer expectations have risen to very high levels. This phenomenon has accelerated the need for large technical enterprises to become more agile, flexible and responsive to consumer demands. Government agencies are not exempt form this trend: U.S. Government agencies are now required to establish strategic plans for their enterprises and to develop business plans that illustrate the future directions of the enterprise and to define the resources required to realize the vision and strategy of the enterprise. This course introduces Engineering Management students to a wide range of approaches designed to facilitate start-up, enable growth and ensure the continued capability of emerging and mature technical enterprises.

ENMA 640. Integrated Systems Engineering I. 3 Credits.
This course examines the role and nature of systems engineering. It is specifically designed to provide the fundamental understanding of systems engineering and complex systems. This course examines a variety of systems engineering topics with emphasis on the: (1) development of the fundamentals of systems engineering, (2) systems engineering life-cycle models and phases, (3) systems design for operational feasibility, and (4) an introduction to planning for systems engineering and management. This course prepares students to assume the role of a systems engineer in planning, directing, conducting, and assessing systems engineering initiatives.

ENMA 641. Requirements Management, Verification and Validation. 3 Credits.
Comprehensive treatment of the nature and utility of requirements, verification, and validation in systems engineering processes. Topics include: establishing user requirements; traceability; baseline and evolving requirements; governing standards; requirements management; issues in requirements for complex systems; role and methods for verification and validation in systems engineering; data treatment and analysis; standards, practices, and issues for verification and validation in systems engineering.

ENMA 645. Preparation for Systems Engineering Professional Certification. 3 Credits.
A comprehensive treatment and review of the International Council on Systems Engineering (INCOSE) Systems Engineering Handbook v4 in preparation for INCOSE Systems Engineering Professional (SEP) Certification. This course should be taken in the final semester in which the student will graduate.

ENMA 650. Mission Analysis and Engineering. 3 Credits.
The course provides an overview of mission engineering and the role of mission engineering and the mission engineer in government acquisitions. The course presents the theoretical foundations that enable a fuller representation of complex problem as well as the required engineering and management approaches needed to deal with the high level of complexity and uncertainty. It applies the theoretical facets to specific engineering problems/cases and explores robust approaches given the conditions of the problem. Developments, on-going research, as well as gaps in knowledge and know-how are discussed. Prerequisites: ENMA 640.

ENMA 660. Systems Architecture and Modeling. 3 Credits.
Students learn the essential aspects of the systems architecture paradigm through development and analysis of multiple architecture frameworks and enterprise engineering. Emphasis is placed on systems modeling and enterprise engineering.

ENMA 667. Cooperative Education. 1-3 Credits.
Available for pass/fail grading only. Student participation for credit based on academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and the Cooperative Education program prior to the semester in which the work experience is to take place.

ENMA 668. Internship. 1-3 Credits.
Academic requirements will be established by the graduate program director and will vary with the amount of credit desired. Allows students an opportunity to gain short-duration career-related experience. Meant to be used for one-time experience. Work may or may not be paid. Project is completed during the term.

ENMA 669. Practicum. 1-3 Credits.
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career related experience. Student is usually already employed. This is an additional project in the organization. Prerequisites: Approval by department and Career Development Services.

ENMA 670. Cyber Systems Engineering. 3 Credits.
This course provides an overview of functioning of cyber systems including how a computer interacts with the outside world. The composition of critical infrastructure and functioning of different engineered systems that form critical infrastructure are discussed. Mutual dependence and interactions between cyber systems and other engineered and the resulting security risks are also explored. Prerequisites: Undergraduate students in STEM fields or graduate students of STEM degree or instructor's approval.

ENMA 671. Knowledge Management and Decision Making. 3 Credits.
This course focuses on the interrelationships between knowledge management and decision making. The course emphasizes the contributions of knowledge management in the decision making process and outcomes. The course describes the relationship of knowledge management with naturalistic decision making, robust decision making, and risk management. Case studies and/or short-projects are required.

ENMA 672. Fundamentals of Knowledge Management. 3 Credits.
This course focuses on the concept of knowledge management, its basics and advanced processes and methods. Knowledge transfer, knowledge elicitation, knowledge creation, and knowledge representation are some of the knowledge processes covered. The course describes the relationship of knowledge management with innovation and organizational learning. Case studies and/or short-projects are required.

ENMA 673. Threat Modeling and Risk Analysis. 3 Credits.
This course discusses how to develop cyber threat models using attack graphs/trees, STRIDE, Universal Modeling Language (UML), attack graphs/trees and common of risk analysis tools. Course also discusses the need for quantitative security analysis and formal validation of security models and basic principles of formal model validation. Prerequisites: ENMA 670 or MSIM 670 and MSIM 672; undergraduate students in STEM fields or graduate students of STEM degree or instructor's approval.

ENMA 690. Systems Engineering Capstone. 1 Credit.
A written, comprehensive demonstration of the candidate’s competence in the fields covered by the systems engineering program that is intended to fulfill the non-thesis master’s examination requirement.

ENMA 695. Topics in Engineering Management. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management. Prerequisites: Permission of the instructor.

ENMA 696. Topics in Engineering Management. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management. Prerequisites: Permission of the instructor.

ENMA 697. Independent Study in Engineering Management. 3 Credits.
Individual study selected by the student. Supervised and approved by a faculty member with the approval of the Graduate Program Director. Prerequisites: Permission of Graduate Program Director.

ENMA 698. Master’s Project. 1-3 Credits.
The master’s project is guided under the supervision of the course instructor. Projects must be approved by the Graduate Program Advisor. Prerequisites: Graduate Program Director permission is required.

ENMA 699. Thesis. 1-6 Credits.
Research leading to a Master of Science thesis. Prerequisites: ENMA 721 and permission of the Graduate Program Director.
ENMA 700. Economic Analysis of Capital Projects. 3 Credits.
This course is targeted at engineering managers who actively participate in the capital budgeting process and project justification. Topics include capital budgeting techniques (including multi-attribute decision making), utility theory, justification of new technologies, and current research in engineering economics. Reading and application of current research in the field is stressed. Case studies are used. Oral presentations and term project required. Prerequisites: ENMA 600.

ENMA 702. Systemic Decision Making. 3 Credits.
As machine age problems have given way to systems age messes, the underlying complexity associated with understanding these situations has increased exponentially. Accordingly, the methods we use to address these situations must evolve as well. This course will introduce students to a method for thinking holistically about problems and messes conceptually founded in systems theory. This paradigm, known as systemic thinking, will be contrasted with traditional systematic thinking, and practical guidelines for the deployment of a systemic thinking approach will be provided. This paradigm will increase the student’s ability to make rational decisions in complex environments.

ENMA 703. Optimization Methods. 3 Credits.
Covers advanced methods in Operations Research and Optimization. Focus will be on developing models and their applications in different domains including manufacturing and service. Modern optimization tools will be used to implement models for case studies, projects and research papers. The knowledge of programming and spreadsheets is expected. Contact instructor for more details.

ENMA 704. Design of Project Knowledge Systems. 3 Credits.
Graduate level research colloquium examining the application of a systems perspective to design, operation, analysis, and evaluation of project knowledge systems. Special emphasis will be placed on knowledge generation and generalization systems. Case studies, problems, and a course project.

ENMA 705. Financial Engineering. 3 Credits.
This course covers concepts in complex investments, how to deal with uncertainty in today’s global markets, and how to engineer and manage financial decisions. The main topics include: cash flows, portfolio theory, capital management, securities, hedge funds, optimal investment and financial engineering evaluations among others.

ENMA 710. Modeling and Analysis of Systems. 3 Credits.
Probability and statistics (or an equivalent course). Covers modern modeling paradigms for deterministic and stochastic complex and dynamic systems. This includes, but not limited to, Discrete Simulation, Queuing Systems, and Agent-based models among others. Great focus will be on system analysis using different developed models in different domains such as production, logistics, security, and service, military and social. The course entails up to two exams, multiple case studies, individual and group projects and research papers. Prerequisites: ENMA 420 or equivalent.

ENMA 711. Methodology for Advanced Engineering Projects. 3 Credits.
The course covers general topics that are necessary for project execution. This includes problem scoping, data collection, hypothesis formulation and testing, experimentation, testing and evaluation, qualitative analysis, quantitative analysis, and validation methods.

ENMA 712. Multi-Criteria Decision Analysis and Decision Support Systems. 3 Credits.
Currently, complex engineering-economic-societal decisions are made by involving numerous sometimes conflicting criteria and attributes, different decision rules and in the presence of various stakeholders with individual preferences who are willing to go into negotiation procedures. A number of multi-criteria decisions tools involving quantitative as well as qualitative methods, together with adequate decision support tools will be introduced. Case studies on a variety of engineering, environmental and security related aspects will also be considered.

ENMA 713. Integrating Ethics and Engineering Management. 3 Credits.
This course is designed to expose prospective engineering managers to the theories and practices that are inherent in the ethical environment of modern organizations. Topics include definitions of ethical behavior and leadership, moral decision-making, the importance of values such as honesty, integrity, and trustworthiness. A full exploration of ethical autonomy, collaboration, communication and moral imagination will be conducted. A variety of methods will be used to facilitate learning, including a textbook, regular journaling, movies and videos, case studies, small group activities, experiential activities and writing assignments. The successful student should gain a full understanding of the requirements for and the practice of ethical leadership and should be able to determine how to create and maintain a work environment that fosters openness and clear communication about issues and problems.

ENMA 714. Crisis Project Management. 3 Credits.
Graduate-level research colloquium examining the existing and potential role of project management approaches and analysis procedures in the handling of crisis-related activities. Emphasis will be placed on the management of organizational level processes and activities related to crisis preparation, handling and recovery. Case studies, problems and reports.

ENMA 715. Systems Analysis. 3 Credits.
The course is designed to provide an understanding of the interdisciplinary aspects of systems development, operation, and support. The course focuses on the application of scientific and engineering efforts to transform an operational need into a defined system configuration through the interactive process of design, test, and evaluation.

ENMA 716. Complex Adaptive Situations Environment. 3 Credits.
The course focuses on the manner in which information, knowledge, and awareness are processed to facilitate decision making, management and engineering in complex adaptive situations. Topics include: knowledge acquisition, formation of technical and contextual awareness, and the role of understanding.

ENMA 717. Cost Engineering. 3 Credits.
Introduction to parametric cost modeling techniques and methodologies; generation and application of statistical relationships between life cycle costs and measurable attributes of complex systems; sources of supporting data; quality function deployment; technology forecasting. Special emphasis on life cycle design for cost; cost risk analysis; and design optimization on cost bases. Case studies and a semester project.

ENMA 720. Multivariate Statistics for Engineering. 3 Credits.
Introduction to modeling multivariate structural and residual variation, using exploratory data analysis, nonparametric regression, dependence regression, and factor analytic models, with a goal of producing robust, generalizable multivariate models that support research findings. Statistical analyses will be performed in the free general public licensed R statistical software with references to Minitab and SPSS. Prerequisite: ENMA 420.

ENMA 721. Foundations of Research. 3 Credits.
This course is intended to prepare students to undertake substantiated, rigorous, scholarly research, particularly theses or dissertations. The course will focus on the approaches necessary to integrate research intent, techniques and constraints. A variety of research approaches will be investigated. Emphasis will be placed on problem formulation, literature review, proposal preparation, oral presentation, experimentation and accepted canons of research. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Research paper required. Prerequisites: ENMA 420 or equivalent.

ENMA 723. Enterprise and Complex System Dynamics. 3 Credits.
The use of system dynamics modeling and simulation in various enterprise and complex system application areas. Topics include: complex and hierarchical system dynamics, tools for systems thinking, the dynamics of growth, modeling and simulation tools, and model development, use and analysis.

ENMA 724. Risk Analysis. 3 Credits.
Approaches to the management of risk; probability assessment methods; risk modeling; use of software packages; extensions of decision analysis, including stochastic dominance and multiattribute methods; applications to project management, scheduling, and cost estimation.
ENMA 735. Team Performance and Decision Making in Engineering. 3 Credits.
This course explores and models the use of teams in organizations with a specific focus on the role of teams in decision making and problem solving. Key areas include team building, assessment of team outcomes, team learning, virtual teams and team decision making. Actual work on teams is required including team deliverables.

ENMA 742. Knowledge Management and Information Technology. 3 Credits.
This course focuses on the enabling nature of communication and information technologies in managing knowledge. The course describes the relationship of knowledge management with library science and content management, network security, data mining, and database management. Case studies and/or short-projects are required.

ENMA 743. Reliability and Maintainability. 3 Credits.
An introduction to the theory and practice of reliability engineering, maintainability and availability. Reliability evaluation models and techniques, failure data collection and analysis, reliability testing and modeling, maintained systems, and mechanical system reliability will be discussed, culminating in a semester-length project. Prerequisites: ENMA 420 or equivalent.

ENMA 744. Human Aspects of Knowledge Management. 3 Credits.
This course focuses on the enabling nature of the individual, group, and organization factors in the management of knowledge. Performance metrics, team processes, and work structure are some of the topics covered in this course at the individual, group, and organization levels. The course describes the relationship of knowledge management with organizational behavior, change management, agile project management. Case studies and/or short-projects are required.

ENMA 750. System of Systems Engineering. 3 Credits.
Comprehensive treatment of System of Systems Engineering (SoSE), including: fundamental systems principles, concepts, and governing laws; complex and simple systems; underlying paradigms, methodologies and essential methods for SoSE analysis, design, and transformation; complex system transformation; current state of SoSE research and application challenges. Explores the range of technological, human/social, organizational/managerial, policy, and political dimensions of the SoSE problem domain.

ENMA 751. Complexity, Engineering and Management. 3 Credits.
This course examines management and engineering of complex systems as it is undertaken in complex situations. The student will develop an understanding of the unconditional attributes of complex systems and situations that become foundational in the development of robust methods to deal with the practical reality of working in dynamic, uncertain environments. Topics will include Complexity, Complex Systems, Complex Adaptive Systems, Complex Responsive Processes, Complex Adaptive Situations Methodology, SOSE, Reciprocity, and Sociotechnical Systems.

ENMA 752. Agent-Directed Simulation and Systems Engineering. 3 Credits.
The student will learn about methods and tools for agent-directed simulation in support of systems engineering as well as applications of systems engineering for the development of complex agent-directed simulation applications. Students should have knowledge of principles of systems engineering, modeling and simulation, and a higher programming language prior to registering.

ENMA 755. Human System Engineering. 3 Credits.
This course introduces concepts of Human System Engineering, focusing on designing systems that include human components. Human System Integration and Human Factors Engineering are discussed, as well as other human centered design approaches. The role of human data in systems and systems of systems design is explored, and methods to capture and represent human data, including architecture frameworks, are presented. Modeling and analysis of human centered systems is done through hands-on projects.

ENMA 760. Advanced Architectures and Tools. 3 Credits.
This course is designed to expand on system architectures concepts through both theory and practice. Topics include the role of architectures in system engineering, alternative methods for architecture development, tools and techniques for architecture design, and various conceptual and technical issues in the architecture development process. Class periods are equally divided between traditional lectures and practice oriented exercises.

ENMA 763. Robust Engineering Design. 3 Credits.
A robust design approach based on “Taguchi Methods,” including off-line quality engineering and applied design-of-experiments methods, full factorial and fractional factorial designs, and response surface methods. The course is designed to enable engineers and engineering managers from all disciplines to recognize potential applications, formulate problems, plan experiments, and analyze data. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Students will engage in case studies, culminating in a semester-long project. Prerequisites: ENMA 420 or equivalent.

ENMA 771. Risk and Vulnerability Management of Complex Interdependent Systems. 3 Credits.
Seminar discussions and team projects. A systematic approach to basic principles of design, economics and management of critical infrastructure systems, including issues of risk, vulnerability and risk governance. Development of advanced methodologies, e.g. system of systems, by use of complexity analysis, dynamic/chaotic behavior, threat analysis, resilient design and management under normal and stress conditions. Adopting an agent based modeling approach under conditions of uncertainty, dysfunctionality, malicious attacks and/or presence of natural perils.

ENMA 776. Engineering Principles of Combat Modeling and Distributed Simulation. 3 Credits.
This course introduces students to the engineering principles of model movement, effects, sensors, and command and control of military operations. An overview of standards for distributed simulation enabling global federations is provided as well as challenges of interoperability, composability, and integratability in C2 systems. Technical solutions are addressed. Prerequisites: ENMA 710, MSIM 601, or equivalent.

ENMA 780. Leadership for Engineering Managers. 3 Credits.
Seminar discussions and team projects. This course is designed to expose students to the concepts, skills, characteristics and emotional composition of effective and successful leaders in the 21st century. The course is intensive and requires students to immerse themselves in the course material and classroom discussion to derive meaning and value from the topics. The course objectives will be achieved by classroom discussion of the assigned material, candid self-assessment, experimental exercises and analysis of the actions of leaders, as described in case studies and literature. Areas of exploration include the fundamentals of leadership, ethical leadership, social capital, emotional intelligence and three-dimensional leadership. Prerequisites: ENMA 601 or Ph.D. status.

ENMA 795. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 796. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 797. Independent Study in Engineering Management. 1-3 Credits.
Designed for advanced individualized study into an engineering management topic area. Independent study projects will be related to engineering management and completed under the supervision of a certified faculty member. Prerequisites: Permission of the instructor and Graduate Program Director.
ENMA 800. Economic Analysis of Capital Projects. 3 Credits.
It is targeted at engineering managers who actively participate in the
capital budgeting process and project justification. Topics include capital
budgeting techniques (including multi-attribute decision making), utility
theory, justification of new technologies, and current research in engineering
economics. Reading and application of current research in the field is
stressed. Case studies are used. Oral presentations and term project required.
Prerequisites: ENMA 600.

ENMA 802. Systemic Decision Making. 3 Credits.
As machine age problems have given way to systems age messes, the
underlying complexity associated with understanding these situations has
increased exponentially. Accordingly, the methods we use to address these
situations must evolve as well. This course will introduce students to a
method for thinking holistically about problems and messes conceptually
founded in systems theory. This paradigm, known as systemic thinking, will
be contrasted with traditional systematic thinking, and practical guidelines
for the deployment of a systemic thinking approach will be provided. This
paradigm will increase the student’s ability to make rational decisions in
complex environments.

ENMA 803. Optimization Methods. 3 Credits.
Covers advanced methods in Operations Research and Optimization. Focus
will be on developing models and their applications in different domains
including manufacturing and service. Modern optimization tools will be
used to implement models for case studies, projects and research papers. The
knowledge of programming and spreadsheets is expected. Contact instructor
for more details.

ENMA 804. Design of Project Knowledge Systems. 3 Credits.
Graduate level research colloquium examining the application of a systems
perspective to design, operation, analysis, and evaluation of project
knowledge systems. Special emphasis will be placed on knowledge
generation and generalization systems. Case studies, problems, and a course
project.

ENMA 805. Financial Engineering. 3 Credits.
This course covers concepts in complex investments, how to deal with
uncertainty in today’s global markets, and how to engineer and manage
financial decisions. The main topics include: cash flows, portfolio theory,
capital management, securities, hedge funds, optimal investment and
financial engineering evaluations among others.

ENMA 810. Modeling and Analysis of Systems. 3 Credits.
Covers modern modeling paradigms for deterministic and stochastic
complex and dynamic systems. This includes, but not limited to, Discrete
Simulation, Queuing Systems, and Agent-based models among others.
Great focus will be on system analysis using different developed models
in different domains such as production, logistics, security, and service,
military and social. The course entails up to two exams, multiple case
studies, individual and group projects and research papers. Prerequisites:
ENMA 420 or equivalent.

ENMA 811. Methodology for Advanced Engineering Projects. 3 Credits.
The course covers general topics that are necessary for project execution.
This includes problem scoping, data collection, hypothesis formulation
and testing, experimentation, testing and evaluation, qualitative analysis,
quantitative analysis, and validation methods.

ENMA 812. Multi-Criteria Decision Analysis and Decision Support
Systems. 3 Credits.
Currently, complex engineering-economic-societal decisions are made by
involving numerous sometimes conflicting criteria and attributes, different
decision rules and in the presence of various stakeholders with individual
preferences who are willing to go into negotiation procedures. A number of
multi-criteria decisions tools involving quantitative as well as qualitative
methods, together with adequate decision support tools will be introduced.
Case studies on a variety of engineering, environmental and security related
aspects will also be considered.

ENMA 813. Integrating Ethics and Engineering Management. 3 Credits.
This course is designed to expose prospective engineering managers to the
theories and practices that are inherent in the ethical environment of modern
organizations. Topics include definitions of ethical behavior and leadership,
moral decision-making, the importance of values such as honesty, integrity,
and trustworthiness. A full exploration of ethical autonomy, collaboration,
communication and moral imagination will be conducted. A variety of
methods will be used to facilitate learning, including a textbook, regular
journaling, movies and videos, case studies, small work group activities,
experiential activities and writing assignments. The successful student
should gain a full understanding of the requirements for and the practice
of ethical leadership and should be able to determine how to create and
maintain a work environment that fosters openness and clear communication
about issues and problems.

ENMA 814. Crisis Project Management. 3 Credits.
Graduate-level research colloquium examining the existing and potential
role of project management approaches and analysis procedures in the
handling of crisis-related activities. Emphasis will be placed on the
management of organizational level processes and activities related to crisis
preparation, handling and recovery. Case studies, problems and reports.

ENMA 815. Systems Analysis. 3 Credits.
The course is designed to provide an understanding of the interdisciplinary
aspects of systems development, operation, and support. The course focuses
on the application of scientific and engineering efforts to transform an
operational need into a defined system configuration through the interactive
process of design, test, and evaluation.

ENMA 816. Complex Adaptive Situations Environment. 3 Credits.
The course focuses on the manner in which information, knowledge, and
awareness are processed to facilitate decision making, management and
engineering in complex adaptive situations. Topics include: knowledge
acquisition, formation of technical and contextual awareness, and the role of
understanding.

ENMA 817. Cost Engineering. 3 Credits.
Introduction to parametric cost modeling techniques and methodologies;
generation and application of statistical relationships between life cycle costs
and measurable attributes of complex systems; sources of supporting data;
quality function deployment; technology forecasting. Special emphasis on
life cycle design for cost; cost risk analysis; and design optimization on cost
bases. Case studies and a semester project.

ENMA 820. Multivariate Statistics for Engineering. 3 Credits.
Introduction to modeling multivariate structural and residual variation, using
exploratory data analysis, nonparametric regression, dependence regression,
and factor analytic models, with a goal of producing robust, generalizable
multivariate models that support research findings. Statistical analyses will
be performed in the free general public licensed R statistical software with
references to Minitab and SPSS. Prerequisite: ENMA 420.

ENMA 821. Foundations of Research. 3 Credits.
This course is intended to prepare students to undertake substantiated,
rigorous, scholarly research, particularly theses or dissertations. The course
will focus on the approaches necessary to integrate research intent,
techniques and constraints. A variety of research approaches will be
investigated. Emphasis will be placed on research formulation, literature
review, proposal preparation, oral presentation, experimentation and
accepted canons of research. Research paper required. Prerequisites:
ENMA 420 or equivalent.

ENMA 823. Enterprise and Complex System Dynamics. 3 Credits.
The use of system dynamics modeling and simulation in various enterprise
and complex system application areas. Topics include: complex and
hierarchical system dynamics, tools for systems thinking, the dynamics of
growth, modeling and simulation tools, and model development, use and
analysis.

ENMA 824. Risk Analysis. 3 Credits.
Approaches to the management of risk; probability assessment methods;
risk modeling; use of software packages; extensions of decision analysis,
including stochastic dominance and multiattribute methods; applications to
project management, scheduling, and cost estimation.
ENMA 835. Team Performance and Decision Making in Engineering. 3 Credits.
This course explores and models the use of teams in organizations with a specific focus on the role of teams in decision making and problem solving. Key areas include team building, assessment of team outcomes, team learning, virtual teams and team decision making. Actual work on teams is required including team deliverables.

ENMA 843. Reliability and Maintainability. 3 Credits.
An introduction to the theory and practice of reliability engineering, maintainability and availability. Reliability evaluation models and techniques, failure data collection and analysis, reliability testing and modeling, maintained systems, and mechanical system reliability will be discussed, culminating in a semester-length project. Prerequisites: ENMA 420 or equivalent.

ENMA 850. System of Systems Engineering. 3 Credits.
Comprehensive treatment of System of Systems Engineering (SoSE), including: fundamental systems principles, concepts, and governing laws; complex and simple systems; underlying paradigms, methodologies and essential methods for SoSE analysis, design, and transformation; complex system transformation; current state of SoSE research and application challenges. Explores the range of technological, human/social, organizational/managerial, policy, and political dimensions of the SoSE problem domain.

ENMA 851. Complexity, Engineering and Management. 3 Credits.
This course examines management and engineering of complex systems as it is undertaken in complex situations. The student will develop an understanding of the unconditional attributes of complex systems and situations that become foundational in the development of robust methods to deal with the practical reality of working in dynamic, uncertain environments. Topics will include Complexity, Complex Systems, Complex Adaptive Systems, Complex Responsive Processes, Complex Adaptive Situations Methodology, SOSE, Reciprocity, and Sociotechnical Systems.

ENMA 852. Agent-Directed Simulation and Systems Engineering. 3 Credits.
The student will learn about methods and tools for agent-directed simulation in support of systems engineering as well as applications of systems engineering for the development of complex agent-directed simulation applications. Students should have knowledge of principles of systems engineering, modeling and simulation, and a higher programming language prior to registering.

ENMA 855. Human System Engineering. 3 Credits.
This course introduces concepts of Human System Engineering, focusing on designing systems that include human components. Human System Integration and Human Factors Engineering are discussed, as well as other human centered design approaches. The role of human data in systems and systems of systems design is explored, and methods to capture and represent human data, including architecture frameworks, are presented. Modeling and analysis of human centered systems is done through hands-on projects.

ENMA 860. Advanced Architectures and Tools. 3 Credits.
This course is designed to expand on system architectures concepts through both theory and practice. Topics include the role of architectures in system engineering, alternative methods for architecture development, tools and techniques for architecture design, and various conceptual and technical issues in the architecture development process. Class periods are equally divided between traditional lectures and practice oriented exercises.

ENMA 863. Robust Engineering Design. 3 Credits.
A robust design approach based on “Taguchi Methods,” including off-line quality engineering and applied design-of-experiments methods, full factorial and fractional factorial designs, and response surface methods. The course is designed to enable engineers and engineering managers from all disciplines to recognize potential applications, formulate problems, plan experiments, and analyze data. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Students will engage in case studies, culminating in a semester-long project. Prerequisites: ENMA 420 or equivalent.

ENMA 871. Risk and Vulnerability Management of Complex Interdependent Systems. 3 Credits.
Seminar discussions and team projects. A systematic approach to basic principles of design, economics and management of critical infrastructure systems, including issues of risk, vulnerability and risk governance. Development of advanced methodologies, e.g. system of systems, by use of complexity analysis, dynamic/chaotic behavior, threat analysis, resilient design and management under normal and stress conditions. Adopting an agent based modeling approach under conditions of uncertainty, dysfunctionality, malicious attacks and/or presence of natural perils. Prerequisites: Permission of the instructor.

ENMA 876. Engineering Principles of Combat Modeling and Distributed Simulation. 3 Credits.
This course introduces students to the engineering principles of model movement, effects, sensors, and command and control of military operations. An overview of standards for distributed simulation enabling global federations is provided as well as challenges of interoperability, composability, and integrability in C2 systems. Technical solutions are addressed. Prerequisites: ENMA 710, MSIM 601, or equivalent.

ENMA 880. Leadership for Engineering Managers. 3 Credits.
Seminar discussions and team projects. This course is designed to expose students to the concepts, skills, characteristics and emotional composition of effective and successful leaders in the 21st century. The course is intensive and requires students to immerse themselves in the course material and classroom discussion to derive meaning and value from the topics. The course objectives will be achieved by classroom discussion of the assigned material, candid self-assessment, experimental exercises and analysis of the actions of leaders, as described in case studies and literature. Areas of exploration include the fundamentals of leadership, ethical leadership, social capital, emotional intelligence and three-dimensional leadership. Prerequisites: ENMA 601 or Ph.D. standing.

ENMA 888. Ph.D. Seminar. 1 Credit.
Discussion of research projects, topics, and problems of Engineering Management faculty, researchers, and students. A weekly exchange of ideas and issues between faculty and Ph.D. students focused on doctoral research.

ENMA 892. Doctor of Engineering Project. 1-12 Credits.
Directed individual study applying advanced-level technical knowledge to identify, formulate, and solve a complex, novel problem in Engineering Management.

ENMA 895. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 896. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 897. Independent Study in Engineering Management. 1-3 Credits.
Designed for advanced individualized study into an engineering management topic area. Independent study projects will be related to engineering management and completed under the supervision of a certified faculty member. Prerequisites: Permission of the instructor and Graduate Program Director.

ENMA 898. Research in Engineering Management. 1-12 Credits.
Supervised research prior to passing Ph.D. candidacy exam. Prerequisites: ENMA 721/ENMA 821 and permission of Graduate Program Director.

ENMA 899. Doctoral Research. 1-12 Credits.
Doctoral research hours. After successfully passing the candidacy examination, all doctoral students are required to be registered for at least one graduate credit each term until the degree is complete. Prerequisites: ENMA 821 and permission of instructor.

ENMA 998. Master's Graduate Credit. 1 Credit.
This course is a pass/fail course for master's students in their final semester. It may be taken to fulfill the registration requirement necessary for graduation. All master's students are required to be registered for at least one graduate credit hour in the semester of their graduation.
ENMA 999. Doctoral Graduate Credit. 1 Credit.
This course is a pass/fail course doctoral students may take to maintain
active status after successfully passing the candidacy examination. All
doctoral students are required to be registered for at least one graduate credit
hour every semester until their graduation.