Department of Modeling, Simulation and Visualization Engineering

1300 Engineering and Computational Sciences Building
757-683-3720

Frederic (Rick) D. McKenzie, Chair
Yuzhong Shen, Graduate Program Director

Department Description:
The MSVE Department offers an undergraduate four-year degree program leading to the Bachelor of Science in Modeling and Simulation Engineering (BS-M&SE). The department also offers programs of graduate study leading to the degrees Master of Engineering, Master of Science, Doctor of Engineering, and Doctor of Philosophy with a major in Modeling and Simulation. The department's academic programs are coupled with a strong department research program conducted jointly with researchers from the Virginia Modeling, Analysis and Simulation Center (VMASC). Research activities range from investigation of fundamental modeling and simulation methods and technologies to applications of modeling and simulation in the domains of medicine and health care, transportation, education and gaming, science and engineering, homeland security and defense, and business enterprise decision support.

Special Facilities:
The MSVE Department is located on the first floor of the E. V. Williams Engineering and Computational Sciences Building on the Old Dominion University Norfolk Campus. In addition to the department and faculty offices, this facility also houses several instructional and research laboratories, a virtual reality theater, and a four-walled C.A.V.E. (Cave Automatic Virtual Environment).

Undergraduate Projects and Research Laboratory
The Undergraduate Projects and Research Laboratory, is mainly used for facilitating modeling and simulation projects-based instruction in both lower and upper division undergraduate levels. This also involves courses in the major with a significant laboratory component. The Laboratory can accommodate 24 students with laptop computers and provide 5 workstations for undergraduate labs and research. Each workstation contains a high performance computer and collaboration spaces. The lab also contains a Polycom Teleconference system to support distance learning. The lab is equipped with 3 digital projectors to support teaching.

Medical Simulations Laboratory
The Medical Simulations Laboratory is mainly used to support teaching and research activities related to medical simulations for planning, training, education, analysis and visualization. It contains 15 high performance PC workstations, 4 haptic devices, three 3D scanners, two 3D printers, 4 reach-in displays, 3 LCD TVs, 3 game consoles from Microsoft, Sony and Nintendo. The laboratory is also equipped with a large selection of software such as Autodesk Maya, Google SketchUp, Microsoft XNA Game Studio, Unity Game Engine, and ArcGIS.

Applied M&S Research Laboratory
The Applied M&S Research Laboratory is the third laboratory area. This graduate research laboratory contains PC workstations and spaces for 10 graduate students and also supports faculty/VMASC collaborative research activities. Several research topics are conducted in this laboratory including high performance computing, cyber security, simulation architectures, transportation systems, military M&S, digital manufacturing, and enterprise decision support. Visualization of these is also a significant part of these areas.

Collaborative Autonomous Systems Laboratory
The Collaborative Autonomous Systems Laboratory supports instructional and multidisciplinary research activities related to autonomous systems. This forth laboratory area is shared with the mechanical and aerospace department. MSVE maintains 4 PC workstations and 10 various types of robotic systems. The lab contains an area dedicated to cyber security research as related to collaborative autonomous systems.

The CAVE (CAVE Automated Virtual Environment)
The CAVE (Cave Automated Virtual Environment) Virtual Reality laboratory area contains several 3D visualization systems. The CAVE is a high-resolution projection-screen virtual reality system. The screens are arranged in a 10 foot cube with computer-generated images projected on three walls and a floor. The CAVE lab also contains a 3 meter Vision Dome projection system and an Immersa-Desk virtual reality display. Two 3D printers are also placed in the CAVE Lab.

Advanced Engineering Environments Laboratory
The Advanced Engineering Environments (AEE) laboratory serves as a focal point for the diverse research activities pertaining to Collaborative distributed Engineering Knowledge discovery and exploitation, intelligent synthesis, and advanced learning technologies, and their application to complex engineering systems. These activities include the synergistic coupling of modeling, visual simulations, intelligent agents, multimedia and synthetic environments, human-computer interactions, computational intelligence, computational, information and collaboration technologies in the multidisciplinary analysis, sensitivity studies, optimization, design and operation of complex engineering systems. The laboratory is located at the Old Dominion University Peninsula Higher Education Center in Hampton, Virginia and contains networked advanced 3D display and projection equipment (for collaborative distributed visualization research), virtual holography tablets, and 12 computing workstations and a variety of 3D display and projection equipment. The facility is supported by BCET in equipment and maintenance.

Associated Centers:
A significant resource to the department is the Virginia Modeling, Analysis and Simulation Center located adjacent to the University's Tri-Cities Higher Education Center in Suffolk, Virginia. VMASC occupies a two-story 60,000 square foot building designed to support state-of-the-art research in modeling, simulation and visualization. Some of the center's facilities are used in the department's educational programs; in addition, VMASC researchers teach courses and mentor students in the department's academic programs.

List of Degrees and Certificates
- Master of Engineering - Modeling and Simulation
- Master of Science, Engineering - Modeling and Simulation
- Doctor of Engineering - Modeling and Simulation
- Doctor of Philosophy, Engineering - Modeling and Simulation
- Graduate Certificate in Modeling and Simulation Engineering
- Advanced Engineering Certificate in Cyber Systems Security

Master of Engineering - Modeling and Simulation
The master's degree in modeling and simulation (M&S) emphasizes a strong, common subject core while providing the student with the flexibility to design a plan of study to meet each individual's study objectives and needs. The purpose of the program's subject core is to provide a common academic foundation for all simulation students. Thus, all students in this program will have grounding in the same methods, principles, and philosophy of simulation. This provides the mechanisms for the simulationist to work across disciplines and domains while maintaining a common frame of reference for communication, technical specialization, and advanced study and research. The Master of Engineering (ME) in Modeling and Simulation requires 30 hours of course credit. The ME program is focused on developing the practical skills and knowledge needed to solve problems requiring applications of modeling and simulation.

Old Dominion University
The program's subject core consists of:

1. an overview of modeling and simulation;
2. an in-depth exploration of specific simulation methodological approaches;
3. simulation system modeling principles and techniques;
4. an introduction to computer visualization and visual simulation; and,
5. principles of stochastic analysis.

Most courses are offered in distance learning format. They are delivered to Old Dominion University's higher education centers and are available synchronously using video teleconferencing software. Additionally, the MSVE department is offering a Master of Engineering Online program.

**Master of Engineering Admission Requirements**

The Master’s Degree in Modeling and Simulation is designed for students having bachelor’s degrees in Engineering, Science or Mathematics, although students from other educational backgrounds may apply with appropriate leveling courses. Prerequisites for admission include: mathematics – two courses in differential and integral calculus and one course in calculus-based probability and statistics; and computer science – algorithmic problem solving using a high-level object-oriented programming language such as C++.

A minimum GPA of 2.80 overall and a minimum GPA of 3.0 in the undergraduate major are required. Students with notable deficiencies may be considered for provisional admission and will be required to complete prerequisite course requirements in addition to the graduate degree requirements. Job experience and training may be considered in evaluating prerequisite requirements.

Applicants should plan to submit a completed application form, transcripts from all colleges and universities attended, GRE scores (verbal, quantitative, and analytical writing - optional for ME applicants with an undergraduate GPA of 2.80 or higher), a resume and personal statement of objectives, two letters of recommendation from former university instructors, and TOEFL scores if an international applicant.

Potential prerequisite courses for the master’s degrees in modeling and simulation include the following:

1. Introductory differential and integral calculus equivalent to MATH 211 (Calculus I) and MATH 212 (Calculus II).
2. Calculus-based probability and statistics; this material is available for graduate credit in ENMA 520, PSYC 727, or PSYC 728.
3. Computer science fundamentals including an object-oriented programming language such as C++, algorithmic problem solving, and data structures.

**Master of Engineering Degree Requirements**

The Master of Engineering program requires completion of 10 three-credit courses; four core courses and six elective courses are required to complete the degree program.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSIM 741</td>
<td>Principles of Visualization</td>
<td>3</td>
</tr>
<tr>
<td>MSIM 551</td>
<td>Analysis for Modeling and Simulation</td>
<td>3</td>
</tr>
<tr>
<td>MSIM 751</td>
<td>Advanced Analysis for Modeling and Simulation</td>
<td>3</td>
</tr>
</tbody>
</table>

Advanced Modeling Course (see list below) 3

Advanced Simulation Course (see list below) 3

Advanced Modeling Course Examples (3 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSIM 607</td>
<td>Machine Learning I</td>
</tr>
<tr>
<td>MSIM 660</td>
<td>System Architecture and Modeling</td>
</tr>
<tr>
<td>MSIM 702</td>
<td>Methods of Rational Decision Making</td>
</tr>
<tr>
<td>MSIM 730</td>
<td>Simulation Formalisms</td>
</tr>
<tr>
<td>MSIM 772</td>
<td>Modeling Global Events</td>
</tr>
<tr>
<td>MSIM 774</td>
<td>Transportation Network Flow Models</td>
</tr>
</tbody>
</table>

Other courses with graduate program director's approval.

Students must take six electives, 3 credit hours each, in addition to the core courses. Several electives are available covering topics such as system dynamics, social networks, graduate level statistics, and combat modeling. Other courses must be approved by the graduate program director.

Certain students will need to take pre-requisite leveling courses that will count towards the six elective course requirement. These courses are: MSIM 510 Model Engineering; MSIM 541 Computer Graphics and Visualization; MSIM 602 Simulation Fundamentals; and, MSIM 603 Simulation Design.

For graduation, students must complete a comprehensive examination and the Responsible Conduct of Research Training for Engineers training online.

**Master of Engineering Online Program**

The MSVE department also offers an ME online degree in Modeling and Simulation via the Blackboard Academic Suite and WebEx that provides online lectures, homework submissions, examinations, discussion boards, wikis, video/audio collaboration sessions and grading. Students having access to reliable high speed internet service can connect and participate in engaging discussion and distributed asynchronous learning with the instructor and other students. All course materials are distributed and collected electronically. Students located in the Hampton Roads region may utilize live courses to fulfill the elective course requirement with approval from the MSVE graduate program director.

**Master of Science, Engineering - Modeling and Simulation**

The master's degree in modeling and simulation (M&S) emphasizes a strong, common subject core while providing the student with the flexibility to design a plan of study to meet each individual's study objectives and needs. The purpose of the program's subject core is to provide a common academic foundation for all simulation students. Thus, all students in this program will have grounding in the same methods, principles, and philosophy of simulation. This provides the mechanisms for the simulationist to work across disciplines and domains while maintaining a common frame of reference for communication, technical specialization, and advanced study and research. The Master of Science (MS) in Modeling and Simulation requires six hours of thesis credit and 24 hours of course credit. The MS program is directed primarily at full-time students who are preparing for a career in advanced M&S research and/or academic positions.

The program's subject core consists of:

1. an overview of modeling and simulation;
2. an in-depth exploration of specific simulation methodological approaches;
3. simulation system modeling principles and techniques;
4. an introduction to computer visualization and visual simulation; and,
5. principles of stochastic analysis.

Most courses are offered in distance learning format. They are delivered to Old Dominion University's higher education centers and are available synchronously using video teleconferencing software.

**Master of Science Admission Requirements**

The Master’s Degree in Modeling and Simulation is designed for students having bachelor’s degrees in Engineering, Science or Mathematics, although students from other educational backgrounds may apply with appropriate leveling courses. Prerequisites for admission include: mathematics – two
courses in differential and integral calculus and one course in calculus-based probability and statistics; and computer science – algorithmic problem solving using a high-level object-oriented programming language such as C++.

A minimum GPA of 2.80 overall and a minimum GPA of 3.0 in the undergraduate major are required. Students with notable deficiencies may be considered for provisional admission and will be required to complete prerequisite course requirements in addition to the graduate degree requirements. Job experience and training may be considered in evaluating prerequisite requirements.

Applicants should plan to submit a completed application form, transcripts from all colleges and universities attended, GRE scores (verbal, quantitative, and analytical writing - required of all MS applicants), a resume and personal statement of objectives, two letters of recommendation from former university instructors, and TOEFL scores if an international applicant.

Potential prerequisite courses for the master’s degrees in modeling and simulation include the following:

1. Introductory differential and integral calculus equivalent to MATH 211 (Calculus I) and MATH 212 (Calculus II).
2. Calculus-based probability and statistics; this material is available for graduate credit in ENMA 520, PSYC 727, or PSYC 728.
3. Computer science fundamentals including an object-oriented programming language such as C++, algorithmic problem solving, and data structures.

Master of Science Degree Requirements

The Master of Science program requires 12 hours of course credit in modeling and simulation foundation courses. These foundation courses include:

- MSIM 741 Principles of Visualization 3
- MSIM 551 Analysis for Modeling and Simulation 3
- or MSIM 751 Advanced Analysis for Modeling and Simulation
- Advanced Modeling Course (see list below) 3
- Advanced Simulation Course (see list below) 3

Advanced Modeling Course Examples (3 credits)

- MSIM 607 Machine Learning I
- MSIM 660 System Architecture and Modeling
- MSIM 702 Methods of Rational Decision Making
- MSIM 730 Simulation Formalisms
- MSIM 772 Modeling Global Events
- MSIM 774 Transportation Network Flow Models

Other courses with graduate program director's approval.

Advanced Simulation Course Examples (3 credits)

- MSIM 711 Finite Element Analysis
- MSIM 722 Cluster Parallel Computing
- MSIM 725 Principles of Combat Modeling and Simulation
- MSIM 742 Synthetic Environments
- MSIM 776 Simulation Modeling in Transportation Networks

Other courses with graduate program director's approval.

The remaining course credits (12 credits) are elective course credits. These courses are selected to achieve one or more program objectives or themes and must be approved by the student’s advisor and/or graduate program director. Elective courses outside the MSVE Department must be approved by the graduate program director. The program concludes with 6 credit hours of thesis credit (MSIM 699) and a thesis defense.

Certain students will need to take pre-requisite leveling courses that will count towards the 12 credit hour elective course requirement. These courses are: MSIM 510 Model Engineering; MSIM 541 Computer Graphics and Visualization; MSIM 602 Simulation Fundamentals; and, MSIM 603 Simulation Design.

For graduation, students must successfully defend their thesis and complete the Responsible Conduct of Research for Engineers training online.

Doctor of Engineering - Modeling and Simulation

The D. Eng. in Modeling and Simulation program focuses on developing the advanced skills and knowledge to enable the graduate to conduct and lead advanced technical M&S projects in an engineering environment. It affords engineering practitioners the opportunity to achieve advanced graduate education beyond the master’s degree.

For complete information on admission requirements and core degree requirements, please refer to the Doctor of Engineering program information at: /graduate/frankbattencollegeofengineeringandtechnology/#doctorofengineeringprogram (http://catalog.odu.edu/graduate/frankbattencollegeofengineeringandtechnology/#doctorofengineeringprogram)

The program of study for the D.Eng. in M&S program is developed with the approval of the graduate program director and the student’s advisor. The program shall include a minimum of 18 credits of professional course work and 18 credits of technical core course work beyond the master’s degree distributed as follows:

Technical Core Courses 18

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSIM 830</td>
<td>Simulation Formalisms</td>
</tr>
<tr>
<td>MSIM 842</td>
<td>Synthetic Environments</td>
</tr>
<tr>
<td>MSIM 851</td>
<td>Advanced Analysis for Modeling and Simulation</td>
</tr>
</tbody>
</table>

Two approved technical elective courses - 6 credits

Advanced Simulation Course Examples (3 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSIM 811</td>
<td>Finite Element Analysis</td>
</tr>
<tr>
<td>MSIM 822</td>
<td>Cluster Parallel Computing</td>
</tr>
<tr>
<td>MSIM 825</td>
<td>Principles of Combat Modeling and Simulation</td>
</tr>
<tr>
<td>MSIM 876</td>
<td>Simulation Modeling in Transportation Networks</td>
</tr>
</tbody>
</table>

Other courses with graduate program director's approval.

No more than three credits from course work satisfying foundation knowledge requirements may be included in the program of study for technical elective credit. At least three-fifths of the non-project coursework must be at the 800-level.

Certain students entering the program will be required to complete additional pre-requisite leveling courses. These courses are: MSIM 510 Model Engineering; MSIM 541 Computer Graphics and Visualization; MSIM 602 Simulation Fundamentals; and, MSIM 603 Simulation Design.

For graduation, students must complete the requirements for their final project and the Responsible Conduct of Research for Engineers training online.

Doctor of Philosophy, Engineering - Modeling and Simulation

The Ph.D. in Modeling and Simulation program focuses on developing the necessary skills and knowledge to enable the graduate to conduct and evaluate independent, original research in an area of modeling and simulation. The goal of the program is to prepare students for careers in teaching and research at academic institutions, as well as the conduct or leadership of research and development in public and private organizations.
Doctor of Philosophy Admission Requirements

Admission to the Ph.D. in M&S program is made in accordance with Old Dominion University and Batten College of Engineering and Technology requirements for doctoral programs as specified in this Catalog. Specific requirements for the modeling and simulation degree include the following:

1. Completion of a master’s degree in an appropriate and closely related field is expected. However, students who have completed 24 credits of graduate courses in an appropriate field from an accredited institution may apply.
2. A minimum GPA in graduate course work of 3.50 (out of 4.0) is required of most students. A student with a GPA greater than 3.25 and with evidence of a high level of professional capability in the field of modeling and simulation may be eligible for admission to the program upon submission of a petition to the graduate program director.
3. Recent scores (typically, not more than five years old) on the Graduate Record Examination’s (GRE) verbal, quantitative, and analytical writing sections must be submitted by all applicants.
4. Three letters of recommendation (typically at least two of which are from faculty in the highest degree program completed when the application is within five years of graduation from that degree program) are required.
5. The applicant must submit a statement of purpose, goals, and objectives related to the program and a resume.

Applicants are expected to have the following foundation knowledge:

2. Computer science fundamentals including an object-oriented programming language such as C++, algorithmic problem solving, and data structures.
3. Knowledge of the content of the foundation courses required in the Modeling and Simulation Master’s Program.

Doctor of Philosophy Degree Requirements

The Ph.D. in modeling and simulation is offered in accordance with the general requirements for doctoral degrees as specified in the Requirements for Graduate Degrees Section of this Catalog. Specific program of study requirements for the concentration in modeling and simulation include the following:

1. Completion of a minimum of 24 credits of course work beyond the master’s degree; and a minimum of 24 credits of dissertation course work.
2. Successful completion of a written diagnostic examination before completion of nine credits of advanced course work.
3. Successful completion of a written and oral qualifying (candidacy) examination near the completion of the course work.
4. Successful presentation of a dissertation research proposal at the beginning of the dissertation research.
5. The successful completion and public defense of a dissertation representing independent, original research worthy of publication in a peer-reviewed scholarly journal.

The program of study for the Ph.D. in M&S program is developed with the approval of the graduate program director and the student’s advisor. The program shall include a minimum of 24 credit hours of course work beyond the master’s degree distributed as follows:

Common Core

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSIM 830</td>
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<td>Synthetic Environments</td>
<td>3</td>
</tr>
<tr>
<td>MSIM 851</td>
<td>Advanced Analysis for Modeling and Simulation</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

Electives - Minimum of 12 credits of elective courses that provide a basis for dissertation research. No more than six credits from course work satisfying foundation knowledge requirements may be included in the program of study for elective credit. At least three-fifths (15 credits) of non-dissertation course work must be at the 800-level. Elective courses outside the MSVE Department must be approved by the graduate program director.

Certain students entering the program will be required to complete additional pre-requisite leveling courses. These courses are: MSIM 510 Model Engineering; MSIM 541 Computer Graphics and Visualization; MSIM 602 Simulation Fundamentals; and, MSIM 603 Simulation Design.

For graduation, students must successfully defend their dissertation and complete the Responsible Conduct of Research for Engineers training online.

Graduate Certificate in Modeling and Simulation Engineering

The Graduate Certificate in Modeling and Simulation Engineering is designed for those who meet the admission requirements of the modeling and simulation master's program and wish to broaden their knowledge of modeling and simulation related principles and practices without pursuing a graduate degree. This is a 12 credit hour non-degree program offered by the Department of Modeling Simulation and Visualization Engineering. The certificate program is open to both degree-seeking and non-degree-seeking graduate students. Certain courses taken for the certificate program may later be applied to the master’s degree in modeling and simulation. For complete information on the admission and certificate requirements, please refer to the Batten College of Engineering and Technology's section on graduate certificate programs at: /graduate/frankbattencollegeofengineeringandtechnology/#interdisciplinarygraduatecertificateprograms (http://catalog.odu.edu/graduate/frankbattencollegeofengineeringandtechnology/ #interdisciplinarygraduatecertificateprograms)

For graduation, students must successfully defend their dissertation and complete the Responsible Conduct of Research for Engineers training online.

Advanced Engineering Certificate in Cyber Systems Security

The certificate program aims to provide a thorough understanding of cyber security threats faced by the stand-alone computer systems, networked systems, IT infrastructure, and cyber physical systems having embedded computer systems operated by individuals, small businesses and large enterprises along with the knowledge required to defend against these threats. The course will enable participants to learn state of the art techniques necessary for analyzing cyber security risks, preventing, detecting and recovering from cyber attacks through class room instructions and hands-on lab work. The program uniquely accommodates students from engineering, math and sciences as well as practicing engineers and managers. The course will make use of the ODU's multidisciplinary strengths in the fields of Cyber Systems, Computer Engineering, Software Engineering and Modeling and Simulation. This program is designed both as a complement for students working on graduate degrees and for those personnel working on information and cyber systems used in industry, small businesses, healthcare, government, military and home land security. It is anticipated that students will complete the program in 2 semesters (full time enrollment) or 2 years (part-time enrollment or working to complement an existing graduate program). For complete information on the admission and certificate requirements, please refer to the Batten College of Engineering and Technology’s section on graduate certificate programs at: /graduate/frankbattencollegeofengineeringandtechnology/
#interdisciplinarygraduatecertificateprograms (http://catalog.odu.edu/graduate/frankbattencollegeofengineeringandtechnology/
#interdisciplinarygraduatecertificateprograms)