Department of
Modeling, Simulation & Visualization Engineering (MSVE)

Old Dominion University

MSVE OVERVIEW

www.odu.edu/msve
2018

Dr. Rick McKenzie
Professor and Chair

The worlds first M&S Department established specifically to support a Bachelor of Science program in M&S Engineering (M&SE). M&SE is a discipline where we utilize basic science principles not primarily to create and analyze a physical mechanical or electrical system but to create and analyze a model of that system.

Old Dominion University | Frank Batten College of Engineering & Technology | www.eng.odu.edu

Old Dominion University

"The Department of the Navy is getting major direct impact not three years down the road but right now immediately from personnel in their current jobs."

Dennis Reed
Department of the Navy M&S Deputy
Integrated Warfighting Capability LVC Architect
NAVAIR M&S Lead

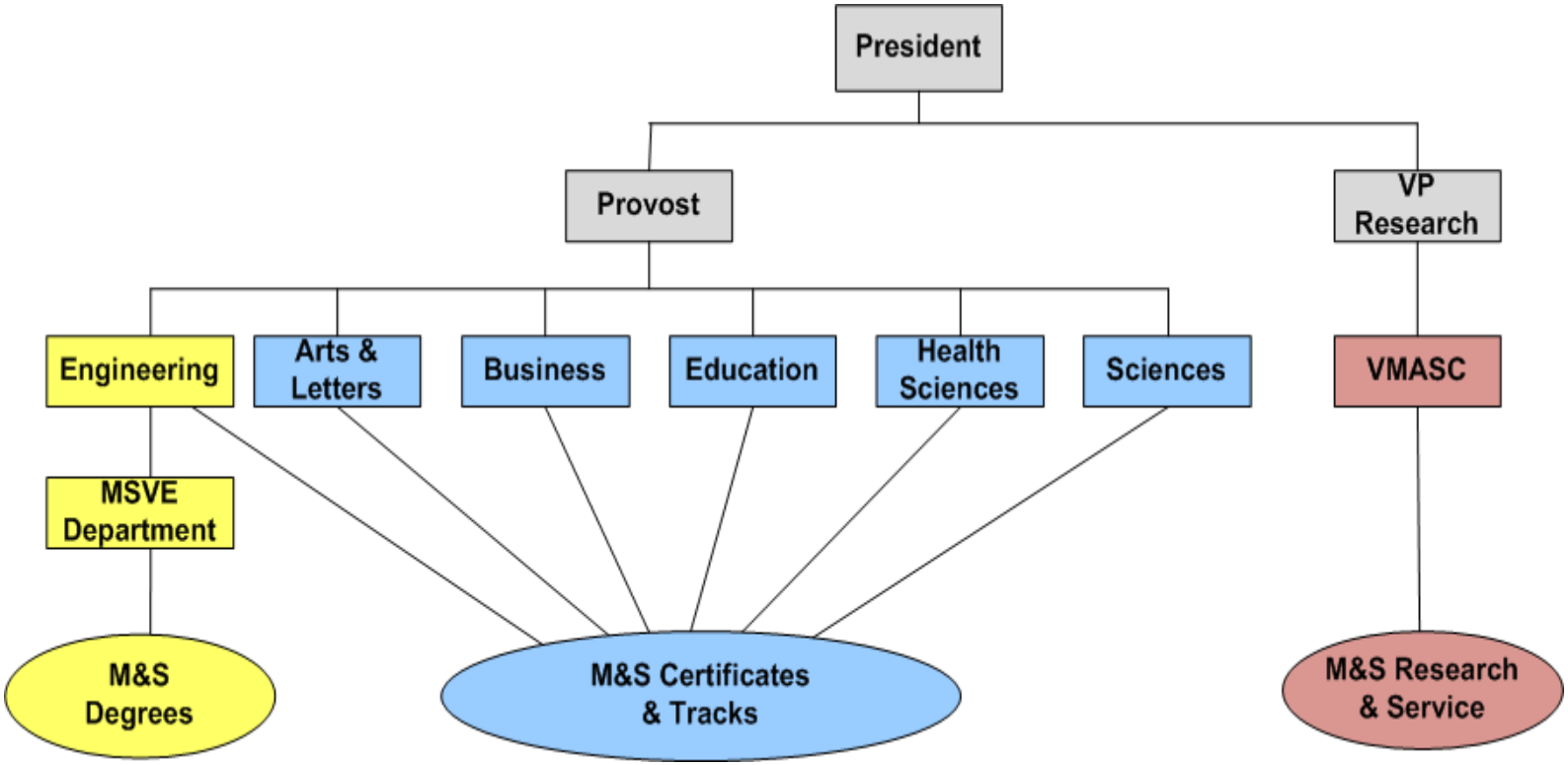
Old Dominion University

- Located near Virginia Beach
  - 3 hours drive south of Washington, DC
  - About 25,000 students
- Engineering College has over 110 Faculty
- MSVE Department Established March 2010
  - First department of its type in the USA.
  - Undergrad program started Fall 2010 (~100 undergraduate students)
  - Grad program for ~15 years - Over 120 Masters and Doctorate students
  - 10 faculty members
- Virginia Modeling Analysis and Simulation Center (VMASC)
  - Research Center, Old Dominion University
  - Activities include faculty and students from all six academic colleges
  - ~35 research & admin staff
  - ~$5.5M in funded research

Modeling and Simulation (M&S) at ODU Brief History

- 1998 Engineering M&S Master's Program Established
- 2000 Engineering M&S PhD Program Established
- 2003 First M&S PhD Degree Awarded
- 2005 ODU Declares M&S a University-Wide Initiative
- 2010 Engineering M&SE BS Program Established – MSVE Department Established
- 2013 First BS-M&SE Degrees Awarded

M&S at Old Dominion University



M&S Academics and Research Span the University

Mielke, R., Leathrum, J., and McKenzie, F., "A Model for University-Level Education in Modeling and Simulation", M&S Journal, Vol. 6, Issue 3, pp. 14-23, December 2011.

What is M&SE

- **A Program of Study in Many Universities.**
  - **But ODU has the only Bachelors in M&S in the Nation!**
- ***Selecting appropriate modeling techniques, creating associated models, simulating them, utilizing visualizations for validation, and evaluating possible solutions.***
- **Then, applying this knowledge to many areas!**
  - Physics-Based Gaming
  - Medical and HealthCare Simulation
  - SeaLevel Rise
  - CyberSecurity
  - High Performance Computing / Big Data
  - etc.

What is M&SE: In Short

- **A Program of Study in Computational Science and Engineering that focuses more on:**
  - The processes involved in developing a model
  - Different types of modeling methodologies where some involve AI techniques
  - Verification & Validation
  - Training & Decision Support
- **Our graduates are:**
  - What-If Decision-Makers
  - Great Programmers
  - Game Developers
  - Employing Analytics
  - Skillful Innovators

M&SE Advantage

- **Broad Approach to Engineering**
  - Applicable to all engineering and science disciplines
  - Engineering is about problem-solving and M&S engineering is about finding and understanding a range of solutions to provide the basis to choose.
- **High Demand for M&SE Professionals**
  - M&S jobs are available in many US and international locations
  - Only ODU offers a BS degree in M&SE
- **Excellent Preparation for Innovation**
  - Engineering provides skills required to design new solutions to societal problems
  - M&SE instills the methods and tools supportive of innovation
    - Rapid design and modeling, cost-saving simulation, effective visualization, robust analysis, and communication across technical boundaries

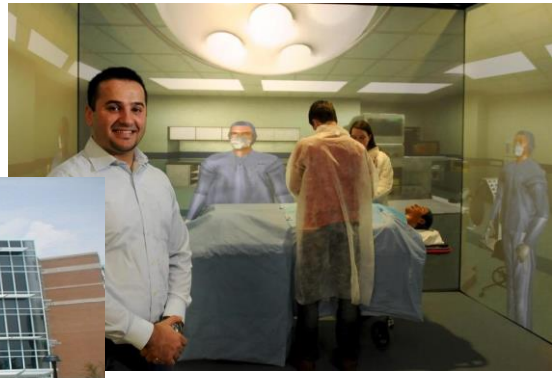
MSVE Department Profile

Department Description

- **Department Office**
  - 1300 ECSB, Norfolk Campus
  - Phone: 757-683-3720
  - www.odu.edu/msve
- **Contact Information**
  - Rick McKenzie, Chair
  - Yuzhong Shen, GPD
  - Jim Leathrum, CDA
  - Tammy Hanna, Academic Advisor
- **Resources**
  - 10 Faculty, 12 Adjuncts, 2 Joint
  - 3 Staff
  - Offices & Laboratories, ECSB
  - Partnership with VMASC

Degree Programs

- **Undergraduate**
  - BS – Modeling and Simulation Engineering
  - Minor – Modeling & Simulation
- **Graduate**
  - MS/ME – Modeling & Simulation
  - D Eng – Modeling & Simulation
  - PhD – Modeling & Simulation
  - Certificate – Modeling & Simulation



MSVE Faculty Research Areas

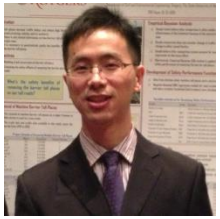
- **Rick McKenzie,** Professor & Chair
  - PhD ECE – University of Central Florida
  - Medical M&S, Standardized Patients

- **Michel Audette,** Associate Professor
  - PhD Biomed Engr. – McGill University
  - Medical M&S, Surgical Simulation

- **Jim Leathrum,** Associate Professor & CDA
  - PhD ECE – Duke University
  - Sim. Architectures, Distributed Sim.

- **Roland Mielke,** University Professor
  - PhD ECE – University of Wisconsin-Madison
  - System Theory, M&S Education, M&S Applications

- **Hong Yang,** Assistant Professor
  - PhD CE – Rutgers, M.S. Statistics – Rutgers
  - Intelligent Transportation Systems, Transportation Safety, Emergency Evacuation



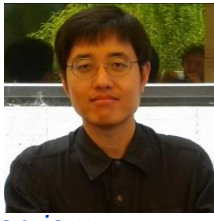
- **Masha Sosonkina,** Professor
  - PhD CS – Virginia Tech
  - Large-Scale Continuous Simulation

- **Yuzhong Shen,** Associate Professor & GPD
  - PhD ECE – University of Delaware
  - Visualization for M&S, Serious Games

- **John Sokolowski,** Associate Professor
  - PhD M&S – Old Dominion University
  - VMASC Executive Director
  - Computational Human Behavior Modeling

- **Sachin Shetty,** Associate Professor
  - PhD M&S – Old Dominion University
  - Network & Cyber Security

- **Zhanping Liu,** Assistant Professor
  - PhD CS – Peking University
  - Computational Visualization & Synthetic Environments



MSVE Laboratories

Undergraduate Projects & Research Laboratory

- Used for facilitating M&S projects-based instruction for undergraduates.

Medical Simulations Laboratory

- Medical simulations research in planning, training, education, and visualization.
  - 15 PCs, 4 haptic devices, three 3D scanners, two 3D printers, 4 reach-in displays, 3 LCD TVs, 3 game consoles from Microsoft, Sony and Nintendo; Autodesk Maya, Google SketchUp, Microsoft XNA Game Studio, Unity 3D Game Engine, and ArcGIS.

Applied M&S Research Laboratory

- Research laboratory used to support faculty collaborative research activities.
  - High performance computing, cyber security, simulation architectures, visualization, transportation systems, military M&S, digital manufacturing, and enterprise decision support.

Collaborative Autonomous Systems Laboratory

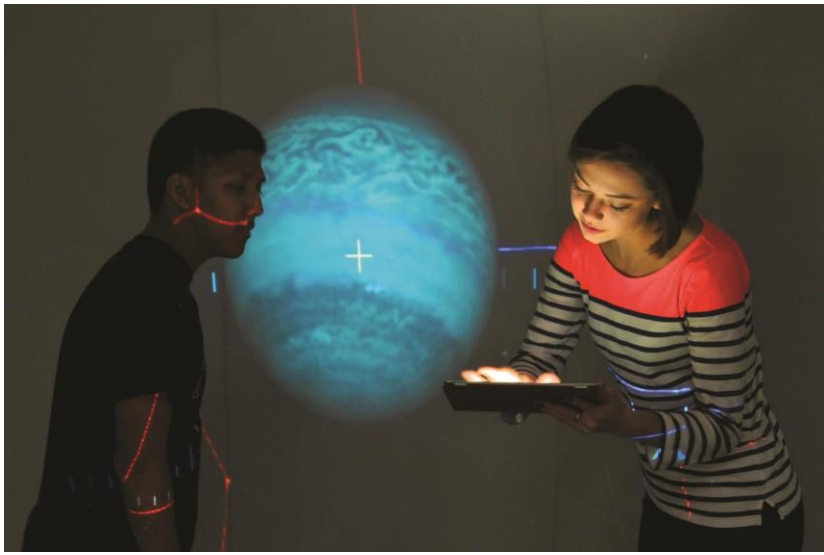
- Supports instructional and multidisciplinary research activities related to autonomous systems – shared with the MAE Department.
  - MSVE maintains several PC workstations and 10 various types of robotic systems. The lab contains an area dedicated to cyber security research as related to collaborative autonomous systems.

The CAVE (Cave Automated Virtual Environment)

- Virtual Reality laboratory – CAVE, 3m Vision Dome, and reach-in VR device.

Bachelor of Science
Modeling and Simulation Engineering
BS – M&SE

ABET Engineering Accreditation Commission

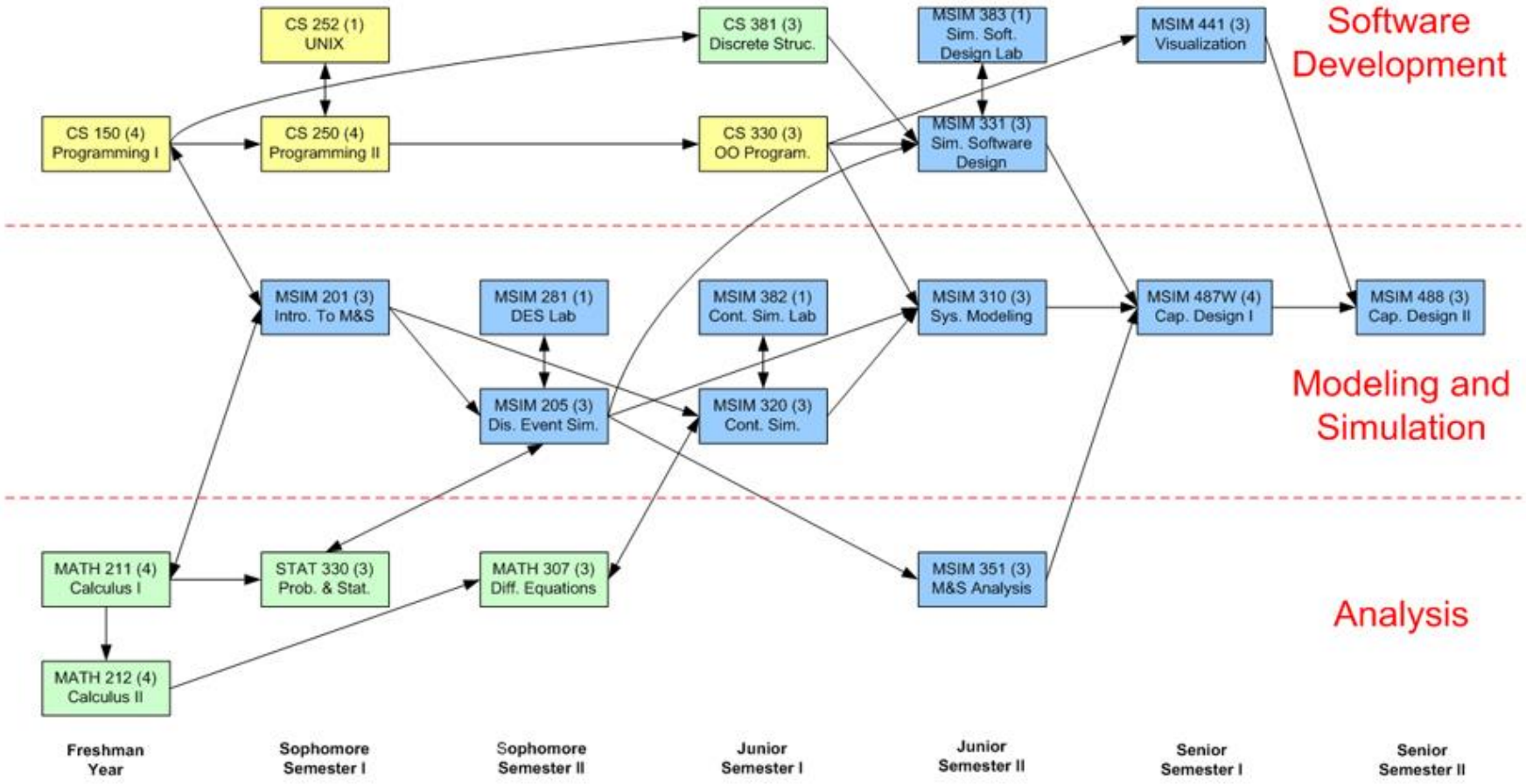


Modeling, Simulation & Visualization Engineering

Highlights of Curriculum

- The worlds first Bachelor of Science program in M&S Engineering (M&SE)
- Modeling and Simulation (M&S) Courses
  - Discrete Event and Motion Simulations, Game Physics, Model Engineering, CyberSecurity Simulations, Networked Simulations
- Software Development Courses
  - C++ Programming, Simulation Software Design, Graphics and Visualization, Game Physics, Game Development
- Analytics
  - Differential Equations, Probabilities & Statistics, M&S Analysis
- odu.edu/msve/scholarships

MSVE Course Sequence

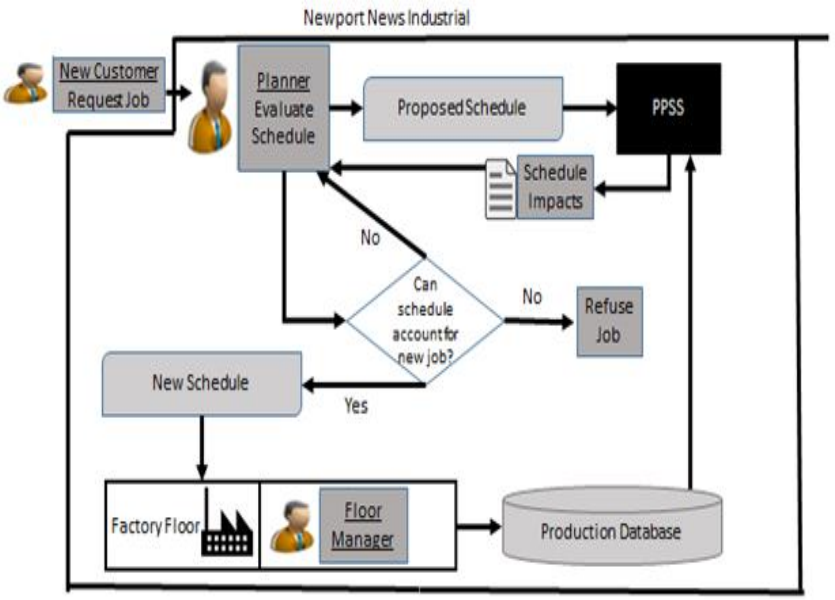


MSVE Senior Design Course

MSIM 487W & 488: Capstone Design

- **Course Content**
  - Engineering Design Process
  - Technical Communication
  - Professional Orientation
  - Capstone Design Project

- **Design Projects**
  - 2012-2013 Project (Mielke, Audette)
    - Obstetrics Training Environment
    - Eastern Virginia Medical School
  - 2013-2014 Project (Mielke, Leathrum)
    - Production Planning and Scheduling System (PPSS)
    - Newport News Industrial



PPSS

- **Input – Initial Job Process Flow Plan**
- **PPSS Capabilities**
  - **Represent Uncertainty in Process Times**
  - **Resolve Resource Utilization Conflicts**
  - **Represent Impact of Rework**
- **Output**
  - **Realizable Candidate Schedules**
  - **Job End Date Estimates**
  - **Bottleneck Identification**

BS/MS Student Profile 2018:

Christine Odenwald

- NASA Intern as a sophomore and junior
- Major: Modeling & Simulation Engineering
- Minor: Computer Science
- Student Org: SWE
- Scholarships: ITEA & VMASC Gene Newman VIA Scholarships

Another Grad Student Profile

Michael Poteat

- Bitcoin Entrepreneur
- Major: Modeling & Simulation Engineering
- Minor: Computer Science
- Senior Design Project: NASA Medical Workstation Evaluation Process
- Scholarships: VIA Transfer and Augustsson BS/MS Scholarships

MARKETS

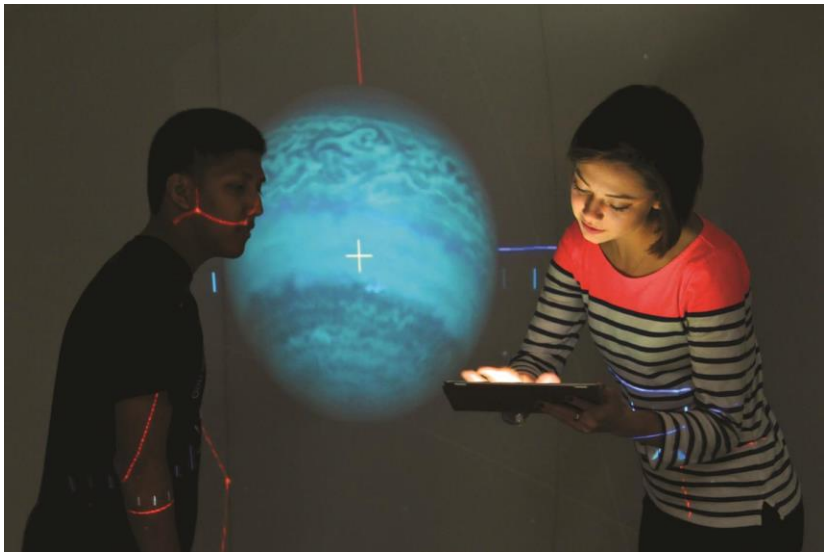
The Rise of Bitcoin Factories: Mining for the Masses

As more people jump into bitcoin mining, companies like Bcause look to provide the infrastructure, security and electricity

By
Stephanie Yang | Photographs by Parker Michels-Boyce for The Wall Street Journal
Updated Feb. 21, 2018 10:00 a.m. ET

Michael Poteat, an engineering student at Old Dominion University in Norfolk, Va., decided to start mining bitcoin four months ago.

Graduate Programs
Modeling and Simulation Engineering



Modeling, Simulation & Visualization Engineering

M&S Master's Degree Curriculum

Leveling (non-M&S BS)

- MSIM 602: Introduction to Modeling and Simulation
- MSIM 603: Simulation Design
- MSIM 510: Model Engineering
- MSIM 541: Visualization for Modeling and Simulation

M&S Masters Core

- MSIM ELE: Advanced Modeling Course (select list)
- MSIM ELE: Advanced Simulation Course (select list)
- MSIM 741: Principles of Visualization
- MSIM 551: Analysis for M&S
- or MSIM 751: Advanced Analysis for M&S

Option

- MS Degree: Thesis Option
- ME Degree: Additional 2 Courses

Graduate Certificate in M&S

- **Requirements (Four Courses)**

Three courses (9 hours) from the following:		9
MSIM 601	Introduction to Modeling and Simulation	
MSIM 602	Simulation Fundamentals	
MSIM 603	Simulation Design	
MSIM 510	Model Engineering	
MSIM 541	Computer Graphics and Visualization	
MSIM 551	Analysis for Modeling and Simulation	
MSIM ELE - MSIM Elective*		3
Total Hours		**12**

- **Naval Air System Command Cohort (2014, 2015, 2016, 2017, 2018)**
  - Provides an essential understanding of M&S methodologies, as well as best practices for the use of advanced M&S technologies — critical components for maintaining a workforce that supports the needs of NAVAIR and the DoD.

Cyber Systems Security

- **A Certificate Program to:**
  - Help engineers and managers gain understanding of the threats faced by the cyber systems and business processes;
  - Provide details of existing practices, policies and technologies required to prevent, detect and recover from attacks;
  - Provide understanding of the architecture of trustworthy cyber systems and implementation of these architectures with available tools and technologies;
  - Develop skills for the prevailing workspace consisting of ever-increasing integration between physical and cyber systems.

- **Requirements**
  - Four Courses

MSIM 570 - Foundations of Cyber Security

MSIM/ENMA 671 - Cyber Systems Engineering

MSIM/ENMA 673 - Threat Modeling and Risk Analysis

MSIM 773/873 - Networked System Security

- **Certificate Director: Dr. Sachin Shetty (sshetty@odu.edu)**

Regular Offerings

- **Semester-long courses and graduate certificate programs (4 Courses) and Master Degree (+6 Courses)**
  - MSVE can offer semester-long courses and a graduate certificate program in computational science and engineering **Modeling and Simulation** via distance learning (DL) in a hybrid live/online format.
  - MSVE can also offer semester-long courses and a graduate certificate program in **Cyber Systems Security** via DL in a hybrid live/online format.
- **Hybrid live/online format is supported by WebEx.**
  - Courses are taught to on-campus students but remote students join synchronously using WebEx.
  - In-class lectures are classroom-captured and archived for viewing within 24 hours for asynchronous participation.

Compressed Format

- **An alternative way is to teach courses on-site (NAVAIR) in a compressed (intensive) fashion for 2.5 weeks.**
  - Course is taught over 2.5 weeks with 5 full days of lecture included.
  - Any books needed for a course are sent on-site about two weeks in advance with possible reading assignments.
  - Software to be installed on the student computers identified early.
  - Typically meet live from 8AM to 5PM MTW with a mix of lecture and hands-on in-class exercises for the 1st week and then MT 2nd week.
  - Homework is requested and a “midterm” exam may take place on Wednesday or the start of the following week.
  - Students get homework and/or projects during the weekend.
  - Students may get final assignments and/or exams (or on-line exam) as well as a final project to complete within a week to 10 days.

Course Descriptions

- **MSIM 602. Simulation Fundamentals. 3 Credits.**
  Introduction to discrete event simulation (DES) including simulation methodology, input data modeling, output data analysis, and an overview of DES tools. Introduction to continuous simulation (CS) including simulation methodology, differential equation models, numerical solution techniques, and an overview of CS tools.
- **MSIM 603. Simulation Design. 3 Credits.**
  Course develops the computer software skills necessary for the design and development of simulation software. Topics covered include software architectures, software engineering, software design, object-oriented programming, abstract data types and classes, data structures, algorithms, and testing and debugging techniques.
- **MSIM 510. Model Engineering. 3 Credits.**
  Understanding of the various modeling paradigms appropriate for capturing behavior and conducting computer simulation of many types of systems. Concepts include UML, concept graphs, Bayesian nets, Markov models, Petri nets, system dynamics, Bond graphs, etc.
- **MSIM 551. Analysis for Modeling and Simulation. 3 Credits.**
  Analysis techniques appropriate to the conduct of modeling and simulation studies. Topics include input modeling, random number generation, output analysis, variance reduction techniques, experimental design and verification & validation.

Sample Elective Offerings

- **MSIM 406/506. Introduction to Distributed Simulation. 3 Credits.**
  Topics include motivation for using distributed simulation, distributed simulation architectures, time management issues, and distributed simulation approaches. Current standards for distributed simulation are presented, such as HLA.
- **MSIM 416/516. Cyber Defense Fundamentals. 3 Credits.**
  Cyber hacking techniques and defense mechanisms to detect and thwart cybercrime. The course first reviews the attacks to wireless networks and the defense strategies. Next, it reviews the attacks to general wired networks and information systems, and defense mechanisms. Last it discusses security policies and architectures.
- **MSIM 660. System Architecture and Modeling. 3 Credits.**
  The essential aspects of the system architecture paradigm through environment and analysis of multiple architecture frameworks and enterprise engineering, such as IDEFO, TOGAF, DODAF and OPM. Emphasis on system modeling and enterprise engineering.
- **MSIM 725. Principles of Combat Modeling and Simulation. 3 Credits.**
  History, basic definitions, and best practice. Algorithms for modeling movement, sensing effects and behavior. Overview of modern combat models. Interoperability and integration into operational environments.
- **MSIM 695 – Open Architectures and LVC Integration. 3 Credits.**
  LVC integration discussed and applied. Definitions, paradigms, applications, and sub-disciplines are introduced.

Results

- **Most recent GPA for all unique students (5 years) who were enrolled for at least 1 semester.**
  - Master's program: 3.49 (n=89)
  - Master's program who earned a BSMSE from ODU: 3.71 (n=7)
  - Master's program who did not earn a BSMSE: 3.47 (n=82)
  - Master's program who took 100% of courses online: 3.42 (n=38)
  - Master's program who took 1+ on-campus course: 3.54 (n=51)
  - **NAVAIR (last 2 years)**
  - Master's program: 3.78 ±0.2
  - Certificate program: 3.65 ±0.43, 3.72 ±0.34

Student Quotes

- **NAVAIR Civilian Employees**
  - *"Of the numerous opportunities I've had the pleasure of participating in, the ODU M&S program is one of the most beneficial to the NAVAIR and DoD programs."*
  - *"The skills and critical-thinking mentality cultivated through the program serve to develop a more capable workforce and speed the delivery of capabilities to the Fleet."*
  - *"Proper modeling and simulation process is a sort of wrapper around the software development cycle that augments it for the specific type of software we are creating."*
  - *"Validation and visualization techniques … are very important for the work I do here"*

Lessons-Learned

- **Compiled from students, instructors and administrators**
  - Remind students that these are real for college credit courses and not executive-type courses.
  - Ensure students have the prerequisites – calculus, statistics, introductory programming (C, C++, Java).
  - Students must attend every lecture.
  - Split the 5 lectures between 2 weeks for demanding courses to give students a chance to do homework and projects.
  - Provide flexibility to move between compressed format and regular semester-long format.
  - Place more programming intensive courses in the masters portion with certificate courses less programming intensive.

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My Contact

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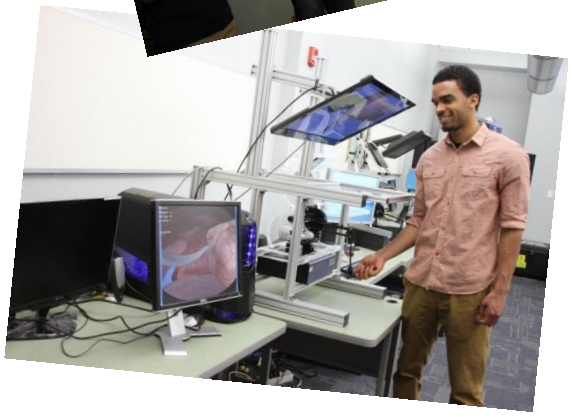
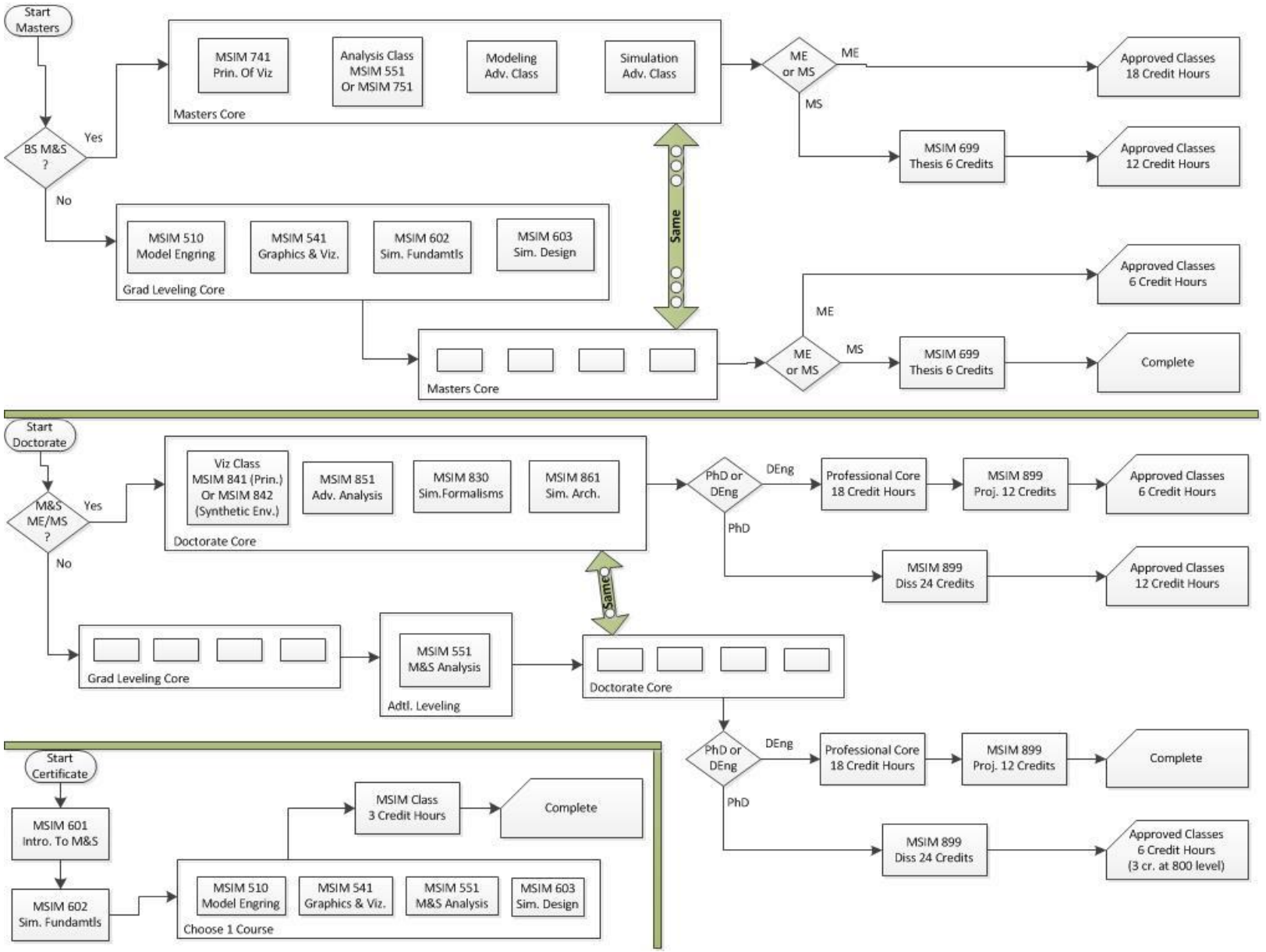
Professor & Chair

Phone: 757-683-5590
rdmckenz@odu.edu



Graduate Curriculum Chart



Student Quotes

- **A. Rhoten – NAVAIR Civilian Employee**
  - Member of the Engineering and Scientist Development Program
  - *"Of the numerous opportunities I've had the pleasure of participating in, the ODU M&S program is one of the most beneficial to the NAVAIR and DoD programs."*
  - *"The skills and critical-thinking mentality cultivated through the program serve to develop a more capable workforce and speed the delivery of capabilities to the Fleet."*

Student Quotes

- **J. Angus – NAVAIR Civilian Employee**
  - Programmer with a BS in Computer Science
  - *"Proper modeling and simulation process is a sort of wrapper around the software development cycle that augments it for the specific type of software we are creating."*
  - *"Validation and visualization techniques … are very important for the work I do here"*