

A Graduate Program in Unmanned and Autonomous Systems Engineering

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Abstract

Unmanned systems fill a vital role in the education community by providing multidisciplinary learning opportunities within science, technology, engineering, and mathematics. At Embry-Riddle Aeronautical University (ERAU), the use of unmanned systems within the undergraduate curriculum has created unique hands-on opportunities for students, and developed research options for faculty in aerospace, computer, electrical, and mechanical engineering and computer science. In fall 2013, ERAU's Daytona Beach campus launched a Master of Science degree in Unmanned and Autonomous Systems Engineering (MSUASE) as a cross-departmental collaboration. This paper provides a detailed overview of the MSUASE program, its mission, objectives, and student outputs. Research projects used for capstone and thesis opportunities are described including ERAU's Maritime Robot X Challenge unmanned surface vehicle and the Cessna 182Q surrogate unmanned aircraft system (UAS). Issues related to the International Trade of Armaments Regulations (ITAR) will be discussed. Finally, a summary of lessons learned will be provided after one year of the program's operation.

Keywords

Unmanned Systems Master's Engineering Curriculum

Introduction

At all academic levels (K-12 and post-secondary), unmanned systems play a role in education as they provide multi-disciplinary opportunities to expose students to real-world solutions and to technical challenges with a STEM focus. At the undergraduate level, unmanned and automated technologies can be found in a multitude of engineering programs across disciplines. At the graduate level, robotics curricula have existed as either part of standalone degree programs or as research concentrations within other engineering disciplines. While similar, there are differences that exist from robotics versus unmanned and autonomous systems. Robotics is a much broader domain that includes a number of subdomains, including unmanned and autonomous systems. Unmanned and autonomous systems work focuses on the transition of traditionally manned systems and processes into unmanned platforms and activities.

In August 2013, the Embry-Riddle Aeronautical University (ERAU) Daytona Beach, FL campus launched a new Master of Science in Unmanned and Autonomous Systems Engineering (MSUASE) program within the College of Engineering supported by the Aerospace Engineering (AE) Department, Mechanical Engineering (ME) Department, and the Electrical, Computer, Software, and Systems Engineering (ECSSE) Department. The MSUASE program supports a

multi-disciplinary pool of students with undergraduate degrees across the spectrum of engineering programs. The program is structured to provide a multi-disciplinary exposure to topics relevant to the engineering of unmanned and autonomous systems to produce well-rounded systems engineers capable of supporting the industry.

This paper provides a detailed overview of the MSUASE program. It discusses the program's mission, program objectives, and student outcomes. Current research projects used for capstone and thesis opportunities are described. Issues related to the International Trade of Armaments Regulations (ITAR) are discussed. Finally, a summary of lessons learned is provided after one year of the program's operation.

Background

In this section, a background of the unmanned systems curriculum at ERAU and across the nation is presented.

History of the Unmanned Systems Academics at ERAU Daytona Beach Campus

ERAU's College of Engineering has been actively involved with unmanned systems for over a decade. The Computer and Software Engineering capstone design course began participation in the Association for Unmanned Vehicle Systems International (AUVSI) Student Unmanned Aircraft System (SUAS) in 2005, and the university has fielded at least one team every subsequent year. Starting in 2007, the Robotics Association of Embry-Riddle (RAER) formed with support from faculty from the ME and ECSSE programs. The organization now includes students from every program within the College of Engineering as well as students from across the university. ERAU RAER is the only university organization in the world that competes in all of AUVSI Foundation's student competitions¹ including SUAS, the International Ground Vehicle Competition (IGVC), the International Aerial Robotics Competition (IARC), Roboat, and Robosub. It has also participated in the NASA Robotic Mining Competition, the Multi-Autonomous Ground Robotics International Challenge (MAGIC), and the Maritime RobotX Challenge. Faculty and students involved with RAER have also found research opportunities and industry collaborations involving both graduates and undergraduates.

Outside of the College of Engineering, beginning in 2008, the ERAU College of Aviation (COA) began a minor in Unmanned Aircraft Systems on the Daytona Beach campus. In 2011, the COA launched an undergraduate degree in Unmanned Aircraft Systems Sciences. The program has proven quite popular with over 50 graduates and over 200 students enrolled by fall 2014. This program focuses on the operational aspects of unmanned aircraft systems. Students in the program are exposed to some technical content through service courses provided by the College of Engineering; however, the graduates are trained as operators and not engineers.

Within the College of Engineering, based upon student interest, the success of its student robot teams, and the success of the COA's program, a team of faculty formed to explore options for unmanned systems related engineering degree programs. It was generally agreed upon that a degree in unmanned systems engineering at the undergraduate level was not appropriate as students need to develop a solid foundation in an engineering discipline before seeking further

specialization in the domain of unmanned systems. Therefore, a graduate program that admitted students from across engineering disciplines was developed. The curriculum of the new program, MSUASE, teaches a systems engineering approach to the development of unmanned and autonomous ground, air, maritime surface, underwater, and space systems.

In the next section, the curriculum is presented, demonstrating a commitment to develop systems thinking and engineering skills that build upon the cross-disciplinary background of the students enrolled. Rather than focus on robotics, which is more general, the focus on unmanned and autonomous systems allows teaching and research to focus upon the adaptation of traditionally manned systems and processes to unmanned solutions, and emphasizes the importance of safety and certification of these systems.

Survey of Related Degree Programs

ERAU is not the only university to have developed graduate degree programs in unmanned and/or autonomous systems. This section briefly surveys master's degree programs in engineering with subject matter related to unmanned systems. It is not exhaustive and focuses upon programs in the United States.

Carnegie Mellon University and its Robotics Institute offers several master's level degrees related to robotic systems. Their MS in Robotics² divides the curriculum into the topics of perception, cognition, action, and math with a supervised research requirement. A second MS degree in Robotic System Development³ supports both recent graduates and practicing professionals with a blending of technical content and systems engineering, business, and management courses.

The University of Pennsylvania offers a MS in Engineering in Robotics⁴. Its curriculum is similar to Carnegie Mellon University with core courses divided into the core areas of Artificial Intelligence, Robot Design and Analysis, Control, and Perception.

Oklahoma State University's Mechanical and Aerospace Engineering (MAE) Department offers a masters degree in MAE with a specialization in unmanned aircraft systems⁵. The program's curriculum features technical topics for the design and engineering of UAS. It also requires courses on system quality and certification of aircraft. It features both a thesis and non-thesis option.

Worcester Polytechnic Institute features as MS degree in Robotics Engineering⁶ with the program divided into foundational requirements (robotics, dynamics, control, etc.), an engineering context (management, entrepreneurship, etc.), capstone or thesis, and a number of electives.

The University of Michigan offers a Master of Engineering degree in Robotics and Autonomous Vehicles⁷ with an engineering core, a specialization (intelligence and learning, information and signal processing, dynamics and control, or design), management and systems, and a one semester capstone project.

Johns Hopkins University offers a Master of Science in Engineering in Robotics⁸ with either a course or essay option. Their program features four main tracks in addition to a common core: medical robotics, perception and cognitive systems, automation science and engineering, and control and dynamics.

MSUASE Program Overview

Due to its multi-disciplinary nature, the MSUASE Program is structured to provide students flexible course options while ensuring that all students learn the fundamentals of unmanned systems. The program is built around a core set of courses along with three options totaling 30 required semester-hours.

The program's accreditation currently falls under the University's Southern Association of Colleges and Schools (SACS). The program utilizes both direct and indirect assessment to determine its ability to meet the program's mission statement: "we graduate technically adept engineers who apply systems thinking and engineering best practices in their professional pursuits in the domain of unmanned and autonomous systems." Students graduating from the MSUASE program shall have the following student outcomes:

- Ability to apply fundamental engineering practices to analyze, design, and support the implementation and development of unmanned and/or autonomous system;
- Ability to apply knowledge of advanced topics in unmanned and autonomous systems engineering; and
- Ability to communicate effectively on issues pertaining to unmanned and autonomous systems.

The five core courses comprise 15 of the 30 required credit-hours. These courses, shown in Table 1, are taught by all three of the constituent departments and are designed to provide an overview of the concepts and issues encountered in unmanned systems. These courses are focused on the presenting a systems perspective to broaden the knowledge base for students coming from single discipline undergraduate backgrounds. In particular, the courses cover control theory, mathematical modeling, sensors, perception and navigation algorithms, and system safety.

Table 1: MSUASE Core Courses

Course	Title	Credits
AE/ME/EE 527	Modern Control Systems	3
EE 510	Linear Systems	3
EE 528	Sensors and Data Units	3
ME 503	Unmanned and Autonomous Vehicle Systems	3
SYS 505	System Safety and Certification	3

In addition to the required courses, students are required to select one of three 15 credit-hour options:

- Thesis Option: 6 credits of approved electives plus a 9 credit research thesis
- Capstone Option: 9 credits of approved electives plus a 6 credit capstone project
- Coursework Option: 15 credits of approved electives

The Thesis Option is the traditional master's degree option in which students are required to prepare and defend an original research work. In addition to the standard thesis, students may be able to meet the requirement by publishing a journal paper or multiple (i.e. at least three) conference papers and defending this work before a committee.

The Capstone Option is an innovative feature of the MSUASE program. Under this option, students complete their degree with a two-semester UAS 691/692 capstone course sequence. The capstone option was created to address the industry need for students who have hands-on experience with unmanned systems, which is limited in traditional course work and may not be addressed in a thesis. In the capstone, students must work on a project that requires them to design and implement some aspect of an unmanned system. The program offers sections of capstone course to second year graduate students given project and advisor availability. The capstone projects integrate MSUASE students into research projects such as those presented in the next section, Current and Future Student Research Opportunities.

The Coursework Option allows students to complete their degree by completing 15 credit-hours of approved electives. This option was created for transfer students who may already have completed a significant number of credits in other degree programs, or international students whose ability to work on thesis or capstone projects may be limited by ITAR restrictions. This option is generally discouraged due to the relative lack of hands-on or research work and requires approval from the Program Coordinator on a case-by-case basis.

In addition to the above options, students can elect a concentration in Unmanned Aircraft Systems by selecting the Capstone Option and taking a predefined set of courses in lieu of the electives. These courses are: AE 506 – Airplane Dynamic Stability, AE 622 – Atmospheric Guidance, Navigation and Control, and AE 626 – Aircraft Fault Tolerance and Advanced Control Theory.

Current and Future Student Research Opportunities

Several ongoing and future projects within the ERAU College of Engineering present opportunities for MSUASE students due to their focus on the design, development and implementation of guidance, navigation and control of unmanned and autonomous systems. This includes methodologies to improve aviation safety, increase autonomy of unmanned robotic systems, construct space exploration robotic systems, and develop sensor fusion and vision-based navigation..

Surrogate Cessna 182 UAS

The Surrogate UAS consists of three primary elements: a surrogate UA, a control station, and a data link. As a surrogate UAS, the Cessna 182, a manned aircraft, is upgraded such that it can

operate autonomously without intervening command / control from the onboard safety/test pilot. The university chose to develop a surrogate UAS instead of a traditional UAS platform to ensure safety and gain approval for operation within the National Airspace System as an experimental aircraft. With a safety pilot onboard, if control of the aircraft is lost, the pilot can disconnect the autopilot and recover the aircraft manually. This allows for safe testing of new control algorithms, while still providing a platform for inflight validation of new control laws. The surrogate UAS is based on a Cessna 182Q shown in Figure 1. The aircraft is a four-seat, fixed gear aircraft powered by a single 230 hp Continental engine with a constant speed propeller. With a gross weight of 2950 lb., and an S-TEC 55x autopilot and servos installed, this aircraft provided enough payload capacity to be fully instrumented with all the necessary sensors and equipment.



Figure 1: Cessna 182 adapted into a Surrogate UAS to support research and testing.

The aircraft has been purchased and completely instrumented and fitted with a flight management system – an onboard computer, a National Instruments cRIO coupled with an S-TEC 55x autopilot, vision and radar-based detection systems, and a path planning computer for avoiding conflicting traffic. Now that the platform has been prepared, it will be available for future work in the development of control laws and testing of sensor configurations.

UAS Ground Control Station

This project aims at developing and implementing a Mobile UAS Ground Control Station (GCS). The system will support aviation safety research with pilot-in-the-loop capabilities using unmanned aerial systems platforms and where flight conditions, such as subsystems failures,

could be simulated in real-time to characterize pilot response, control laws performance and human-machine and control laws interactions. A primary achievement of this project will provide a platform to validate and assess new concepts and technologies that are beneficial for improving engineering fidelity of early systems integration testing based on pilot feedback and their interaction with on-board flight controls systems.

Maritime RobotX Challenge

Embry-Riddle is one of only three universities in the United States and 15 worldwide to compete in the AUVSI/Office of Naval Research (ONR) sponsored Maritime RobotX Challenge⁹. This competition required development of a fully autonomous unmanned surface vehicle (USV) based on the 5m Wave Adapted Modular Vessel (WAM-V), shown in Figure 2. Development of this system required a student team to construct a propulsion system, design power systems, design a sensor package, and implement the perception and navigation software required to complete a series of autonomous challenges. The students completed the initial phase in nine months, achieving full operational capability and finishing fourth overall at the 2014 challenge in Singapore. The project will be ongoing in preparation for the next competition and is an excellent candidate for a MSUASE capstone course.



Figure 2: ERAU's Maritime RobotX Entry

Detect and Avoid Technologies

In summer 2013, ERAU stood up a working group to focus upon research relevant to UAS detect-and-avoid technologies, i.e. technologies that allow a UAS to detect other aircraft (cooperative or non-cooperative) as well as structures and terrain, maintain self-separation, and avoid collision. This working group has begun the integration of detect-and-avoid technologies on the Surrogate UAS discussed above including computer vision, LIDAR, and Automatic Dependent Surveillance – Broadcast (ADS-B). Additionally, electrical engineering faculty and

students have conducted funded research in passive radar technologies for low size, weight, and power (SWAP) applications such as medium-to-small size UAS¹⁰. Finally, the surrogate UAS discussed earlier in this paper is equipped to support a variety of detect-and-avoid technologies including onboard ADS-B, cameras, and radar.

Smart Material Project

Smart materials offer several potential advantages for unmanned aircraft flight control applications compared to traditional servo actuators. One important benefit is that smart materials are lightweight and can be embedded directly into the structure of a wing or control surface. Therefore, they can reduce the overall weight of the vehicle and eliminate the need for mechanical appendages that may compromise the form factor of the wing; these benefits become more significant as the size of the vehicle decreases. In addition, smart materials can be used to realize continuous camber change of aerodynamic surfaces. Such designs offer improved aerodynamic efficiency compared to the discontinuous deflections of traditional hinged control surfaces driven by servo actuators.

In this project, a macro-fiber composite (MFC) aileron actuators are designed for implementation on a medium-scale, fixed-wing UAS in order to achieve roll control. Several MFC aileron actuator designs have been evaluated through a combination of theoretical and experimental analysis. The current design consists of glass fiber composite ailerons with two unimorph MFC actuators embedded in each aileron to produce upward deflection. In addition, a closed-loop, autonomous flight control system for a small UAS is being developed in preparation for conducting simulations and flight testing of an autonomous system with MFC aileron actuators.

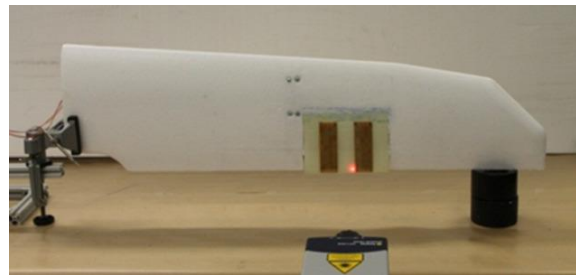


Figure X. Smart Materials Embedded in a UAS

Space Robotic Systems

In this project, Embry-Riddle Aeronautical University (ERAU) and Honeybee Robotics (HBR) are developing an integrated autonomous free-flyer robotic spacecraft system to support the exploration and subsequent resource utilization of asteroids as well as other planetary bodies and moons. The spacecraft addresses the first step towards In Situ Resource Utilization from Near Earth Object bodies. In particular, the research team focuses on flight control and reconfiguration for guidance under extreme environments, vision-aided navigation approaches, and sampling systems design, testing and evaluation. It is anticipated that this project will provide a theoretical and experimental framework to investigate the capabilities of a marsupial-based robotic system to explore and extract samples from terrains that would be inaccessible to traditional rover-type

vehicles and where traditional flight guidance and navigation sensors, such as GPS receivers and magnetometers, are not functional.

ITAR and Sensitive Information

The International Trade in Arms Regulations (ITAR) and Export Controls provide a challenge for faculty and students at academic institutions involved with unmanned systems projects (research, co-curricular, or extracurricular). Under both instances, there are limitations regarding the access of particular technologies and their supporting materials to foreign nationals.

ITAR originates from Title 22 Code of Federal Regulations Parts 120 – 130¹¹ and the United State Munitions List (USML)¹², defined in ITAR 121.1. Maintained by the State Department, ITAR does not only regulate equipment, but also technical information and services related to sensitive technologies. When something falls under ITAR, the regulations prohibit its export to a foreign person regardless of whether or not they are a student/staff/faculty residing within the United States or are abroad. The definition of “export” as laid out in ITAR 120.17 is fairly broad. It includes: the disclosure of the restricted article or transfer of it to a foreign embassy or foreign person and the performance of services for or on behalf of a foreign government of foreign nationals. The definitions of ITAR restricted items is defined by ITAR 120.6, defining defense article; ITAR 120.10, defining technical data; and ITAR 120.09, defining technical services. A defense article is typically the more obvious category of ITAR restricted items as it is primarily hardware and software specified under the USML. Technical data includes all data necessary for the design, manufacturing, testing, repair, configuration, and utilization of a defense article, which includes items such as blueprints, design documents, and user manuals. The final category, defense services, is the providing of services to foreign nationals, foreign governments, and similar foreign controlled entities involving defense articles including, but not limited to design, engineering, and training.

The second major category of restricted materials are those designated by the US Department of Commerce as Dual-Use Goods and Technologies, which are addressed by the Export Administration Regulations (EAR)¹³. Unlike weapons, which fall under ITAR, dual-use export controlled articles can serve a military/strategic function as well as a common civilian function. Export controlled items must be kept out of the hands of persons or nations with the intent to do harm to the United States of America and its interests domestic and abroad. As with ITAR, the export of dual-use goods is broadly defined to include the physical exchange of materials to disclosures such as an oral briefing.

For the MSUASE program at ERAU, ITAR and Export Control restrictions were considered at the onset of the program. ERAU’s Bachelor of Science in Unmanned Aircraft Systems Sciences (BS-UASS), which trains UAS operators, is restricted to US citizens only with proof of citizenship required to gain access to their laboratories. For that program, this made sense as the flight simulators used were ITAR restricted as were their usual manuals.

The college currently utilizes secure storage facilities to store ITAR controlled, export controlled, and other sensitive items. Access control to the secure storage is strictly limited to select faculty and staff. Individual faculty members are responsible for conducting a periodic

inventory of all restricted materials and follow university procedures to report the loss or accidental disclosure of restricted materials. Restricted materials are also clearly labeled identifying that they are a sensitive material, the type (such as ITAR Controlled, Export Controlled, Non-Disclosure, Secret, or Classified). Lastly, labs and secure storage areas can only be serviced by approved personnel.

The MSUASE program's basic curriculum does not include any ITAR restricted materials. It makes use of publically available textbooks, technical publications, and technologies. The only exception regarding access by foreign nationals could exist with a capstone design project where one or multiple technologies used is ITAR restricted. In those situations, one of two routes can be taken, one option is that necessary precautions are put in place to exclude access by the foreign student to the restricted materials. A second option is for the student to choose a thesis that does not require ITAR technology, or in extreme cases choose the coursework only option.

Lessons Learned

Embry-Riddle's MSUASE program is unique in subject matter (unmanned and autonomous systems), approach (project-based hands-on experiential learning), and organization (supported by the AE, ME, and ECSSE Departments). Since its starting date in fall 2013, lessons have been learned towards the improvement and enhancement of the MSUASE program. These include the implementation of strategies to increase enrollment, to partner external entities and industry interested on our students for internships, to handle ITAR regulations, and to involve students in an active learning process through courses with a significant hands-on activities component.

For the last one, a significant pedagogical support has been introduced through projects to enrich classes by incorporating research findings and technology into the program courses. This has created premises for the integration of unmanned and autonomous system courses into the curriculum within an experiential and active learning environment aimed at increasing student involvement, motivation, and hence program enrollment. It is expected that this strategy will ease the transition for our graduates and bridge the gap between industry and academia. According to the recently published controls curriculum survey conducted by IEEE Control Systems Society (CSS), "hands-on experience" has been considered by both industry and academia to be the area most in need of strengthening to better prepare future control engineers¹⁴. The hands-on experience refers to laboratory implementation using high-level systems (rapid prototyping), and hardware. Thus, in our MSUASE program, the implementation of UAS simulation and experimental tools, for example, has allowed students to test their algorithms in simulation and then compare the results to those obtained in real systems. It has made the students part of design projects from initial concept to final testing phase by complementing theory with practice.

Interaction from the unmanned systems industry at trade shows such as the AUVSI Unmanned Systems 2013 and 2014 conference have also yielded some first hand insight from potential employers. First, representatives from industry were very supportive of ERAU's choice to focus on development of a cross-disciplinary pool of engineers. However, on multiple occasions, we were advised to communicate details of the program with human resources as degrees with

unique titles can potentially be overlooked. Most interestingly, the majority of industry representatives expressed an interest in a distance delivery option so that they could provide specialized training to their employees either through a master's degree or through a certification program.

The program coordination team and university marketing are exploring a number of approaches to attract students to the MSUASE program. Within the university, promotion of the program through various forums, social media, and classroom visits has been used to inform the current undergraduate students within the College of Engineering of the program and its job prospects within the unmanned systems industry. To recruit students from outside of the university, program faculty and recruiters have visited a number of conferences such as AIAA SciTech, the ASEE National Exposition, ASEE Southeast Section annual conference, IEEE Southeast Con, and AUVSI to meet student researchers and promote the program. At the AUVSI competitions, ERAU has maintained an active presence and distributed literature for all engineering programs including the MSUASE program. Lastly, print advertising in national magazines and student newspapers is ongoing to grow awareness with potential applicants.

Lastly, there is still significant public concern over unmanned systems with respect to several topics including privacy, public safety, and controversial applications (e.g. weaponized unmanned systems). To address this issue, the MSUASE program coordinator presented a paper at the ASEE National Expo in 2014 discussing the ethical and professional issues associated with organizing such a program and developing its curriculum. A mindfulness of these concerns is necessary especially when publically discussing the program such as at a public forum or to the media.

Conclusion

After one year of operation, the MSUASE program has shown continued promise as a new degree program at ERAU that provides a unique multi-disciplinary opportunity for both students and program faculty. At the start of the fall 2014 term, the program had 10 students enrolled and graduated its first student in December 2014. Inquiries from prospective students have showed a continued growing interest in the program; however, effective advertisement of the program has been one of its greatest challenges.

As the program grows, there are a number of paths and future considerations that need to be made. One change suggested by a key stakeholder (industry) under consideration is the development of an online option for the program. This subject is currently being researched to determine suitable delivery mechanisms that can convey both the technical materials as well as the project-based experiential learning that is hallmark to the program.

Given suitable enrollments, another area of proposed future growth is the development of additional areas of concentration and capstone design courses. Currently, there is only an unmanned aircraft systems area of concentration. The program will consider, given higher enrollments and sufficient demand from students and industry stakeholders, new areas of concentration in ground, maritime, and space unmanned systems.

References

2015 ASEE Southeast Section Conference

- 1 AUVSI Foundation, “Competitions,” Online at: <http://www.auvsifoundation.org/foundation/competitions>, 2014.
- 2 Carnegie Mellon University, “Carnegie Mellon: The Robotics Institute - Masters of Science Program Curriculum,” Online at: http://ri.cmu.edu/ri_static_content.html?menu_id=340, 2014.
- 3 Carnegie Mellon University, “Carnegie Mellon: The Robotics Institute - MRSD Program Curriculum,” Online at: http://ri.cmu.edu/ri_static_content.html?menu_id=470, 2014.
- 4 The University of Pennsylvania, “Master’s in Robotics,” Online at: <https://www.grasp.upenn.edu/education/masters>, 2014.
- 5 Oklahoma State University, “Master’s Degree in Mechanical and Aerospace Engineering Unmanned Aerial Systems (UAS),” Online at: <http://temp-mae.okstate.edu/sites/default/files/MS%20UAS%20Option.pdf>, 2014.
- 6 Worcester Polytechnic Institute, “Robotics Engineering,” Online at: <http://www.wpi.edu/academics/robotics/>, 2014
- 7 University of Michigan, “Master of Engineering in Robotics and Autonomous Vehicles,” Online at: <http://isd.engin.umich.edu/degree-programs/robotics-and-autonomous-vehicles/index.htm>, 2014.
- 8 Johns Hopkins University, “Robotics MSE,” Online at: <http://lcsr.jhu.edu/mse/>, 2014.
- 9 Coyle, Eric, Patrick Currier, Christopher Hockley, and Timothy Zuercher. “The Development of the ERAU Maritime RobotX Challenge Autonomous System,” Associate for Unmanned Vehicle Systems International, Unmanned Systems 2014, 2014.
- 10 Barott, William C., Eric Coyle, Ted Dabrowski, Christopher Hockley, and Richard S. Stansbury. “Passive Multispectral Sensor Architecture for Radar-EOIR Sensor Fusion for Low SWAP UAS Sense and Avoid,” IEEE Position Location and Navigation Symposium, Monterrey, CA, May 2014.
- 11 United States Department of State, “Title 22 Code of Federal Regulations Part 120– International Traffic in Arms Regulations,” Online at: http://www.pmddtc.state.gov/regulations_laws/documents/official_itar/2013/ITAR_Part_120.pdf, 2014.
- 12 United States Department of State, “Title 22 Code of Federal Regulations Part 121 – The United States Munitions List,” Online at: http://www.pmddtc.state.gov/regulations_laws/documents/official_itar/2013/ITAR_Part_121.pdf, 2014.
- 13 Department of Commerce, “Export Administration Regulations (EAR),” Online at: http://www.bis.doc.gov/index.php/forms-documents/doc_view/410-part-730-general-information, 2014.
- 14 Cook, Jeffrey A. and Tariq Samad, "Controls Curriculum Survey-A CSS Outreach Task Force Report," IEEE Control Systems Society, 2009.

Richard S. Stansbury

Dr. Richard S. Stansbury is an Associate Professor of Computer Engineering and Computer Science at Embry-Riddle Aeronautical University in Daytona Beach, FL and program coordinator for the Master of Science in Unmanned and Autonomous Systems Engineering. Joining the ERAU faculty in 2007, his research transitioned to unmanned aircraft systems. He has supported FAA funded projects to survey UAS technologies and identify regulatory gaps. He is leading ERAU's bid for an FAA Center of Excellence in Unmanned Aircraft Systems under the multi-university ASSURE Coalition.

Patrick Currier

Dr. Patrick Currier is an Assistant Professor of Mechanical Engineering at Embry-Riddle Aeronautical University. He has extensive experience developing autonomous and unmanned systems with areas of expertise including unmanned systems development, system integration, and dynamic modeling and control. He served as project lead for Team VictorTango in the Urban Challenge, was vehicle integration lead for the DoD GUSS project, and Principal Investigator for development of the Raider II By-Wire system and design of a novel Boeing 3D printed Unmanned Aerial Vehicle. He currently serves as an advisor to the Robotics Association at Embry-Riddle, which competes in seven different student robotics competitions, and as the lead advisor for the ERAU EcoCAR 2 hybrid vehicle development team.

Hever Moncayo

Dr. Hever Moncayo is an Assistant Professor of Aerospace Engineering at Embry-Riddle Aeronautical University in Daytona Beach, FL and is a member of the Master of Science in Unmanned and Autonomous Systems Engineering Committee. His research has been supported by grants that include Defense Department, NASA and FAA. His research interests include intelligent/adaptive fault tolerance flight control systems, adaptive flight control laws for unmanned air vehicles, and non-linear modeling and simulation of aircraft and aircraft sub-systems.