Unmanned Aerial Systems: Research, Development, Education & Training at Embry-Riddle Aeronautical University

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UNMANNED AERIAL SYSTEMS
RESEARCH, DEVELOPMENT, EDUCATION & TRAINING

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Dean of Research and Graduate Studies
**Foreword**

With technological breakthroughs in miniaturized aircraft-related components, including but not limited to communications, computer systems and sensors, state-of-the-art unmanned aerial systems (UAS) have become a reality. This fast-growing industry is anticipating and responding to a myriad of societal applications that will provide new and more cost-effective solutions that previous technologies could not, or will replace activities that involved humans in flight with associated risks.

Embry-Riddle Aeronautical University has a long history of aviation-related research and education, and is heavily engaged in UAS activities. This document provides a summary of these activities, and is divided into two parts. The first part provides a brief summary of each of the various activities, while the second part lists the faculty associated with those activities. Within the first part of this document, we have separated UAS activities into two broad areas: Engineering and Applications. Each of these broad areas is then further broken down into six sub-areas, which are listed in the Table of Contents. The second part lists the faculty, sorted by campus (Daytona Beach-D, Prescott-P, and Worldwide-W) associated with the UAS activities. The UAS activities and the corresponding faculty are cross-referenced.

We have chosen to provide very short summaries of the UAS activities rather than lengthy descriptions. If more information is desired, please contact me directly, or visit our research website (https://erau.edu/research), or contact the appropriate faculty member using their e-mail address provided at the end of this document.

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**Acknowledgements**

A number of people have worked to produce this UAS document. Clearly, the faculty providing information related to their involvement in UAS research and/or teaching are greatly appreciated; without their contributions this document would not exist. Their names appear in the appendix. Teresa Ochoa and Teri Gabriel helped collect information from the contributing faculty. Teri Gabriel worked tirelessly with the provided information, sorting, editing, and formatting to produce the final document. Jeanette Barott helped edit the final document. The help and advice of some of our faculty with UAS proficiency was critical, especially in earlier versions of this document, and for that I'd like to thank Drs. Alex Mirot, Brent Terwilliger, Ken Witcher, Stephen Bruder, Brian Davis, Massoud Bazargan, Dahai Lu, and Richard Stansbury. I would also like to thank the University Research Council for their continued help. The councilors have changed over the years, but they have included: Drs. Susan Allen, Quentin Bailey, Massoud Bazargan, Alan Bender, Sergey Drakunov, Thomas Field, Soumia Ichoua, Mark Sinclair, Ahmad Sleiti, Todd Smith, Alan Stolzer, and Steve Hampton.

Last, but not least, I would like to thank the University Administration for its continued support of UAS related activities across our university.
A team of faculty and students are developing an unmanned Optionally Piloted Unmanned Aircraft System (OPUAS) to support the exploration and subsequent resource utilization of asteroids as well as other planetary bodies and moons. The project, sponsored by the FAA, dealt with advanced verification techniques for safety-critical airborne hardware complying with DO-294. (D20)

Aerobiological Sampling using UAVs
This project involves collecting biological samples in the planetary boundary layer above agricultural fields. The goals were to find optimal autonomous flight patterns and to track the transport of plant pathogens. (W02 & W05)

Aerodynamic Design Considerations for UAS during Refueling Operations
This research investigates the aerodynamics associated with Unmanned Aerial Systems during refueling operations. (W05)

An Optionally Piloted Unmanned Aircraft System
A team of faculty and students are developing an unmanned (suromagi) aircraft that will autonomously fly a series of waypoints and avoid local air traffic (both cooperative and non-cooperative aircraft). (D14, D16, D17, D21, & D22)

CFD Analysis of Aerodynamic Surface Finishes
This project involves CFD modeling of low-speed boundary layer airflow on various UAS surface finishes. (W08 & W10)

Embry-Riddle Aeronautical University
UNMANNED AERIAL SYSTEMS • RESEARCH, DEVELOPMENT, EDUCATION, & TRAINING

UNMANNED AIRCRAFT SYSTEM CAPABILITIES

Engineering
El. Design, Development, and Validation
Inclusive of the entire system including vehicle, control stations and payload

Advanced Verification Techniques
The project, sponsored by the FAA, dealt with advanced verification techniques for safety-critical airborne hardware complying with DO-294. (D20)

Aero Foil Design for Low Speed and High Altitude Flight
This is a Numerical and Wind tunnel experiment using Taught method for parameter selection. (W02 & W05)

Aerobiological Sampling using UAVs
This project involves collecting biological samples in the planetary boundary layer above agricultural fields. The goals were to find optimal autonomous flight patterns and to track the transport of plant pathogens in the planetary boundary layer. (D21)

Aerodynamic Design Considerations for UAS during Refueling Operations
This research investigates the aerodynamics associated with Unmanned Aerial Systems during refueling operations. (W05)

An Optionally Piloted Unmanned Aircraft System
A team of faculty and students are developing an unmanned (suromagi) aircraft that will autonomously fly a series of waypoints and avoid local air traffic (both cooperative and non-cooperative aircraft). (D14, D16, D17, D21, & D22)

CFD Analysis of Aerodynamic Surface Finishes
This project involves CFD modeling of low-speed boundary layer airflow on various UAS surface finishes. (W08 & W10)

Development of a Fully 3-D Printed Fixed-Wing UAV
Boeing sponsored project involving developing tools and techniques for rapid parametric-based design and manufacture of UAV using 3-D printing technology. (D19, D27, D28 & D29)

Drone Net – An Architecture for UAS Traffic Management
Drone Net is a conceptual architecture to integrate passive sensor nodes in a local sensor network along with traditional active sensing methods for small Unoccupied Aerial System detection, tracking, and identification. (P08, P10 & P11)

Free-Flying Unmanned Robotic Spacecraft for Asteroid Resource Prospecting and Characterization Phase II
In this project, Embry-Riddle 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 proposed spacecraft will address the first step towards In Situ Resource Utilization (ISRU) near Earth Object (NEO) bodies; namely it will prospect it with sample acquisition devices and characterize the NEO for ISRU potential. (D16 & D17)

High-Fidelity Modeling of Gust-Airfoil Interactions for UAVs
In this project, conducted in collaboration with WPAFB and Eglin AFB, AFRL scientists employ DOD HPC and ERAU computer facilities to conduct high-fidelity, Low-Reynolds, aeroelastic gust-airfoil interaction studies to model unsteady responses and their control for small UAVs operating in highly unsteady urban canyons. The focus is on modeling airfoil interactions with canonical upstream flow configurations including time-harmonic and sharp-edge gusts, vortices, and synthetic turbulence with prescribed characteristics tailored to a specified unsteady flight-path environment. (D15)

Hypersonic Flight of UAV as a Cargo Vessel
This project involved the computational fluid mechanics analysis of hypersonic flight parameters. (W02, W05, W10)

NOAA Gale: An Unmanned Aircraft for In-Situ Study of Tropical Cyclones
ERAU has developed an unmanned aircraft for NOAA, which deploys from a WP-3D Orion hurricane hunting aircraft. It is designed to provide real-time meteorological sampling from within tropical cyclones. (D22 & D23)

Pelican Water-Deployable UAV
This project is a development of a water-deployable UAV for marine operations for use in remote sensing applications, such as wildlife monitoring. A system originally developed for sUAS was redesigned to allow for launching from boats and recovery by water landing. A design was created and testing was performed to determine the optimum landing profile of a flying wing in a water recovery. (D27)

Drogue Re-fueling of Unmanned Aerial Vehicles
The Use of Orthogonal Arrays in Optimum Conditions for Drogue Re-fueling of Unmanned Aerial Vehicles
Using statistical and mathematical analysis methods, drogue movement during low speed flight of re-fueling UAVs is being studied. (W05, W08 & W10)

UAS Ground Collision Severity Evaluation
The objectives of this study are: (1) to analyze the response and failure behavior of several typical UAS impact with human body on the ground; and (2) establish the damage threshold of UAS and its correlation with the key parameters in the crash accidents (e.g. shape, size and materials of UAS; impact energy and impulse, etc). To achieve this goal, advanced computational modeling techniques (e.g. finite element method/FEM) will be used to simulate the typical UAS/people impact scenarios, and design guidance can be further suggested to improve the crash worthiness of UAS and safety of personnel on the ground. (D32, D33 & D34)

UAS Maintenance, Modification, Repair, Inspection, Training, and Certification Considerations
This research project identifies research topics specific to UAS maintenance, modification, repair, inspection, training, and certification considerations and was awarded as part of the ASSURE Center of Excellent program under guidance by the Federal Aviation Administration. It provides an in-depth analysis of maintenance operations and considerations that differ from the operation of manned aircraft. (D04, D30 & D31)
E2. Communications and Security
A Technology Survey and Regulatory Gap Analysis of Command, Control, and Communication (C3)
A survey of technologies for UAS command, control, and communication was performed. Given these technologies, the federal aviation regulations were assessed to determine which regulations were applicable, needed re-interpretation, needed revision, or were missing. (D22 & D24)

Drone Net – An Architecture for UAS Traffic Management
Multi-modal Sensor Networking Experiments
The details of this research are described under E1. Design, Development, and Validation. (P08, P09, P10 & P11)

Aerobiological Sampling Using UAVs
The details of this research are described under E1. Design, Development, and Validation. (W02 & W05)

Aero Foil Design for Low Speed and High Altitude Flight
The details of this research are described under E1. Design, Development, and Validation. (W02 & W05)

Aerodynamic and Acoustic Modeling of a VTOL UAV
The details of this research are described under E1. Design, Development, and Validation. (W02 & W05)

Development of a Fully 3-D Printed Fixed-Wing UAV
The details of this research are described under E1. Design, Development, and Validation. (D19, D27, D28 & D29)

Effects of Visual Interaction on Unmanned Aircraft Operator Situation Awareness in a Dynamic Simulated Environment
This study represents a longitudinal study to further the findings of an earlier study examining UAS operator situation awareness. It is hypothesized that increased situation awareness can be achieved for UAS operators through incorporation of operational reference cues (e.g., aural-visual, visual cueing) into the human-machine-interface (HMI) of the UAS ground control station (GCS). (W03, W06 & W07)

Free-Flying Unmanned Robotic Spacecraft for Asteroid Resource Prospecting and Characterization Phase II
The details of this research are described under E1. Design, Development, and Validation. (D16 & D17)

Guidance, Navigation, and Control (GNC) for Autonomous UAVs in Urban Environments
This project entails development, simulation, and testing of GNC algorithms to enable small UAS to operate autonomously in complex urban environments. These GNC algorithms include mapping unknown environments using processed vision and LI-DAR sensor data, optimal path planning with obstacle avoidance, and vision-guided navigation. (D17)

High-Fidelity Modeling of Gust-Induced Interactions for UAVs
The details of this research are described under E1. Design, Development, and Validation. (D15)

Human Computer Interfaces for Supervisory Control of Multi-mission, Multi-agent Autonomy (OSD12-HS1)
The Interface for Supervisory Adaptive Autonomous Control (ISAAC) was developed, providing a Decision Support System and intuitive Graphical User Interface with the goal of enabling supervisory control and ameliorating the problems of system complexity and workload facing operators of multiple unmanned/autonomous assets. (D09)

Pilot-in-the-Loop Mobil Research Test Bed
In this project, a Mobil UAV Ground Control Station (GCS) will be developed and implemented. The system will support aviation safety research with pilot-in-the-loop-capabilities using unmanned aerial systems platforms and where adverse flight conditions, such as subsystems failures, could be simulated in real-time to characterize pilot responses, control laws performance, and human-machine interactions. (D16)

Reinforcement Learning of Imperfect Sensor for Autonomous Aerial Vehicles
This study utilized the Signal Detection Theory (SDT) to model the sensor sensitivity on autonomous aerial vehicles, investigating the interaction between sensor sensitivity and the Reinforcement Learning algorithm on agent performance for target search and identification. (D09)

Static Testing of Propulsion Elements for Small Multicopter Unmanned Aerial Vehicles
The details of this research are described under E1. Design, Development, and Validation. (W13)

Surveillance Criticality for SAA
The details of this research are described under E2. Communications and Security. (D10)

Synthetic Jet-Based Robust MAV Flight Controller
The details of this research are described under E1. Design, Development, and Validation. (D10)

Telerobotic Perception During Asteroid and Mars Regolith Operations Sensor Research and Development
The details of this research are described under E1. Design, Development, and Validation. (D16 & D17)

UAS-Aircraft Rescue Fire Fighting Response Conceptual and Application Analysis
The application of UAS to support Aircraft Rescue Fighting response was selected to serve as an initial test case for the use of category representative UAS attribute performance models (APMs) and the Capability Analysis and Effectiveness Response for Unmanned Systems (CAERUS) M&S framework to investigate and analyze potential effectiveness. The intent was to ascertain the utility of employing UAS to support ARFF response efforts. (W01, W03, W06, W07 & W08)

UAS Ground Collision Severity Evaluation
The details of this research are described under E1. Design, Development, and Validation. (D32, D33 & D34)

UAS Maintenance, Modification, Repair, Inspection, Training, and Certification Considerations
The details of this research are described under E1. Design, Development, and Validation. (D04, D30 & D31)

UAV Flight Control with Macro-Fiber Composite Actuators
In this project, macro-fiber composite (MFC) actuator designs are being implemented on a medium-scale, fixed-wing UAV in order to achieve roll control. Several MFC actuator designs are evaluated through a combination of theoretical and experimental analysis. (D16, D17 & D18)

Unmanned System Attribute Performance Model Development
Our team of researchers has been actively compiling published performance data associated with commercially-off-the-shelf (COTS) group 1 to 3 fixed-wing and vertical takeoff and landing (VTOL) UAS in an effort to develop statistical models of each category (282 unique platform configurations captured, to date). (W03, W06 & W07)

Wake Vortex Safety Analysis in the Context of UAV Integration in the NAS
This project is a collaboration with several research organizations under the supervision of the FAA. The focus of the current research effort is on developing and employing variable-fidelity prediction approaches to examine safety implications of the future integration of variable-size UAS systems in the FAA Integrated Safety Assessment Model developed for analysis of risk implications of UAS operations in the terminal zones and beyond. (D15)
E4. Autonomy and Control
A Technology Survey and Regulatory Gap Analysis of Emergency Preparedness and Flight Termination (ERFT) Systems for UAS
A survey of technologies for UAS emergency recovery systems and flight termination systems was performed. Given these technologies, the federal aviation regulations were assessed to determine which applications were applicable, needed re-interpretation, needed revision, or were missing. (D22 & D24)

Aerobiological Sampling using UAVs
The details of this research are described under E1. Design, Development, and Validation. (D28)

Android Autopilot System
In this project, a flexible, cross-platform autopilot system capable of integrating autonomous behaviors—including obstacle avoidance, motion planning, and automatic task allocation—is being developed. The system is designed to run on Android and Linux operating systems and will be demonstrated using an Android smartphone as a complete autopilot solution including sensors, processing, and payload capability. (D27)

Application of Autonomous Soaring
The project, performed in collaboration with the Management Center Innsbruck (MI2), studied the application of autonomous soaring in order to extend the flight time of autonomous surveillance aircraft. (D20)

Development of a Fully 3-D Printed Fixed-Wing UAV
The details of this research are described under E1. Design, Development, and Validation. (D18, D27, D29 & D29)

Distributed Detection and Control of Collective Behaviors in Multi-Agent Systems
Multi-agent systems can be defined as a group of dynamical systems, in which certain emergent behaviors are exhibited through the local interaction among group members that individually have the capability of self-operating. The key issues we study include the analysis of network controllability and the design of coordination control protocol in order to achieve autonomous and optimal task allocation. Also, the detection and resilient control of emergent behaviors in large-scale multi-agent systems are of keen interest. Our analysis is conducted through modeling, detection, learning, and estimation of agent interaction dynamics and interaction topologies, and the design of resilient cooperative control protocols. (D30)

Free-Flying Unmanned Robotic Spacecraft for Asteroid Resource Proportioning and Characterization Phase II
The details of this research are described under E1. Design, Development, and Validation. (D18 & D17)

Guidance, Navigation and Control (GNC) for Autonomous UAVs in Urban Environments
The details of this research are described under E3. Modeling and Simulation. (M45). (D17)

Image Processing In Support of “Sense-and-Avoid” for UAS Operations
Our UAV is designed to be able to see—to determine the distances, azimuth and elevation angles of other flying objects. To do this, we use an integrated radar and image processing system, where the radar is used to provide distance information and rough angle information and image processing is used to acquire accurate angle information. (D17, D19, D21, D22, & D26)

Implementing Low Cost Two-Person Supervisory Control for Small Unmanned Aerial Systems
The purpose of this research was to examine literature, guidance, regulations, and other influencing factors to assess the necessity of redundancy management practices to identify recommended control strategies, procedures, operational criteria, and design of a proof of concept system to operate UAS with optimal safety and operational benefits within recommended and legislated boundaries. (W03 & W06)

Lypunov-based Adaptive Regulation of Limit Cycle Oscillations in Aircraft Wings using Synthetic Jet Actuators
A Synthetic Jet Actuator-based nonlinear adaptive controller is developed, which is capable of completely suppressing Limit Cycle Oscillations in UAS systems with uncertain actuator dynamics. A rigorous Lypunov-based stability analysis is utilized to provide asymptotic (zero steady-state error) plunging regulation, considering a detailed dynamic model of the plunging and plunging dynamics; and numerical simulation results are provided to demonstrate that simultaneous plunging and plunging suppression is achieved using the proposed control law. (D12 & D15)

Multi-Rotor Vector Control User Interface
This research represents the conceptual design of a multi-rotor control methodology to support observing areas outside direct line-of-sight (LOS) to locate objects of interest in tactical environments. It is hypothesized that the design of an interface featuring vector/autopilot control would reduce operator attentional demands. It is hypothesized that the design of an interface featuring vector/autopilot control would reduce operator attentional demands. (W06 & W07)

Pilot-in-the-Loop Mobil Research Test Bed
The details of this research are described under E3. Modeling and Simulation. (M45). (D16)

Smart Materials for UAV Flight Control and Morphing
This study involves the development of smart material actuators for UAV flight control and wing morphing. (D16, D17 & D18)

Synthetic Jet-Based Robust MAV Flight Controller
The details of this research are described under E1. Design, Development, and Validation. (D10)

Telerobotic Perception During Asteroid and Mars Regolith Operations Sensing, Research and Development
The details of this research are described under E3. Modeling and Simulation. (W03, W06 & W07)

UAS Sense and Avoid
This project involves the development of vision-based algorithms for identifying and estimating the location of uncooperative air traffic in support of sense and avoid operations. (D14, D16, D17, D21, D22 & the Eagle Flight Research Center)

UAV Autopilot Design Project
In this project, an autopilot will be designed for autonomous UAVs that will allow its use in the presence of unpredictable atmospheric disturbances while minimizing energy expenditures, thereby extending the range of UAVs. (D17)

UAV Flight Control with Macro-Fiber Composite Actuators
The details of this research are described under E3. Modeling and Simulation. (M45). (D16, D17 & D18)

Vision-Aided Navigation
This research includes identifying known landmarks or tracking visual features in order to provide inertial measurements when GPS is not available. (D17)

Simulation for secure and avoid studies

E5. Propulsion and Power
Development of a Fully 3-D Printed Fixed-Wing UAV
The details of this research are described under E1. Design, Development, and Validation. (D19, D27, D28 & D29)

High-Fidelity Modeling of Gust-Airfoil Interactions for UAVs
The details of this research are described under E1. Design, Development, and Validation. (D15)

Static Testing of Propulsion Elements for Small Multicopter Unmanned Aerial Vehicles
The details of this research are described under E1. Design, Development, and Validation. (W13)

Unmanned System Attribute Performance Model Development
The details of this research are described under E3. Modeling and Simulation. (W03, W06 & W07)

E6. Operational Environment
A Multispectral Sensing and Data Fusion Center at Embry-Riddle
The details of this research are described under E3. Modeling and Simulation. (M45). (D15, D40, P04, P06, W03 & W12)

DroneNet – An Architecture for UAS Traffic Management
Multi-modal Sensor Networking Experiments
The details of this research are described under E1. Design, Development, and Validation. (P08, P09, P10 & P11)

Emergency Management: Exploring Hard and Soft Data Fusion Modeling with UAS and Non-Governmental Human Intelligence Resources
This research establishes a framework for the extension of data fusion to emergency management (EM) in consideration of identified EM themes, UAS integrations, and behavioral limitations within an autonomous yet collaborative network. Hard sensor use in emergency management (e.g., satellites) has evolved to include governmental UAS but could have the potential to include non-governmental systems. Soft sensors in emergency management processes (people) include the flow of information from governmental and non-governmental sources. Data fusion in emergency management extension is a method of integrating governmental and non-governmental hard and soft information sources at varying levels of information automation for enhanced managerial decision making and utilization of limited resources for crisis management. (W12)

Emergency Response using UAS
The purpose of this research was to examine past uses, current and potential opportunities, and influencing factors associated with the use of UAS technology to support aviation accident and emergency response. (D09, W01, W03, W04, W06, W07 & W08)

Image Processing In Support of “Sense-and-Avoid” Operations
The details of this research are described under E4. Autonomy and Control. (D17, D19, D21, D22, & D26)

Implementing Low Cost Two-Person Supervisory Control for Small Unmanned Aerial Systems
The details of this research are described under E4. Autonomy and Control. (W03 & W06)

Integrating Unmanned Aircraft Systems into Airport Operations and Master Plans
The purpose of this research was to identify and establish best practices for development of a model supporting integration of UAS operations into airport master plans. This qualitative, observational, and multiple-case study incorporated the evaluation of airport master plan development (Fallen, NV), UAS operations and specific UAS airport integration issues. (P03, W03, W06, W08, W09)
Predictive UAS Emergency Management Sensor Detection Analysis and Application

This research provides data from various types of sensors that will likely be able to assist first responders and accident investigators. The applications potentially apply to all types of transportation. (D40, P04 & W03)

Public Perception of Unmanned Aerial Systems (UAS): A Survey of Public Knowledge Regarding Roles, Capabilities, and Safety While Operating Within the National Airspace System (NAS)

This research explores the understanding and depth of knowledge possessed by the public-at-large concerning safety issues surrounding the integration and future deployment of Unmanned Aerial Systems (UASs) in the National Airspace System (NAS). (D09, W03, & W07)

Static Testing of Propulsion Elements for Small Multicopter Unmanned Aerial Vehicles

The details of this research are described under E2, Communications and Security. (D10)

UAS at Airports

As part of an Airport Cooperative Research Program (ACRP) 03-42), Department of Transportation sub award under Boeing Hamilton, Embry-Riddle is part of a team that is developing guidance documents for UAS operations at or near airports. Different guidebooks will be developed to focus on different areas such as airport integration, stakeholder engagement, and best practices for public information on UAS/Airport policy with the goal of developing a toolkit for educational purposes. (D22, D36, P03 & W06)

UAS Ground Collision Severity Evaluation

The details of this research are described under E1, Design, Development, and Validation. (W13)

Surveillance Criticality for SAA

The details of this research are described under E2, Communications and Security. (D10)

An Unmanned Aircraft Classification Scheme to Aid the Development of Regulations for Operations in NAS

An investigation of UAS classification techniques and UAS concept-of-operations (CONOPS) was performed to determine how different aircraft and different missions are differentiated from one another. Using House of Quality analysis, rules were written to determine aircraft requirements given mission and, alternatively, mission envelope given aircraft. (D22)

Detect and Avoid (DAA)

ERAT is participating with the RTCA SC228 workshop to develop Minimum Operational Performance Standards (MOPS) for DAA. (D03)


The details of this research are described under E1, Design, Development, and Validation. (P08, P09, P10 & P11)

Human Factors: UAS GCS, Training, Certification, Procedures

This research seeks to provide guidance toward the development of new regulatory and guidance materials related to UAS control station design and ergonomics, pilot and crewmember training, and pilot and crewmember procedures and operational requirements. It will extend research being conducted under the ASSURE task A7 “UAS Human Factors Control Station Design Standards” and includes two parallel, collaborating efforts. One will focus upon the development of control station requirements and the other will focus on pilot and crew training and procedures. (D13)

Implementing Low Cost Two-Person Supervisory Control for Small Unmanned Aerial Systems

The details of this research are described under E4, Autonomy and Control. (W03 & W08)

Integrating Unmanned Aircraft Systems into Airport Operations and Master Plans

The details of this research are described under E6, Operational Environment. (P03, W03, W06, W08, W09)

Joint UAS and Air Traffíc Management

Air Traffic Students developed an application to allow UAS users to potentially upload to Flight Service Stations UAS flight plans for a block of airspace, much like the Military Grid Reference System. (P03, P06 & P07)

Privacy and Unmanned Aerial Systems Integration into the National Airspace System

The study identified underlying themes common to the dissent for UAS-related technologies as well as for UAS integration. Further, commonalities and occurrences in previous privacy-related confrontations were characterized in order to serve as a guide for efforts to resolve the UAS privacy quandary. (D09, W03 & W07)

Predictive UAS Emergency Management Sensor Detection Analysis and Application

The details of this research are described under E6, Operational Environment. (D40, P04 & W03)

Public Perception of Unmanned Aerial Systems (UAS): A Survey of Public Knowledge Regarding Roles, Capabilities, and Safety While Operating Within the National Airspace System (NAS)

The details of this research are described under E6, Operational Environment. (D09, W03, & W07)

State and Local Legislation: More Hurdles for Unmanned Aerial Systems Integration

This research covers the regulatory and legislative hurdles that currently exist for UAS stakeholders. This research analyzes state and local regulation to identify themes and trends in the development and passage of laws limiting UAS operations. (W03, W06 & W07)

UAS at Airports

The details of this research are described under E6, Operational Environment. (D22, D36, P03 & W06)

UAS Detection Utilizing Multimodal Technology

In this collaboration project, the colleges of Engineering and Aviation are using comparison radar, infrared imagery, and acoustics for detecting and identifying small UAS. (P03 & P09)

UAV Maintenance, Modification, Repair, Inspection, Training, and Certification Considerations

This research focuses on the non-military use of UAS technology and its ethical impact on privacy. (D02 & D05)

Wake Vortex Safety Analysis in the Context of UAS Integration in the NAS

The details of this research are described under E3, Modeling and Simulation (M&S), (D15)

Wiki on UAS

Focusing on the US industry only, and organized around major stakeholding, this wiki identifies and explores some of the looming challenges of integrating Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS), and proposes a potential solution path to ameliorate these challenges. The study concludes with a focus on the role of US aviation industry leadership in managing the collective motivations and abilities of the highlighted stakeholders as the national and global aviation system undergoes intense modernization through the 2025-2030 timeframe. (W11)

A2. The Business Enterprise


The details of this research are described under E1, Design, Development, and Validation. (P08, P09, P10 & P11)

Integrating Unmanned Aircraft Systems into Airport Operations and Master Plans

The details of this research are described under E6, Operational Environment. (P03, W03, W06, W08, W09)

Joint UAS and Air Traffic Management

The details of this research are described under A1, Regulation, Policy and Ethics. (P03, P05 & P07)

The Business Enterprise

In this project the development of a leasing market for UAS is researched. (D02)

UAS at Airports

The details of this research are described under E6, Operational Environment. (D22, D36, P03 & W06)

UAS Detection Utilizing Multimodal Technology

The details of this research are described under A1, Regulation, Policy and Ethics. (P03 & P09)

Unmanned Systems Career Opportunities, Educational Alignment, and Critical KSAs

Primary factors associated with the growth, availability, and sustainability of career and job opportunities in the unmanned systems field were examined and analyzed. These factors include critical topics, knowledge, skills, and abilities (KSA), and technologies; available educational programs; and anticipated economic development areas, as described by industry, government, and academic sources. (W06)

A3. Operational Employment

CFD Analysis of Aerodynamic Surface Finishes

The details of this research are described under E1, Design, Development, and Validation. (W05 & W10)


The details of this research are described under E1, Design, Development, and Validation. (P08, P09, P10 & P11)
Emergency Response using UAS
The details of this research are described under E8. Operational Environment. (D09, W01, W03, W06, W07 & W08)

Hypersonic Flight of UAV as a Cargo Vessel
The details of this research are described under E1. Design, Development, and Validation. (W02, W05, W10)

Joint UAS and Air Traffic Management
The details of this research are described under A1. Regulation, Policy and Ethics. (P03, P05 & P07)

The use of Orthogonal Arrays in Optimum Conditions for Drogue Re-fueling of Unmanned Aerial Vehicles
The details of this research are described under E1. Design, Development, and Validation. (W05, W08 & W10)

Meteorology Research Evaluation
Embry-Riddle is investigating the possibility of acquiring and using a small UAS for meteorological research. The assessment entails establishing precedents for such uses, identifying operational requirements to legally operate a UAS for such purposes, itemizing sensor and equipment capabilities for collecting and storing meteorological data, determining purchase and operating costs, providing options for obtaining different types of vehicles, establishing the flight profiles that would be employed, and examining inter-departmental collaboration potential. (Department asset)

Predictive UAS Emergency Management Sensor Detection Analysis and Application
The details of this research are described under E6. Operational Environment. (D40, P04 & W03)

Static Testing of Propulsion Elements for Small Multirotor Unmanned Aerial Vehicles
The details of this research are described under E1. Design, Development, and Validation. (W13)

UAS-Aircraft Rescue Fire Fighting Response Conceptual and Application Analysis
The details of this research are described under E3. Modeling and Simulation. (W01, W03, W06, W07 & W08)

UAS Detection Utilizing Multimodal Technology
The details of this research are described under A1. Regulation, Policy and Ethics. (P03 & P09)

UAS Operational Employment
Developed a national curriculum for Unmanned Aircraft System (UAS) technicians in collaboration with the Virginia Polytechnic Institute and the American Institute of Aeronautics and Astronautics. Recently edited a textbook on Small Unmanned Systems and Safety for the Unmanned Safety Institute. Currently developing a training curriculum for integration group II UAS into Embry-Riddles latest iteration of the UAS curriculum. Currently working on the development of an Unmanned Cognitive Risk Management (UVRM) tool for the U.S. Navy. This UVRM tool would dynamically measure risk in a complex UAS mission as variables change over the duration of the operation. (D05)

Use of UAS Support ARFF
The use of multiple UAS to support Aviation Rescue & Fire Fighting (ARFF) activities will be explored using mixed-methods data collection and analysis, and simulation. (D09, W03, W06 & W07)

Wake Vortex Safety Analysis in the Context of UAS Integration in the NAS
The details of this research are described under E3. Modeling and Simulation (M&S). (D15)

Wiki on UAS
The details of this research are described under E1. Design, Development, and Validation. (W11)

A4. Remote Sensing with UAS
A Multispectral Sensing and Data Fusion Center at Embry-Riddle
The details of this research are described under E3. Modeling and Simulation (M&S). (D17, D40, P04, P05, W03 & W12)

Aerobiological Sampling Using UAVs
The details of this research are described under E1. Design, Development, and Validation. (D28)

Android Autopilot System
The details of this research are described under E4. Autonomy and Control. (D27)

Application of Autonomous Soaring
The details of this research are described under E4. Autonomy and Control. (D20)

Detect and Avoid (DAA)
The details of this research are described under A1. Regulation, Policy, and Ethics. (D03)

Development of a Fully 3-D Printed Fixed-Wing UAV
The details of this research are described under E1. Design, Development, and Validation. (D19, D27, D29 & D29)

Development of Multispectral Passive Aircraft Detection and Classification
This project seeks to develop a small, lightweight, and low power sensor suite for detecting neighboring aircraft. The system is designed for small (under 55 lbs) UAS, and utilizes passive sensing from the RF, infrared, and visible spectra. (D19 & D26)

Drone Net – An Architecture for UAS Traffic Management
Multi-modal Sensor Networking Experiments
The details of this research are described under E1. Design, Development, and Validation. (P08, P09, P10 & P11)

Free-Flying Unmanned Robotic spacecraft for Asteroid Resource Prospecting and Characterization Phase II
The details of this research are described under E1. Design, Development, and Validation. (D16 & D17)

Intelligence, Surveillance and Reconnaissance
This study is a review of the technology and practices for remote sensing using different platforms including UAVs, satellite and cyber techniques. This project is in conjunction with the development of new curriculum as well as a chapter in a book. (P01)

Laser-based Remote and Short Range Sensors
This research focuses on new types of laser-based remote and short range sensors. (D25)

Predictive UAS Emergency Management Sensor Detection Analysis and Application
The details of this research are described under E6. Operational Environment. (D40, P04 & W03)

Surveillance Criticality for SSA
The details of this research are described under E2. Communications and Security. (D10)

Telerobotic Perception During Asteroid and Mars Regolith Operations Sensor Research and Development
The details of this research are described under E1. Design, Development, and Validation. (D18 & D17)

Unmanned Aerial Systems for Agricultural Monitoring
The project entails of the development of a low-cost UAS and payload capable of monitoring water levels of agricultural fields using visible and near-infrared spectrum photography. (D26)

A5. Education and Training
UAS Degree Program
A UAS degree program was developed at ERAU. Research on the effect of manned pilot experience on the ability to learn to fly UAS was performed. (D01)

A Multispectral Sensing and Data Fusion Center at Embry-Riddle
The details of this research are described under E3. Modeling and Simulation (M&S). (D17, D40, P04, P05, W03 & W12)

AE623 – “Atmospheric Guidance, Control and Navigation” (Lecture)
This class helps the students to design flight control laws and test them aboard a UAV test-bed platform. Instrumentation and hardware assembly are the principal characteristics of this class. (D16)

Aero Foil Design for Low Speed and High Altitude Flight
The details of this research are described under E1. Design, Development, and Validation. (W02 & W08)

Consumer Multitractor sUAS Evaluation and Assessment
A research team at Embry-Riddle developed and implemented a mixed-methods (i.e., sequential explanatory) research strategy to examine a series of consumer multitractor sUAS (instruments). The purpose was to measure and identify suitability of the systems as initial platforms for novice operators, as well as overall performance and cost-effectiveness of the platforms. (D09, W03, W08 & W07)

Crew Resource Management Training
This research involves the development of Crew Resource Management Training for UAS as part of the undergraduate degree and is in response to the FAA requirement for UAS crews to have CRM training. (D04, D05, D06, D13, W03 & W07)

Drone Net – An Architecture for UAS Traffic Management
Multi-modal Sensor Networking Experiments
The details of this research are described under E1. Design, Development, and Validation. (P08, P09, P10 & P11)

Evaluating the Effectiveness of Previous Manned Flight Training on UAS Flight
ERAU is engaged in a multi-faceted project evaluating the effectiveness of previous manned flight training on UAS flight. (D03 & D04)

Human Factors Considerations for UAS Procedures and Control Stations
ASSURE FAA Center of Excellence for Unmanned Aircraft Systems A10: A multi-university team led by Embry-Riddle investigating control station design, ergonomics, mobility, and environment and their impact on UAS procedures for fixed-wing UAS greater than 55 pounds operating within class G, non-towered airports, and low activity towered class D airports. (D13 & D22)
Human Factors: UAS GCS, Training, Certification, Procedures
The details of this research are described under A1. Regulation, Policy, and Ethics. (D13)

Joint UAS and Air Traffic Management
The details of this research are described under A1. Regulation, Policy and Ethics. (P03, P05 & P07)

Predictive UAS Emergency Management Sensor Detection Analysis and Application
The details of this research are described under E6. Operational Environment. (D40, P04 & W03)

Real World Design Challenge – STEM Education Outreach
The Real World Design Challenge (RWDC) is a national high school Science, Technology, Engineering, and Math (STEM) design competition focused on introducing students to concepts, topics, and methods associated with engineering disciplines and real world challenges. The five-year focus of the challenge was identified as unmanned aircraft systems and precision agriculture (starting in 2013). ERAU has been tasked with developing both the State and National challenges for RWDC, using a multi-disciplinary team of contributors from across the University. (W04 & W05)

Static Testing of Propulsion Elements for Small Multicopter Unmanned Aerial Vehicles
The details of this research are described under E1. Design, Development, and Validation. (W13)

UAS at Airports
The details of this research are described under E6. Operational Environment. (D22, D36, P03 & W06)

UAS Detection Utilizing Multimodal Technology
The details of this research are described under A1. Regulation, Policy and Ethics. (P03 & P09)

UAS Education and Training
Subject Matter Expert for the US Air Force’s UAS formal training unit developed and reviewed courseware, syllabi and classroom materials for all Air Force Unmanned Aircraft Systems training units. We partnered with AECOM to develop the X-GEN Medium Altitude Endurance UAS simulator and documentation that would meet both the academic requirements of the newly minted degree and industry demands. Study encompasses the development of a bold new course to integrate UAS simulation through the acquisition of the largest private UAS laboratory in the country. This lab has the capability to conduct research with MALE category UAS in both single pilot and crewed environments and to conduct training research with small UAS via a Sensfly eBee and DJI Inspire simulation software using both individual and crewed environments. (D05)

UAS ERAU Workshop
The project involves a module on UAS Integration into the NAS. (D09, D07 & D08)

UAS Flight Operations Capabilities
The UAS flight component of the Daytona Beach Campus has four Superbat small UAS, 2 HC-40 hybrid quadcopter airplanes, a Sensfly eBee, and DJI Inspires. The assets allow for research in vertical flight training methods, mapping environments, and crewed operations in field service environments. (department asset)

UAS Maintenance, Modification, Repair, Inspection, Training, and Certification Considerations
The details of this research are described under E1. Design, Development, and Validation. (D04, D30 & D31)

UAS Operational Employment
The details of this research are described under A3. Operational Employment. (D06)

Unmanned Systems Career Opportunities, Educational Alignment, and Critical KSAs
The details of this research are described under A2. The Business Enterprise. (W08)

Wiki on UAS
The details of this research are described under A1. Regulation, Policy, and Ethics. (W11)

A6. Human Performance and Machine Interaction
Advancement and Application of Unmanned Aerial System Human-Machine-Interface (HMI) Technology
The objective of this study is to identify common themes in the advancement and application of human-machine interface technologies in UAS control. This research includes review of available literature and associated technology designs to identify how the UAS community can best leverage this technology and interaction concepts to support safe and efficient operations of UAS. (D09, W03, W06, & W07)

Crew Resource Management Training
The details of this research are described under A5. Education and Training. (D13 & D22)

Human Factors Considerations for UAS Procedures and Control Stations
The details of this research are described under A5. Education and Training. (W12)

Human Factors Issues in Autonomous Aerial Vehicles
This project analyzes the effects of multiple-UAV monitoring, automation level, task uncertainty, systems reliability, time pressure, and pilot experiences on pilot performance of autonomous aerial vehicle missions. (D09)

Implicit Coordination and Awareness Displays in Unmanned Aircraft Systems (UAS)
Because UAS teams are distributed, there are communication issues due to loss of sensory cues and non-verbal cues from teammates, as well as limited bandwidth for diagnosis, problem solving, and collaboration among team members. In this project, two methods for overcoming some of these coordination limitations have been suggested – 1) awareness displays and 2) implicit communication - both of which are the focus of this research. (D13)

Joint UAS and Air Traffic Management
The details of this research are described under A1. Regulation, Policy and Ethics. (P03, P09 & P07)

Measuring Shared Mental Models in Unmanned Aircraft Systems
This ongoing research focuses on measuring the shared mental model of the distributed members of the team and examining the effect that the distributed nature of the team has had on communication and operational effectiveness. (D05 & D13)

Multi-Rotor Vector Control User Interface
The details of this research are described under E4. Autonomy and Control. (W06 & W07)

Pilot-in-the-Loop Mobil Research Test Bed
The details of this research are described under E3. Modeling and Simulation. (D16)

Predictive UAS Emergency Management Sensor Detection Analysis and Application
The details of this research are described under E6. Operational Environment. (D40, P04 & W03)

Reinforcement Learning of Imperfect sensor for autonomous aerial vehicles
The details of this research are described under A3. Operational Employment. (D09, W03, W06, & W07)

Surveillance Criticality for SAA
The details of this research are described under E2. Communications and Security. (D10)

UAS Detection Utilizing Multimodal Technology
The details of this research are described under A1. Regulation, Policy and Ethics. (P03 & P09)

UAS Ground Collision Severity Evaluation
The details of this research are described under E1. Design, Development, and Validation. (D32, D33 & D34)
### Project by Area Table

<table>
<thead>
<tr>
<th>Area</th>
<th>Projects/Research Areas</th>
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<tbody>
<tr>
<td><strong>E1. Design, Development, and Validation</strong></td>
<td>An Optionally Piloted Unmanned Aircraft System</td>
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<td><strong>E2. Communications and Security</strong></td>
<td>An Unmanned Aircraft Classification Scheme to Aid the Development of Regulations for Operations in the NAS</td>
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<tr>
<td><strong>E3. Modeling and Simulation (M&amp;S)</strong></td>
<td>Android Autopilot System</td>
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<td><strong>E5. Propulsion and Power</strong></td>
<td>Capability Analysis and Effectiveness Response for Unmanned Systems (CAERUS) Framework</td>
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<tr>
<td><strong>E6. Operational Environment</strong></td>
<td>CFD Analysis of Aerodynamic Surface Finishes</td>
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<tr>
<td><strong>A1. Regulation, Policy, and Ethics</strong></td>
<td>Consumer Multirotor sUAS Evaluation and Assessment</td>
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<td>Crew Resource Management Training</td>
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<td>Development of a Multispectral Passive Aircraft Detection and Classification</td>
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<td><strong>A6. Human Performance and Machine Interaction</strong></td>
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- A Multispectral Sensing and Data Fusion Center at Embry-Riddle
- A Technology Survey and Regulatory Gap Analysis of Command, Control, and Communication (C3)
- A Technology Survey and Regulatory Gap Analysis of Emergency Recovery and Flight Termination (ERFT) Systems for UAS
- Advanced Verification Techniques
- Advancement and Application of Unmanned Aerial System Human-Machine-Interface (HMI) Technology
- AE623 - "Atmospheric Guidance, Control and Navigation" (lecture)
- Aerofoil Design for Low Speed and High Altitude Flight
- Aerobiological Sampling using UAVs
- Aerodynamic Design Considerations for UAS during Refueling Operations
- Aerospace Safety Education
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- **Measuring Shared Mental Models in Unmanned Aircraft Systems**
- **Meteorology Research Evaluation**
- **Multi-Rotor Vector Control User Interface**
- **NOAA Gale: An Unmanned Aircraft for In-Situ Study of Tropical Cyclones**
- **Pelican Water-Deployable UAV**
- **Pilot-in-the-Loop Mobil Research Test Bed**
- **Predictive UAS Emergency Management Sensor Detection Analysis and Application**
- **Privacy and Unmanned Aircraft Systems Integration into the National Airspace System**
- **Public Perception of Unmanned Aircraft Systems (UAS): A Survey of Public Knowledge Regarding Roles, Capabilities, and Safety While Operating Within the National Airspace System (NAS)**
- **Real World Design Challenge - STEM Education Outreach**
- **Reinforcement Learning of Imperfect Sensor for Autonomous Aerial Vehicles**
- **Robust Nonlinear Aircraft Tracking Control using Synthetic Jet Actuators**
- **Smart Materials for UAV Flight Control and Morphing**
- **State and Local Legislation: More Hurdles for Unmanned Aerial Systems (UAS) Integration**
- **Static Testing of Propulsion Elements for Small Multirotor Unmanned Aerial Vehicles**
- **Surveillance Criticality for SAA**
- **Synthetic Jet-Based Robust MAV Flight Controller**
- **TeamAIR**
- **Telerobotic Perception During Asteroid and Mars Regolith Operations Sensor Research and Development**
- **The Business Enterprise**
- **The use of Orthogonal Arrays in Optimum Conditions for Drogue Re-fueling of Unmanned Aerial Vehicles**
|--------------------------------------|-------------------------------|----------------------------------|--------------------------|-------------------------|-----------------------------|

- UAS - Aircraft Rescue Fire Fighting Response Conceptual and Application Analysis
- UAS at Airports
- UAS Degree Program
- UAS Detection Utilizing Multimodal Technology
- UAS Education and Training
- UAS ERAU Workshop
- UAS Flight Operations Capabilities
- UAS Ground Collision Severity Evaluation
- UAS Maintenance, Modification, Repair, Inspection, Training, and Certification Considerations
- UAS Operational Employment
- UAS Regulation, Policy, and Ethics
- UAS Sense and Avoid
- UAV Autopilot Design Project
- UAV Flight Control with Macro-fiber Composite Actuators
- Unmanned Aerial Systems for Agricultural Monitoring
- Unmanned Aviation Systems (UAS) and Integration with National Air Space (NAS)
- Unmanned System Attribute Performance Model Development
- Unmanned Systems Career Opportunities, Educational Alignment, and Critical KSAs
- Use of UAS Support ARFF
- Vision-Aided Navigation
- Wake Vortex Safety Analysis in the Context of UAS Integration in the NAS
- Wiki on UAS
### Unmanned Aircraft System (UAS) Capabilities Matrix

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Expertise</th>
<th>Keywords</th>
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<tbody>
<tr>
<td>Ted Beneigh</td>
<td>Prime author of ERAU's BASS UAS Degree. Performing research on the effect of manned pilot experience on the ability to learn to fly UAS.</td>
<td>UAS Pilot experience</td>
</tr>
<tr>
<td>Daniel Friedenzohn</td>
<td>Studying how society is addressing privacy, regulatory, and business issues pertaining to UAS and how a leasing market will develop for UAS.</td>
<td>Legal, privacy, leasing, insurance, policy</td>
</tr>
<tr>
<td>Tom Haritos</td>
<td>Participating with the RTCA SC228 workgroup to develop Minimum Operational Performance Standards (MOPS) for DAA.</td>
<td>Remote Sensing Detect and Avoid Applications UAS Education and Training UAS Classification and Certification UAS Simulation applications Human-Computer Interaction (HCI)</td>
</tr>
<tr>
<td>Dan Macchiarella</td>
<td>Media specialist on issues of nondisclosure and security</td>
<td>Nondisclosure and security</td>
</tr>
<tr>
<td>Janet K. Marnane</td>
<td>Expertise in Crew Resource Management, Decision Making; Commercial Operations; and Aviation Regulation/legislation</td>
<td>Decision Making Commercial Operations CRM Aviation Regulation/Legislation</td>
</tr>
<tr>
<td>Clyde Rinkinen</td>
<td>Involved in ATM for 33 years and is a SME for integrating UAS into the NAS.</td>
<td>Integrating UAS into the NAS</td>
</tr>
</tbody>
</table>

### Principal Investigator | Expertise | Keywords
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<tr>
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<tbody>
<tr>
<td>Sarah Ochs</td>
<td>Manager of UAS Workshops/Short-Courses for Daytona Beach</td>
<td>Logistical Planner and Event Director</td>
</tr>
<tr>
<td>Dahai Liu</td>
<td>Expertise in Human Machine Interface in UAS; Supervisory Control of UASs; Reinforcement Learning in Autonomous UASs; Modeling and Decision.</td>
<td>Workload Situation Awareness Supervisory Control Reinforcement Learning: HMI; Decision Support</td>
</tr>
<tr>
<td>Mohammad Moallemi</td>
<td>Sense and avoid systems, Pilot-controller interactions, Separation and collision avoidance functions, Airborne surveillance systems and equipment, Modeling &amp; simulation of UAS.</td>
<td>Technology Operational Safety Situation awareness UAS in the NAS Air Traffic Management</td>
</tr>
<tr>
<td>Sergey V. Drakunov</td>
<td>Expertise in control algorithms design for autopilots for autonomous UASs and multiple UAS formations.</td>
<td>Autopilots for autonomous UASs Control for multiple autonomous UASs formations</td>
</tr>
<tr>
<td>William MacKunis</td>
<td>Expertise in Feedback Tracking Control of an Unmanned Aerial Vehicle.</td>
<td>Autopilots for autonomous UASs</td>
</tr>
<tr>
<td>Joseph Cerreta</td>
<td>Research to develop regulatory and guidance materials related to UAS control station design and ergonomics, pilot and crewmember training, and pilot and crewmember procedures and operational requirements.</td>
<td>UAS Human Factors Ground Control Station Crewmember Training UAS Operational Training UAS Operational Procedures</td>
</tr>
<tr>
<td>Pat (Richard) Anderson</td>
<td>Faculty Advisor for NASA UAS Challenge to create an optionally piloted UAS surrogate with sense-and-avoid capability. Expertise in UAS guidance navigation and control.</td>
<td>Optionally piloted vehicle guidance, navigation, and control (GNCC) aircraft certification</td>
</tr>
<tr>
<td>Principal Investigator</td>
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</tr>
<tr>
<td>Richard Prazenica</td>
<td>Specializes in: Guidance, navigation, and control of autonomous UAVs in complex environments; vision-aided navigation; terrain mapping from vision and LIDAR data; path planning and obstacle avoidance; UAV sense and avoid; smart materials for UAV flight control.</td>
<td>Smart Materials, Smart Structures, Adaptive Structures, Morphing Wings, Structural Health Monitoring</td>
</tr>
<tr>
<td>Dae Won Kim</td>
<td>Specializes in smart materials and systems, and structural health monitoring.</td>
<td>RF engineering communications, sensing radar, passive radar, sense-and-avoid</td>
</tr>
<tr>
<td>William C. Barott</td>
<td>Specializes in RF engineering, including passive radar.</td>
<td>UAS sensing, sense-and-avoid acoustics, propulsion</td>
</tr>
<tr>
<td>Brian Butka</td>
<td>Interested in sensing of UAVs with radar and acoustics, and electrical system design.</td>
<td>sense-and-avoid acoustics, propulsion</td>
</tr>
<tr>
<td>Jianhua Liu</td>
<td>Radar expertize and faculty advisor for image processing for &quot;Sense-and-avoid&quot; for NASA UAS AOC competition.</td>
<td>sense-and-avoid radar, image processing communication</td>
</tr>
<tr>
<td>Richard Stansbury</td>
<td>Specializes in Technology surveys/regulatory gap analysis of UAS sub-systems; UAS classification / categorization; UAS sense-and-avoid; ADS-B based surveillance for commercial space.</td>
<td>UAS/NAS Integration, ADS-B, UAS sense-and-avoid</td>
</tr>
<tr>
<td>Massood Townshidnejad</td>
<td>Has performed UAS NAS Integration studies with FAA Technology Center (technology surveys and regulatory gap analyses).</td>
<td>UAS NAS Integration</td>
</tr>
<tr>
<td>Eric Coyle</td>
<td>Expertize in System design and integration including novel applications of new technologies; Integration of advanced ground-based autonomy algorithms into UAS, development of technologies to shorten design and integration cycles; and rapid development of small UAS systems using low-cost components.</td>
<td>UAS integration autonomy, 3D printing, mobile devices, student teams</td>
</tr>
<tr>
<td>Patrick Currier</td>
<td>Expertize in Unmanned and Autonomous Vehicles; mechanisms and robotics.</td>
<td>Unmanned and Autonomous Vehicles mechanism and robotics</td>
</tr>
<tr>
<td>Charles Reinholtz</td>
<td>Expertize in UAS NAS Integration.</td>
<td>UAS NAS Integration</td>
</tr>
<tr>
<td>Timothy Wilson</td>
<td>Chair &amp; Professor</td>
<td>ECSSE, Daytona Beach, COE, <a href="mailto:wilson@erau.edu">wilson@erau.edu</a></td>
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**UNMANNED AERIAL SYSTEMS • RESEARCH, DEVELOPMENT, EDUCATION, & TRAINING**

**EMBRY-RIDDLE AERONAUTICAL UNIVERSITY**
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<tr>
<th>Principal Investigator</th>
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<tr>
<td><strong>D29</strong> Heidi Steinhauser</td>
<td>Chair &amp; Associate Professor Freshman Engineering</td>
<td>Fixed-wing UAV 3-D printing technology. Design, development and validation of UAV.</td>
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<td>Daytona Beach COE</td>
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<tr>
<td><strong>D30</strong> John M. Robbins</td>
<td>Associate Professor Aeronautical Science</td>
<td>Precision Agriculture Remote Sensing UAS Applications UAS Operations and Integration UAS Maintenance, Training, Policy, and Regulation</td>
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<td>Daytona Beach COA</td>
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<td><a href="mailto:ROBBINSJ@erau.edu">ROBBINSJ@erau.edu</a></td>
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<tr>
<td><strong>D31</strong> Mitchell A. Geraci</td>
<td>Associate Professor Aviation Maintenance</td>
<td>UAS Maintenance Policy UAS Maintenance Regulation UAS Maintenance Training</td>
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<td>Daytona Beach COA</td>
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<td><a href="mailto:geracim@erau.edu">geracim@erau.edu</a></td>
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<tr>
<td><strong>D32</strong> Feng Zhu</td>
<td>Assistant Professor Mechanical Eng</td>
<td>UAS in the NAS Finite element Method Computational Modeling. Crashworthiness of UAS, and safety of personnel on the ground</td>
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<td>Dayton Beach COE</td>
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<td><a href="mailto:ZHU@erau.edu">ZHU@erau.edu</a></td>
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<tr>
<td><strong>D33</strong> Eduardo Divo</td>
<td>Interim Chair &amp; Associate Professor Mechanical Eng</td>
<td>UAS in the NAS Finite element Method Computational Modeling. Crashworthiness of UAS, and safety of personnel on the ground</td>
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<td><a href="mailto:DIVD@erau.edu">DIVD@erau.edu</a></td>
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<tr>
<td><strong>D34</strong> Victor Huayamave</td>
<td>Assistant Professor Mechanical Eng</td>
<td>UAS in the NAS Finite element Method Computational Modeling. Crashworthiness of UAS, and safety of personnel on the ground</td>
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<td><a href="mailto:HUAYAMAV@erau.edu">HUAYAMAV@erau.edu</a></td>
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<tr>
<td><strong>D35</strong> Thomas (Tianyu) Yang</td>
<td>Professor Electrical and Computer Engineering</td>
<td>Study of the analysis of network controllability and the design of coordination control protocol in order to achieve autonomous and optimal tasking allocation. Detection and resilient control of emergent behaviors in large scale multi-agent systems.</td>
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<td>Daytona Beach COE</td>
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<td></td>
<td><a href="mailto:Yang49@erau.edu">Yang49@erau.edu</a></td>
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<tr>
<td><strong>D36</strong> Vitaly S. Guzhva</td>
<td>Professor Finance</td>
<td>Studying the impact of UAS operations on ATM safety; UAS rule-making support; UAS-related economic analysis.</td>
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<td>Dayton Beach COB</td>
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<td><a href="mailto:guzhva@erau.edu">guzhva@erau.edu</a></td>
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<tr>
<td><strong>D37</strong> William A. Engblom</td>
<td>Professor Mechanical Engineering</td>
<td>Specializes in high fidelity UAS aerodynamics simulation; Tethered UAS; UAS aircraft configuration design; UAS propulsion system selection and design.</td>
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<td>Daytona Beach COE</td>
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<td><a href="mailto:Engblom@erau.edu">Engblom@erau.edu</a></td>
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<tr>
<td><strong>D38</strong> Borja Marots</td>
<td>Research Engineer Flight Research Center</td>
<td>Specializes in UAS controls, flight testing, system design and development.</td>
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<td><a href="mailto:CARBALLB@erau.edu">CARBALLB@erau.edu</a></td>
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<tr>
<td><strong>D39</strong> Remzi Seker</td>
<td>Professor Electrical and Computer Engineering</td>
<td>Expertize in UAS Cyber Security.</td>
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<td><a href="mailto:seker@erau.edu">seker@erau.edu</a></td>
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<tr>
<td><strong>D40</strong> Troy Henderson</td>
<td>Assistant Professor Aerospace Engineering</td>
<td>Specializes in guidance, navigation and control; Vision-aided navigation; Terrain mapping; Obstacle detection, tracking, and identification; Image processing; Mission/Experiment planning.</td>
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<td><a href="mailto:HENDERTS@erau.edu">HENDERTS@erau.edu</a></td>
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<tr>
<td><strong>P01</strong> Jon Haass</td>
<td>Associate Professor Cyber Sec &amp; Intelligence</td>
<td>Expertize in UAS Cyber Security &amp; Intelligence.</td>
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<td>Prescott COA</td>
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<tr>
<td><strong>P02</strong> Vincent Pujalte</td>
<td>Assistant Professor Applied Aviation Sci</td>
<td>Specializes in flight control system integration; teaches AS473 and AS220.</td>
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<td><a href="mailto:pujalte@erau.edu">pujalte@erau.edu</a></td>
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<tr>
<td>Principal Investigator</td>
<td>Expertise</td>
<td>Keywords</td>
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<tr>
<td>Sarah Nilsson</td>
<td>Assistant Professor of Aeronautical Science</td>
<td>Prescott, COA, <a href="mailto:FishECS@erau.edu">FishECS@erau.edu</a></td>
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<tr>
<td></td>
<td>Specializes in UAS Law in the United States; UAS International Law; UAS Management; Anti-Drone Technology; UAS Litigation; Integrating UAS into Airport Master Plans; UAS Local Ordinances in the US; UAS Privacy and Trespass Issues; UAS Education under Part 101 and 107.</td>
<td>UAS Law; Litigation; Local Ordinances in the US; State Laws; Risk Management; Anti-Drone; Part 107; Privacy; Airport Master Plans; UAS International Law</td>
</tr>
<tr>
<td>Erin E. Bowen</td>
<td>Dept. Chair &amp; Associate Professor of Behavioral &amp; Safety Sciences</td>
<td>Prescott, COA, <a href="mailto:bowene1@erau.edu">bowene1@erau.edu</a></td>
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<tr>
<td></td>
<td>Specializes in UAS Applications for Disaster Scene Analysis, Aviation Psychology, and UAS Training Design &amp; Assessment</td>
<td>Training Procedures, Assessment/Performance</td>
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<tr>
<td>Johnny L. Young</td>
<td>Assistant Professor of Unmanned Aerial Systems</td>
<td>Prescott, COA, <a href="mailto:YOUNG42@erau.edu">YOUNG42@erau.edu</a></td>
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<td></td>
<td>Specializes in the integration of UAS into the National Airspace System, use of UAS in Aircraft Accident investigation, UAS Management, UAS Education under Part 107, UAS Flight Instruction, and Payload Operation.</td>
<td>UAS Integration, Accident Investigation, Risk Management, UAS Flight Instruction, Payload Operation</td>
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<td>Timothy B. Holt</td>
<td>Interim Dean &amp; Associate Professor of Aeronautical Science</td>
<td>Prescott, COA, <a href="mailto:Holtt@erau.edu">Holtt@erau.edu</a></td>
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<td></td>
<td>Recognized expertise in both underwater acoustic and surface imagery analysis. Instructor and evaluator on all modes of Non-Acoustic processing (RADAR, Infrared, electronic surveillance processing, imagery and magnetic anomaly). System safety, rescue operations, and UAS integration are also areas of expertise. The ASSURE point of contact for the Prescott campus.</td>
<td>Data Analysis, Safety, Integration, ASSUR</td>
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<tr>
<td>Jennifer C. Perry</td>
<td>Assistant Professor of Air Traffic Management</td>
<td>Prescott, COA, <a href="mailto:penryj13@erau.edu">penryj13@erau.edu</a></td>
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<td></td>
<td>Air Traffic Management; National Aerospace System; UAS law in the United States; Aviation Simulation; Human Factors and Education; UAS International Law; UAS Management; Anti-Drone Technology; Integrating UAS into Airport Master Plans; UAS Education under Part 101 and 107.</td>
<td>ATM, UTM, UAS Law, Human Factors, Simulation, Risk Management, Aviation Education, Anti-Drone, Part 107, Privacy, Airport Master Plans</td>
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<td>Stephen Bruder</td>
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<td>Samuel B. Siewert</td>
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<td>Iacopo Gentilini</td>
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<tr>
<td>David Thirtyacre</td>
<td>Chair of Department of Flight Worldwide</td>
<td>Prescott, COA, <a href="mailto:thirtyard@erau.edu">thirtyard@erau.edu</a></td>
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<td></td>
<td>UAS operations, formal flight test, Low Observable (LO) Design, LO Operations, Sensors, Human-Machine Interface, Air Combat, Aerodynamics, Pilot training, STEM education, Professional Development Course, UAS Competition, UAS Mobile UAS unit.</td>
<td>Flight test, unmanned aircraft operations, Training, System integration, UAS application UAS Workshops, UAS Challenge, Sensors</td>
</tr>
<tr>
<td>Orin Godsey</td>
<td>Associate Professor of Aeronautics Worldwide</td>
<td>Prescott, COA, <a href="mailto:godseyo@erau.edu">godseyo@erau.edu</a></td>
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<td></td>
<td>Specializes in the aerodynamics of flight and wing design incorporating low speed and high altitude operations, weather influences on operations at low speeds, variable pitch propeller design and aerodynamics, and inflight refueling and flight characteristics.</td>
<td>Refueling of UAV Aerodynamics, Wing and Propeller design Flight</td>
</tr>
<tr>
<td>David Ison</td>
<td>Assistant Professor of Worldwide</td>
<td>Prescott, COA, icoa, ICARUS Research Group</td>
</tr>
<tr>
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<td>Specializes in the integrating of UAS into Airport Master Plans; Human Machine Interface; Disaster Response and Recovery; Privacy; Legislation and UAS; Low Cost Two-Person Supervisory Control for UAS; Privacy issues of UAS legislation.</td>
<td>Integrating UAS into Airport Master Plans Human Machine Interface Disaster Response &amp; Recovery Privacy, Legislation and UAS Low Cost Two-Person Supervisory Control for uUAS Legislation; regulation; privacy</td>
</tr>
</tbody>
</table>
| W04 | Robert Deters  
Assistant Professor  
Worldwide  
COA  
DETERSRI1@erau.edu | Specializes in Precision Agriculture Application and STEM Education; Real World Design Challenge. | Precision Agriculture Application  
STEM Education  
Design |
|---|---|---|---|
| W05 | Ian McAndrew  
Department Chair Graduate Studies  
Worldwide  
COA  
mcan4411@erau.edu | Specializes in the aerodynamics of flight and wing design incorporating low speed and high altitude operations, weather influences on operations at low speeds, variable pitch propeller design and aerodynamics, and inflight refueling and flight characteristics. | UAV refueling stability  
Weibull Analysis  
UAV Maintenance and Integration into the ATC where English is not a primary language  
Aerodynamics  
Wing and Propeller design  
Statistical analysis of flight data |
| W06 | Brent Terwilliger  
Assistant Professor  
Aeronautics  
Worldwide  
COA  
terwillb@erau.edu | Specializes in the design, development, integration, test, application, and evaluation of unmanned systems and human-machine-interfaces; UAS regulatory and operational environment; Modeling and simulation (M&S); Situational awareness; STEM education; Curricula development and execution; Documentation. | Unmanned aircraft, system integration, unmanned system application, HMI, M&S, UAS curricula  
development, documentation, UAS |
| W07 | Dennis Vincenzi  
Department Chair  
Undergraduate Studies  
Worldwide  
COA  
vincenzi@erau.edu | Specializes in unmanned systems, including unmanned aerial systems (UAS), unmanned ground vehicles (UGVs), and robotic systems; Situation awareness; Modeling and simulation (M&S); System design, development, integration, and test; Application, operation, and support of UAS; regulatory environment; Human-machine-interface. | UAS, UGVs, and robotic systems; Situation awareness; Modeling and simulation (M&S); System design, development, integration, and test; Human-machine-interface |
| W08 | Ken Witcher  
Dean  
Aeronautics  
Worldwide  
COA  
witchea@erau.edu | Specializes integrating UAS into Airport Master Plans; Refueling of unmanned aerial vehicles; Weibull analysis of docking probability of unmanned aircraft refueling; low speed stability and weather implications for landing and taking off. | Integrating UAS into Airport Master Plans  
Refueling of UAV  
Weibull analysis |
| W09 | David Worrells  
Associate Professor  
Aeronautics  
Worldwide  
COA  
WORRELLD@erau.edu | Specializes in integrating UAS into Airport Master Plans, and integration of UAS in to the National Airspace System. | Integrating UAS into Airport Master Plans  
Integration of UAS in National Airspace System |
| W10 | Elena Vishnevskaya  
Assistant Professor  
Worldwide  
COAS  
NAVARRJ1@erau.edu | Mathematical modelling and data analysis calculations with experimental design; Weibull analysis of docking probability of unmanned aircraft refueling; low speed stability and weather implications for landing and taking off. | Refueling of UAV  
Integration into ATC where English is not a primary language |
| W11 | Kelly George  
Associate Professor  
Worldwide  
COAS  
georgeb8@erau.edu | Co-authored a Wiki on UAS for the DAS 735 course (ERAU Ph.D. in Aviation program) | Economics  
Developing industries  
Monetary & fiscal policy |
| W12 | Sonya A. H. McMullen  
Assistant Professor  
Graduate Studies  
Worldwide  
COA  
hall76d@erau.edu | Specializes in data fusion methods with emergency management; processes for enhanced proactive decision-making | Data fusion  
Crisis Management  
Non-Governmental Human Intelligence  
Mediums |
| W13 | Stefens Kleinke  
Assistant Professor  
Aeronautics  
Worldwide  
COA  
lklimes@erau.edu | Specializes in modeling & simulation, human-machine interaction, development of aeronautical planning and decision making; sensor technology, integration, & application in UAS operations; aerodynamics and aircraft performance; propulsion systems | Training, Education, Operation,  
Sensors, Application, Systems  
Development & Integration,  
Aerodynamics & Aircraft Performance, Simulation |