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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

EMBRY-RIDDLE
Aeronautical University

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 Liu, 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.

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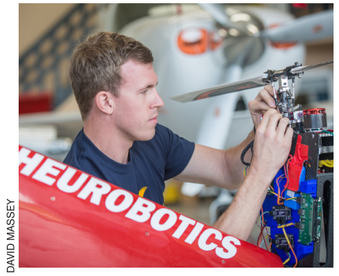

DAVID MASSEY

CONNOR McSHANE

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EMBRY-RIDDLE AERONAUTICAL UNIVERSITY UNMANNED AIRCRAFT SYSTEM CAPABILITIES

DAVID MASSEY

Optionally piloted aircraft in the Eagle Flight Research Center.

Engineering

EI. 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-254. (D20)

Aero Foil Design for Low Speed and High Altitude Flight
This is a Numerical and Wind tunnel experiment using Taughi 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. (D28)

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 (surrogate) 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. (W05 & 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 Multi-modal Sensor Networking Experiments
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, P, 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) form 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 is a project to develop a water-deployable UAV for maritime 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)

UAS of various classes and types each must be evaluated as part of the development and testing process.

Robust Nonlinear Aircraft Tracking Control using Synthetic Jet Actuators
A robust, nonlinear tracking control strategy was developed for an aircraft equipped with synthetic jet actuators (SJA). The control law was shown to yield zero steady-state error trajectory tracking in the presence of dynamic system uncertainty, actuator nonlinearity, and unknown, nonlinear external disturbances (e.g., wind gusts). (D12)

Static Testing of Propulsion Elements for Small Multirotor Unmanned Aerial Vehicles
This project: researches established methodologies that allow standardized testing and comparison between sUAS propulsion systems; investigates the ability to make performance predictions based on the standardized tests; and then utilizes the gathered performance data for more representative simulation and modeling of sUAS in the Aerial Robotics Virtual simulation lab. (W13)

Synthetic Jet-Based Robust MAV Flight Controller
This project conducts theoretical and high-fidelity numerical analyses of a UAV robust flight controller employing synthetic-jet actuators (SJAs). The technology demonstration feasibility study focuses on SJA-based suppression of gust-induced airfoil flutter. (D15)

TeamAIR
This project involved the design and construction of a fixed-wing UAS for the Association of Unmanned Vehicle Systems International (AUVSI) Small UAS engineering competition. This UAS is capable of autonomously searching a military airfield for static targets. (P02)

Telerobotic Perception During Asteroid and Mars Regolith Operations Sensor Research and Development
In this project, Embry-Riddle together with NASA Kennedy Space Center, is investigating the effect of difficult lighting and dust conditions on Telerobotic Perception Systems to better assess and refine regolith operations for asteroid, Mars, and polar lunar missions. (D16 & D17)

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 refueling UAVs is being studied. (W05, W08 & W10)

UAS Ground Collison 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 crashworthiness 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)

DAVID MASSEY

Surveillance Criticality for SAA
This research will determine the sufficiency of existing airborne surveillance equipment on manned aircraft (e.g. transponders and/or ADS-B) in providing separation provision and collision avoidance functions for UAS. The research will tackle the question of how the current technologies should be modified to be adaptable for UAS and what novel capabilities are required. Safety evaluation of separation and collision avoidance functions and hazard assessment will be performed, supported by airborne surveillance systems and equipment to identify aircraft systems and equipment standards shortcomings to meet NAS operational safety objectives. (D10)

Unmanned Aviation Systems (UAS) and Integration with National Air Space (NAS)
This project involves the role of secure communications in the deployment of ADS-B for both manned and unmanned flight. Similarities and differences are determined for secure communication – ground to air, air to satellite, ground to satellite, air to air. (P01)

E3. Modeling and Simulation (M&S)

A Multispectral Sensing and Data Fusion Center at Embry-Riddle
This multi-campus project set up a virtual data and analysis capability (Multispectral Sensing and Data Fusion Center) for sensor data collected by small UAS and other platforms. This effort will support the Predictive UAS Emergency Management Sensor Detection Analysis and Application project as well as future projects. Currently, the virtual lab capability is being used to collect sensor data of a target grid for the development of a predictive model of commercial off-the-shelf sensor capabilities. (D17, D40, P04, P05, W03 & W12)

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)

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

Capability Analysis and Effectiveness Response for Unmanned Systems (CAERUS) Framework
The CAERUS framework was developed to support detailed examination of performance and suitability of unmanned system configurations, including UAS, to perform envisioned applications. The framework features use of M&S concepts and techniques to gain insight regarding identifying design issues, configuration considerations, and system performance. (W01, W03, W06, W07, & W08)

Visual depiction of UAS in orbit over stationary object of interest (target), generated using CAERUS Framework.

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 Situational Awareness in a Dynamic Simulated Environment
This study represents a longitudinal study to further the findings of an earlier study examining UAS operator situational awareness. It is hypothesized that increased situational awareness can be achieved for UAS operators through incorporation of operational reference cues (e.g., aural vibrational, 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 UAVs to operate autonomously in complex urban environments. These GNC algorithms include mapping unknown environments using processed vision and LIDAR sensor data, optimal path planning with obstacle avoidance, and vision-aided navigation. (D17)

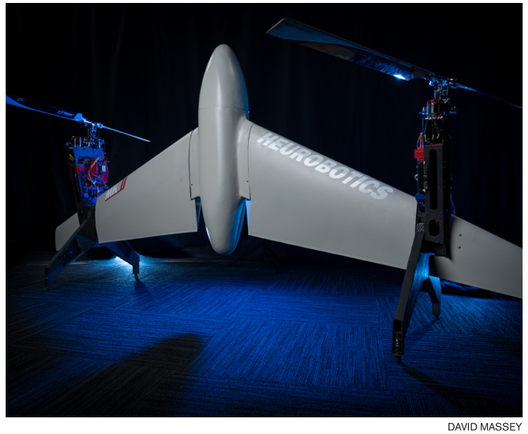
High-Fidelity Modeling of Gust-Airfoil Interactions for UAVs
The details of this research are described under E1. Design, Development, and Validation. (D15)

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 response, 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 Multirotor Unmanned Aerial Vehicles
The details of this research are described under E1. Design, Development, and Validation. (W13)



DAVID MASSEY

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. (D15)

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 Fire 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) aileron actuators are designed for implementation on a medium-scale, fixed-wing UAV in order to achieve roll control. Several MFC aileron 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 UAS 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 Recovery 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 advanced 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 (MCI), 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. (D19, D27, D28 & 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 tasking 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. (D35)

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
The details of this research are described under E3. Modeling and Simulation (M&S). (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 stratagem, processes and procedures, operational criteria, and design of a proof of concept system to operate sUAS with optimal safety and operational benefits within recommended and legislated boundaries. (W03 & W06)

Lyapunov-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 UAV systems with uncertain actuator dynamics. A rigorous Lyapunov-based stability analysis is utilized to provide asymptotic (zero steady–state error) plunging regulation, considering a detailed dynamic model of the pitching and plunging dynamics; and numerical simulation results are provided to demonstrate that simultaneous pitching 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 allocation, supporting the maintenance of localized situational awareness. (W06 & W07)

Pilot-in-the-Loop Mobil Research Test Bed
The details of this research are described under E3. Modeling and Simulation (M&S). (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. (D15)

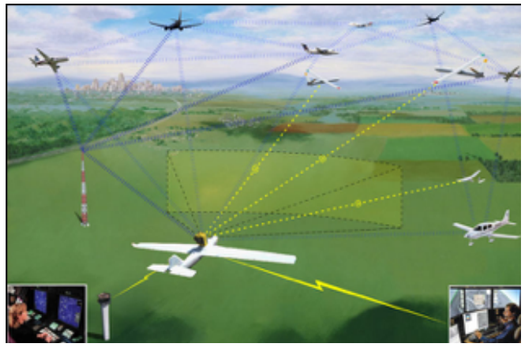
Telerobotic Perception During Asteroid and Mars Regolith Operations Sensor Research and Development
The details of this research are described under E1. Design, Development, and Validation. (D16 & D17)

UAS 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. (D11)

UAV Flight Control with Macro-Fiber Composite Actuators
The details of this research are described under E3. Modeling and Simulation (M&S). (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 Multirotor 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 (M&S). (D17, D40, P04, P05, W03 & W12)

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)

Emergency Management: Exploring Hard and Soft Data Fusion Modeling with UAS and Non-Governmental Human Intelligence Mediums
This research establishes a framework for the extension of data fusion to emergency management (EM) in consideration of identified EM themes, UAS integration, 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 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)

JOE CERRETA

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 perception 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 Multirotor 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)

UAS at Airports
As part of an Airport Cooperative Research Program (ACRP 03-42), Department of Transportation sub award under Booz Allen 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. (D32, D33 & D34)

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)

Application

A1. Regulation, Policy, and Ethics

A Technology Survey and Regulatory Gap Analysis of Command, Control, and Communication (C3)
The details of this research are described under E2. Communications and Security. (D22 & D24)

A Technology Survey and Regulatory Gap Analysis of Emergency Recovery and Flight Termination (ERFT) Systems for UAS
The details of this research are described under E4. Autonomy and Control. (D22 & D24)

An Unmanned Aircraft Classification Scheme to Aid the Development of Regulations for Operations in NAS
An investigation of current 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 envelop given aircraft. (D22)

Detect and Avoid (DAA)
ERAU is participating with the RTCA SC228 workgroup to develop Minimum Operational Performance Standards (MOPS) for DAA. (D03)

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)

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 & W06)

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
Air Traffic Students developed an application to allow UAS users to potentially upload to Flight Service Stations sUAS flight plan for a block of airspace, much like the Military Grid Reference System. (P03, P05 & P07)

Privacy and Unmanned Aerial Systems Integration into the National Airspace System
This 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 (UAS) Integration
This research covers the regulatory and legislative hurdles that currently exist for UAS stakeholders. This research analyzes state and local legislation 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)

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 Regulation, Policy, and Ethics
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 stakeholders, 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 airspace system undergoes intense modernization through the 2025-2030 timeframe. (W11)

A2. The Business Enterprise

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)

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)

DAVID MASSEY

The usage capabilities are widespread. As seen here, this quadcopter type UAS can be mounted with a variety of sensors such as cameras, infrared detection systems, or other analysis tools.

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 sustainment of career and job opportunities in the unmanned systems field were examined and analyzed. These factors included critical topics, knowledge, skills, and abilities (KSAs), 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)

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)

Emergency Response using UAS
The details of this research are described under E6. 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)

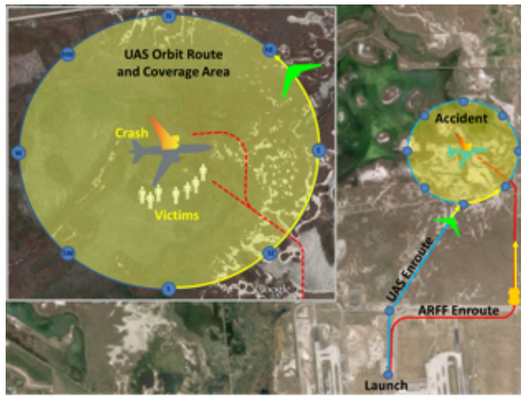
The use of Orthogonal Arrays in Optimum Conditions for Drogue Re-fueling of Unmanned Aerial Vehicles
The details of this research are described under E1. Design, Development, and Validation. (W05, W08 & W10)

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 Application Analysis – UAS ARFF Theory of Operation

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 A1. Regulation, Policy, and Ethics. (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, D28 & 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 UAS, satellites 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 focusses 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 SAA
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. (D16 & 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 & W05)

Consumer Multirotor 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 multirotor 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 platforms. (D09, W03, W06 & 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)


DAVID MASSEY

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 & W06).

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 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 Long 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 vis a Sensefly 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. (D05, D07, & D08)

UAS Flight Operations Capabilities
The UAS flight component of the Daytona Beach Campus has four Superbat small UAS, 2 HQ-40 hybrid quadcopter airplanes, a Sensefly 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)

JOE CERRETA

UAS Operational Employment
The details of this research are described under A3. Operational Employment. (D05)

Unmanned Systems Career Opportunities, Educational Alignment, and Critical KSAs
The details of this research are described under A2. The Business Enterprise. (W06)

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. (D04, D05, D06, D13, W03 & W07)

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

Effects of Visual Interaction on Unmanned Aircraft Operator Situational Awareness in a Dynamic Simulated Environment
The details of this research are described under E3. Modeling and Simulation. (W03, W06 & W07)

Emergency Management: Exploring Hard and Soft Data Fusion Modeling with UAS and Non-Governmental Human Intelligence Mediums
The details of this research are described under E6. Operational Environment. (W12)

Emergency Response using UAS
The details of this research are described under E6. Operational Environment. (D09, W01, W03, W06, W07 & W08)

Evaluating the Effectiveness of Previous Manned Flight Training on UAS Flight
The details of this research are described under A5. Education and Training. (D03 & D04)

Human Computer Interfaces for Supervisory Control of Multi-mission, Multi-agent Autonomy (OSD12-HS1)
The details of this research are described under E3. Modeling and Simulation (M&S). (D09)

Human Factors Considerations for UAS Procedures and Control Stations
The details of this research are described under A5. Education and Training. (D13 & D22)

Human Factors Issues in Autonomous Aerial Vehicles
This project analyzed 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)

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Joint UAS and Air Traffic Management
The details of this research are described under A1. Regulation, Policy and Ethics. (P03, P05 & 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 E3. Modeling and Simulation. (D09)

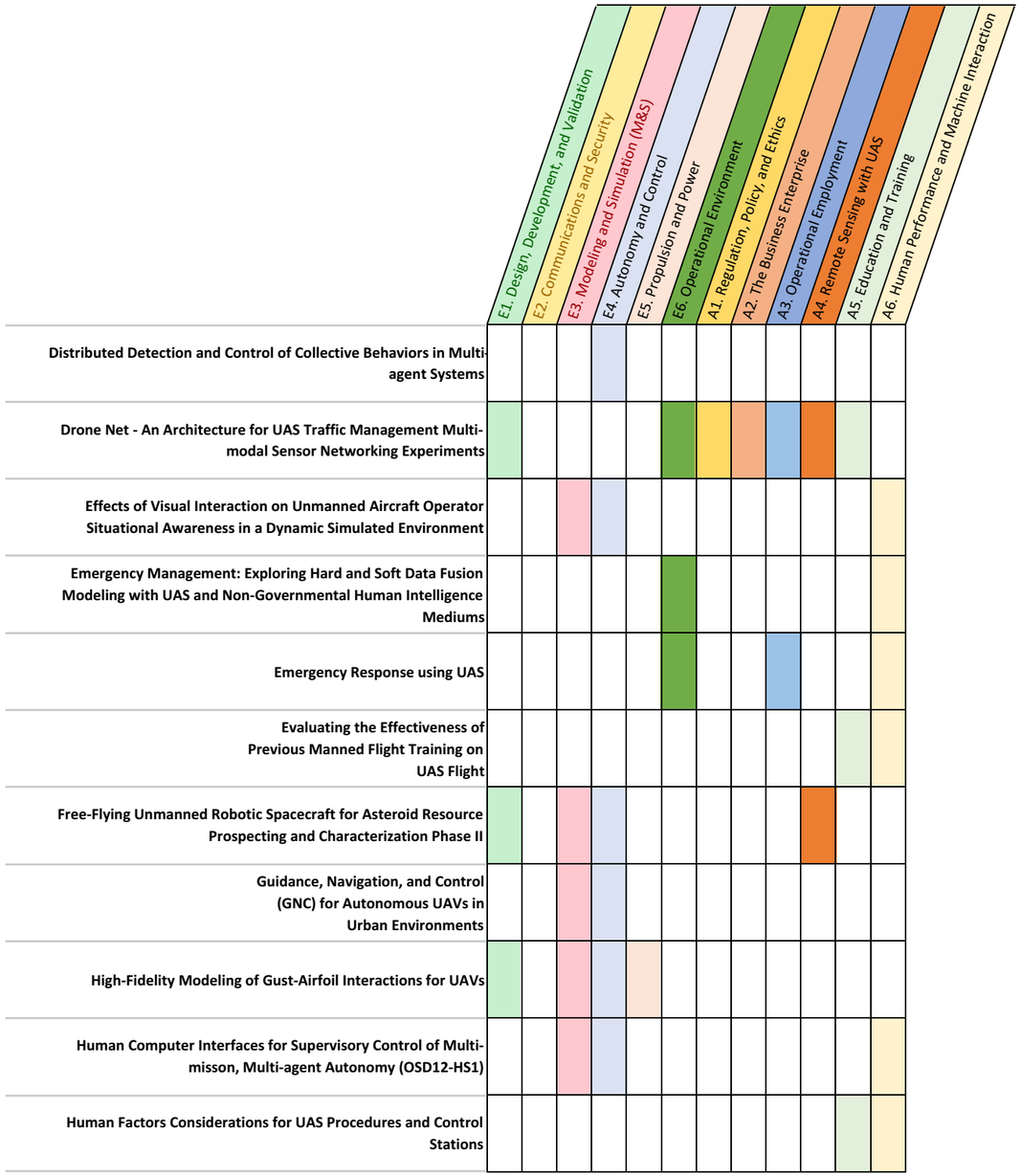
Surveillance Criticality for SAA
The details of this research are described under E2. Communications and Security. (D10)

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

	E1. Design, Development, and Validation	E2. Communications and Security	E3. Modeling and Simulation (M&S)	E4. Autonomy and Control	E5. Propulsion and Power	E6. Operational Environment	A1. Regulation, Policy, and Ethics	A2. The Business Enterprise	A3. Operational Employment	A4. Remote Sensing with UAS	A5. Education and Training	A6. Human Performance and Machine Interaction
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)										■	■	
Aero Foil Design for Low Speed and High Altitude Flight	■		■							■	■	
Aerobiological Sampling using UAVs	■		■	■						■		
Aerodynamic Design Considerations for UAS during Refueling Operations	■											
Aerospace Safety Education										■	■	
An Optionally Piloted Unmanned Aircraft System	■											
An Unmanned Aircraft Classification Scheme to Aid the Development of Regulations for Operations in the NAS				■			■					
Android Autopilot System				■					■			
Application of Autonomous Soaring				■					■			
Capability Analysis and Effectiveness Response for Unmanned Systems (CAERUS) Framework			■									
CFD Analysis of Aerodynamic Surface Finishes	■	■						■				
Consumer Multirotor sUAS Evaluation and Assessment											■	
Crew Resource Management Training											■	■
Detect and Avoid (DAA)							■			■		■
Development of a Fully 3-D Printed Fixed-Wing UAV	■		■	■	■					■		
Development of a Multispectral Passive Aircraft Detection and Classification										■		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A2. The Business Enterprise
A3. Operational Employment
A4. Remote Sensing with UAS
A5. Education and Training
A6. Human Performance and Machine Interaction
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Guidance, Navigation, and Control (GNC) for Autonomous UAVs in Urban Environments
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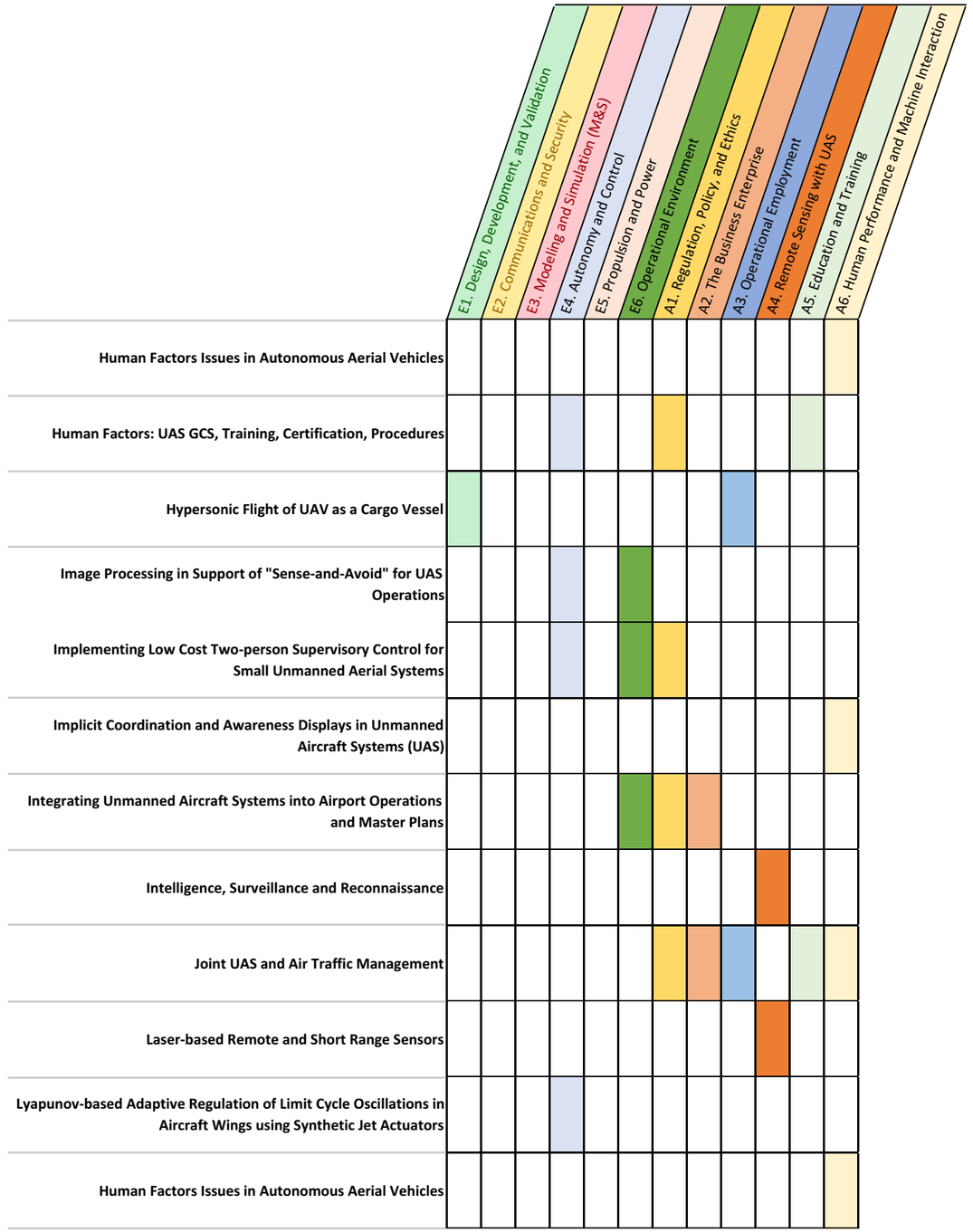
Human Factors Considerations for UAS Procedures and Control Stations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Human Factors: UAS GCS, Training, Certification, Procedures
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Image Processing in Support of "Sense-and-Avoid" for UAS Operations
Implementing Low Cost Two-person Supervisory Control for Small Unmanned Aerial Systems
Implicit Coordination and Awareness Displays in Unmanned Aircraft Systems (UAS)
Integrating Unmanned Aircraft Systems into Airport Operations and Master Plans
Intelligence, Surveillance and Reconnaissance
Joint UAS and Air Traffic Management
Laser-based Remote and Short Range Sensors
Lyapunov-based Adaptive Regulation of Limit Cycle Oscillations in Aircraft Wings using Synthetic Jet Actuators
Human Factors Issues in Autonomous Aerial Vehicles

	E1. Design, Development, and Validation	E2. Communications and Security	E3. Modeling and Simulation (M&S)	E4. Autonomy and Control	E5. Propulsion and Power	E6. Operational Environment	A1. Regulation, Policy, and Ethics	A2. The Business Enterprise	A3. Operational Employment	A4. Remote Sensing with UAS	A5. Education and Training	A6. Human Performance and Machine Interaction
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 Aerial 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												

	E1. Design, Development, and Validation	E2. Communications and Security	E3. Modeling and Simulation (M&S)	E4. Autonomy and Control	E5. Propulsion and Power	E6. Operational Environment	A1. Regulation, Policy, and Ethics	A2. The Business Enterprise	A3. Operational Employment	A4. Remote Sensing with UAS	A5. Education and Training	A6. Human Performance and Machine Interaction
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												

	E1. Design, Development, and Validation	E2. Communications and Security	E3. Modeling and Simulation (M&S)	E4. Autonomy and Control	E5. Propulsion and Power	E6. Operational Environment	A1. Regulation, Policy, and Ethics	A2. The Business Enterprise	A3. Operational Employment	A4. Remote Sensing with UAS	A5. Education and Training	A6. Human Performance and Machine Interaction
UAS -Aircraft Rescue Fire Fighting Response Conceptual and Application Analysis												
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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

	Principal Investigator	Expertise	Keywords
D01	**Ted Beneigh** Professor Aeronautical Sciences Daytona Beach COA beneight@erau.edu	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.	UAS Pilot experience
D02	**Daniel Friedenzohn** Associate Dean College of Aviation Daytona Beach COA FRIEDEND@erau.edu	Studying how society is addressing privacy, regulatory, and business issues pertaining to UAS and how a leasing market will develop for UAS.	Legal, privacy, leasing, insurance, policy
D03	**Tom Haritos** Assistant Professor Aeronautical Sciences Daytona Beach COA HARITOAA@erau.edu	Participating with the RTCA SC228 workgroup to develop Minimum Operational Performance Standards (MOPS) for DAA.	Remote Sensing Detect and Avoid Applications UAS Education and Training UAS Classification and Certification UAS Simulation applications Human-Computer Interaction (HCI)
D04	**Dan Macchiarella** Professor Aeronautical Sciences Daytona Beach COA macchian@erau.edu	Media specialist on issues of nondisclosure and security	Nondisclosure and security
D05	**Alex Mirot** Associate Professor Aeronautical Sciences Daytona Beach COA mirota@erau.edu	Expertize in UAS Regulation, Policy, and Ethics, UAS Operations and Applications, Team work, Crew Resource Management and UAS Education, Training and Certification.	Regulation, Policy, and Ethics Operations and Applications Team Work Crew Resource Management Education, Training and Certification
D06	**Janet K. Marnane** Assistant Professor Aeronautical Sciences Daytona Beach COA marnanej@erau.edu	Expertize in Crew Resource Management, Decision Making; Commercial Operations; and Aviation Regulation/legislation	Decision Making Commercial Operations CRM Aviation Regulation/Legislation
D07	**Clyde Rinkinen** Associate Professor Air Traffic Mgnt Daytona Beach COA rinki613@erau.edu	Involved in ATM for 33 years and is a SME for integrating UAS into the NAS.	Integrating UAS into the NAS
D08	**Sarah Ochs** Professional Programs Daytona Beach COA ochs839@erau.edu	Manager of UAS Workshops/ Short-Courses for Daytona Beach	Logistical Planner and Event Director
D09	**Dahai Liu** Professor Graduate Studies Daytona Beach COA Liu89b@erau.edu	Expertize in Human Machine Interface in UAS; Supervisory Control of UASs; Reinforcement Learning in Autonomous UAVs; Modeling and Simulation.	Workload Situation Awareness Supervisory Control Reinforcement Learning; HMI; Decision Support
D10	**Mohammad Moallemi** Research Associate Daytona Beach NEAR Lab moallemm@erau.edu	Sense and avoid systems, Pilot-controller interactions, Separation and collision avoidance functions, Airborne surveillance systems and equipment, Modeling & simulation of UAS Air traffic management	Technology Operational Safety Situation awareness UAS in the NAS Air Traffic Management
D11	**Sergey V. Drakunov** Associate Dean for Research and Graduate Studies Daytona Beach COAS DRAKUNOV@erau.edu	Expertize in control algorithms design for autopilots for autonomous UAVs and multiple UAVs formations.	Autopilots for autonomous UAVs Control for multiple autonomous UAVs formations
D12	**William MacKunis** Assistant Professor Engineering Physics Daytona Beach COAS MACKUNIW@erau.edu	Expertize in Feedback Tracking Control of an Unmanned Aerial Vehicle.	Autopilots for autonomous UAVs
D13	**Joseph Cerreta** Assistant/Associate Professor Aeronautical Science Daytona Beach COA cerretaj@erau.edu	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.	UAS Human Factors Ground Control Station Crewmember Training UAS Operational Training UAS Operational Procedures
D14	**Pat (Richard) Anderson** Professor Aerospace Engineering Daytona Beach COE andersop@erau.edu	Faculty Advisor for NASA UAS Challenge to create an optionally piloted UAS surrogate with sense-and-avoid capability. Expertize in UAS guidance navigation and control.	Optionally piloted vehicle guidance, navigation, and control (GNC) aircraft certification

	Principal Investigator	Expertise	Keywords
D15	**Vladimir Golubev** Professor Aerospace Engineering Daytona Beach COE golubd1b@erau.edu	Specializes in Unsteady Aerodynamics, Flow/Flight/Propulsion Control, Aeroacoustics, Aeroelasticity, and Computational Fluid Dynamics	Synthetic Jet Actuators Gust-Airfoil Interactions Micro Air Vehicles Transitional Flows Flow-Acoustic Resonant Interactions
D16	**Hever Moncayo** Assistant Professor Aerospace Engineering Daytona Beach COE moncayoh@erau.edu	Specializes in Guidance, Navigation and Control, Flight dynamics Modeling and simulation, and Aerospace Fault Tolerance.	Unmanned systems Aviation Safety Navigation and control Fault Tolerance
D17	**Richard Prazenica** Assistant Professor Aerospace Engineering Daytona Beach COE prazenir@erau.edu	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.	LIDAR, computer vision, sense-and-avoid autonomous GNC path planning
D18	**Dae Won Kim** Associate Professor Aerospace Engineering Daytona Beach COE kimd3c@erau.edu	Specializes in smart materials and systems, and structural health monitoring.	Smart Materials Smart Structures Adaptive Structures Morphing Wings Structural Health Monitoring
D19	**William C. Barott** Professor Electrical Engineering Daytona Beach COE barottw@erau.edu	Specializes in RF engineering, including passive radar. Teaches Sensors and Datalinks for the MSUASE program.	RF engineering communications sensing radar passive radar sense-and-avoid
D20	**Brian Butka** Associate Professor ECSSE Daytona Beach COE butkab@erau.edu	Interested in sensing of UAVs with radar and acoustics, and electrical system design.	UAS sensing sense-and-avoid acoustics propulsion
D21	**Jianhua Liu** Associate Professor ECSSE Daytona Beach COE liu620@erau.edu	Radar expertize and faculty advisor for image processing for "Sense-and-avoid" for NASA UAS AOC competition.	sense-and-avoid radar image processing communication

	Principal Investigator	Expertise	Keywords
D22	**Richard Stansbury** Associate Professor ECSSE Daytona Beach COE stansbur@erau.edu	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	UAS/NAS Integration UAS in NextGen ADS-B UAS sense-and-avoid
D23	**Massood Towhidnejad** Professor ECSSE Daytona Beach COE towhid@erau.edu	Gale UAS project director.	NextGen UAS NAS Integration
D24	**Timothy Wilson** Chair & Professor ECSSE Daytona Beach COE wilsonti@erau.edu	Has performed UAS NAS Integration studies with FAA Technology Center (technology surveys and regulatory gap analyses).	UAS NAS Integration
D25	**Susan Allen** Distinguished Professor Mechanical Eng Daytona Beach COE ALLENS17@erau.edu	Has two patents (related) on laser sensors.	Lasers, remote sensing stand-off sensors laser-based sensors
D26	**Eric Coyle** Associate Professor Mechanical Eng Daytona Beach COE COYEE1@erau.edu	Expertize in Signal Processing, Computer Vision, UAS Platform and Payload Design.	Sense-and-Avoid Multi-Spectral Imaging
D27	**Patrick Currier** Associate Professor Mechanical Eng Daytona Beach COE CURRIERP@erau.edu	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	UAS integration autonomy 3D printing mobile devices student teams
D28	**Charles Reinholtz** Professor Mechanical Eng Daytona Beach COE reinholc@erau.edu	Expertize in Unmanned and Autonomous Vehicles; mechanisms and robotics.	Unmanned and Autonomous Vehicles mechanism and robotics

	Principal Investigator	Expertise	Keywords
D29	**Heidi Steinhauer** Chair & Associate Professor Freshman Engineering Daytona Beach COE steinhah@erau.edu	Developing tools and techniques for rapid parametric based design and manufacture of UAV using 3-D printing technology.	Fixed-wing UAV 3-D printing technology Design, development and validation of UAV
D30	**John M. Robbins** Associate Professor Aeronautical Science Daytona Beach COA ROBBINSJ@erau.edu	Specializes in Precision agriculture; remote sensing; UAS applications; UAS operations and integration; and UAS maintenance, training, policy and regulation.	Precision Agriculture Remote Sensing UAS Applications UAS Operations and Integration UAS Maintenance, Training, Policy, and Regulation
D31	**Mitchell A. Geraci** Associate Professor Aviation Maintenance Daytona Beach COA geracim@erau.edu	Specializes in UAS Maintenance, Repair, Inspection, Record Keeping, and Certification.	UAS Maintenance Policy UAS Maintenance Regulation UAS Maintenance Training
D32	**Feng Zhu** Assistant Professor Mechanical Eng Daytona Beach COE ZHUF1@erau.edu	Specializes in UAS operations in the NAS, Finite element methods (FEM), Computational Modeling, Crashworthiness of UAS, and safety of personnel on the ground	UAS in the NAS Finite element Method Computational Modeling
D33	**Eduardo Divo** Interim Chair &Associate Professor Mechanical Eng Daytona Beach COE DIVOE@erau.edu	Specializes in UAS operations in the NAS, Finite element methods (FEM), Computational Modeling, Crashworthiness of UAS, and safety of personnel on the ground	UAS in the NAS Finite element Method Computational Modeling
D34	**Victor Huayamave** Assistant Professor Mechanical Eng Daytona Beach DOE HUAYAMAV@erau.edu	Specializes in UAS operations in the NAS, Finite element methods (FEM), Computational Modeling, Crashworthiness of UAS, and safety of personnel on the ground	UAS in the NAS Finite element Method Computational Modeling
D35	**Thomas (Tianyu) Yang** Professor Electrical and Computer Engineering Daytona Beach COE Yang482@erau.edu	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.	Detection, learning, and estimation of agent interaction dynamics and interaction topologies Resilient cooperative control protocols

	Principal Investigator	Expertise	Keywords
D36	**Vitaly S. Guzhva** Professor Finance Daytona Beach COB guzhvav@erau.edu	Studying the impact of UAS operations on ATM safety; UAS rule-making support; UAS-related economic analysis	UAS safety; UAS rule-making; UAS economics
D37	**William A. Engblom** Professor Mechanical Engineering Daytona Beach COE Engb17de@erau.edu	Specializes in high fidelity UAS aerodynamics simulation; Tethered UAS; UAS aircraft configuration design; UAS propulsion system selection and design.	UAS Aerodynamics; Tethers; UAS design
D38	**Borja Martos** Research Engineer Flight Research Center Daytona Beach CARBALLB@erau.edu	Specializes in UAS controls, flight testing, system design and development.	UAS controls Flight testing System design and development
D39	**Remzi Seker** Professor Electrical and Computer Engineering Daytona Beach COE sekerr@erau.edu	Expertize in UAS Cyber Security.	UAS as a Service, ADS-B, Privacy, IoT, UAS/NAS Integration, Digital Forensics
D40	**Troy Henderson** Assistant Professor Aerospace Engineering Daytona Beach COE HENDERTS@erau.edu	Specializes in guidance, navigation and control; Vision-aided navigation; Terrain mapping; Obstacle detection, tracking, and identification; Image processing; Mission/Experiment planning.	Image processing Computer vision Navigation filtering Object detection
P01	**Jon Haass** Associate Professor Cyber Sec & Intelligence Prescott, COA HAASSJ@erau.edu	Expertize in UAS Cyber Security & Intelligence.	Cyber Security & Intelligence
P02	**Vince Pujalte** Assistant Professor Applied Aviation Sci Prescott COA pujalo63@erau.edu	Specializes in flight control system integration; teaches AS473 and AS220.	Flight control system integration

	Principal Investigator	Expertise	Keywords
P03	**Sarah Nilsson** Assistant Professor Aviation Law Prescott COA FISHESCA@erau.edu	Specializes in UAS law in the United States; UAS International Law; UAS Risk 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.	UAs Law; Litigation; Local Ordinances; State Laws; Risk Management; Anti-Drone; Part 107; Privacy; Airport Master Plans; UAS International Law
P04	**Erin E. Bowen** Dept. Chair & Associate Professor Behavioral & Safety Sciences Prescott COAS BOWENE1@erau.edu	Specializes in UAS Applications for Disaster Scene Analysis, Aviation Psychology, and UAS Training Design & Assessment	Training Procedures Assessment/Performance
P05	**Johnny L. Young** Assistant Professor Unmanned Aerial Systems Prescott COA YOUNGJ42@erau.edu	Specializes in the integration of UAS into the National Airspace System, use of UAS in Aircraft Accident investigation, UAS Risk Management, UAS Education under Part 107, UAS Flight instruction, and Payload Operation.	UAS Integration Accident Investigation Risk Management UAs Flight Instruction Payload Operation
P06	**Timothy B. Holt** Interim Dean & Associate Professor Aeronautical Science Prescott COA holtt@erau.edu	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.	Data Analysis, Safety, Integration, ASSUR
P07	**Jennah C. Perry** Assistant Professor Air Traffic Management Prescott COA perryj13@erau.edu	Air Traffic Management; National Aerospace System; UAS law in the United States; Aviation Simulation; Human Factors and Education; UAS International Law; UAS Risk Management; Anti-Drone Technology; Integrating UAS into Airport Master Plans; UAS Education under Part 101 and 107.	ATM, UTM, UAS Law, Human Factors, Simulation, Risk Management, Aviation Education, Anti-Drone, Part 107, Privacy, Airport Master Plans
PO8	**Stephen Bruder** Associate Professor Computer and Electrical Engineering Prescott COE BRUDERS@erau.edu	ICARUS Research Group Drone Net – UAS Traffic Management Multi-modal Sensor Networking Experiments Passive sensor nodes Small Unoccupied Aerial System detection, tracking, and identification	UAS Detection, NIR Cameras, Acoustic Arrays, IMU, ADS-B, Sensor Data Fusion, Deep Learning, Computer Vision

	Principal Investigator	Expertise	Keywords
P09	**Samuel B. Siewert** Assistant Professor Software Engineering Prescott COE siewerts@erau.edu	ICARUS Research Group Drone Net – UAS Traffic Management Multi-modal Sensor Networking Experiments Passive sensor nodes Small Unoccupied Aerial System detection, tracking, and identification	UAS Detection, NIR Cameras, Acoustic Arrays, IMU, ADS-B, Sensor Data Fusion, Deep Learning,]Computer Vision
P10	**Mehran Andalibi** Assistant Professor Mechanical Engineering Prescott COE ANDALIBM@erau.edu	ICARUS Research Group Drone Net – UAS Traffic Management Multi-modal Sensor Networking Experiments Passive sensor nodes Small Unoccupied Aerial System detection, tracking, and identification	UAS Detection, NIR Cameras, Acoustic Arrays, IMU, ADS-B, Sensor Data Fusion, Deep Learning, Computer Vision
P11	**Iacopo Gentilini** Associate Professor Aerospace & Mechanical Engineering Prescott COE ANDALIBM@erau.edu	ICARUS Research Group Drone Net – UAS Traffic Management Multi-modal Sensor Networking Experiments Passive sensor nodes Small Unoccupied Aerial System detection, tracking, and identification	**UAS Detection, NIR Cameras, Acoustic Arrays, IMU, ADS-B, Sensor Data Fusion, Deep Learning, Computer Vision**
W01	**David Thirtyacre** Chair Department of Flight Worldwide COA thirtyad@erau.edu	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, ERAU Mobile UAS unit.	Flight test, unmanned aircraft operations, Training, System integration, UAS application UAS Workshops, UAS Challenge, Sensors
W02	**Orin Godsey** Associate Professor Aeronautics Worldwide COA godseyo@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.	Refueling of UAV Aerodynamics Wing and Propeller design Flight
W03	**David Ison** Assistant Professor Worldwide COA isond46@erau.edu	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 sUAS; Privacy issues of UAS legislation.	Integrating UAS into Airport Master Plans Human Machine Interface Disaster Response & Recovery Privacy, Legislation and UAS Low Cost Two-Person Supervisory Control for sUAS Legislation; regulation; privacy

	Principal Investigator	Expertise	Keywords
W04	**Robert Deters** Assistant Professor Worldwide COA DETERSR1@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 mcand4f1@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 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, STEM, UAS curricula development, documentation, sUAS
W07	**Dennis Vincenzi** Department Chair Undergraduate Studies Worldwide COA vincenzd@erau.edu	Specializes in unmanned systems, including unmanned aerial systems (UAS), unmanned ground vehicles (UGVs), and robotic systems; Situational 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; Situational awareness; Modeling and simulation (M&S); System design, development, integration, and test; Human-machine-interface
W08	**Ken Witcher** Dean Aeronautics Worldwide COA witchea8@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

	Principal Investigator	Expertise	Keywords
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 UAS Integration into ATC where English is not a primary language
W11	**Kelly George** Associate Professor Worldwide COAS georged8@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 Emergency Management Non-Governmental Human Intelligence Mediums
W13	**Stefen Kleinke** Assistant Professor Aeronautics Undergraduate Studies Worldwide COA kleinkes@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

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