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

Michael P. Hickey, Editor
Dean of Research and Graduate Studies
12/1/2014
Foreword

With technological breakthroughs in miniaturized aircraft-related components, including but not limited to communications, computer systems and sensors and, 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 either new or 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. The document 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 the 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. Should more information be desired, please contact me directly or alternatively visit our research web pages (http://research.erau.edu) and contact the appropriate faculty member directly.

M. P. Hickey, Dean of Research & Graduate Studies

hicke0b5@erau.edu
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 is greatly appreciated, and without their contributions this document would not exist. Their names appear in the appendix. Teresa Ochoa helped collect information from the contributing faculty. Teri Gabriel worked tirelessly with the provided information, sorting, editing and formatting to produce the final document. The help and advice of some of our faculty having UAS expertise was critical, 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 help: Drs. Susan Allen, Quentin Bailey, Massoud Bazargan, Alan Bender, Sergey Drakunov, Thomas Field, Soumia Ichoua, Mark Sinclair, Ahmad Sleiti, Todd Smith, and Alan Stolzer.

Last, but not least, I would like to also thank the three campus Chief Academic Officers, Dr. Richard Heist (Daytona Beach Campus), Dr. Richard Bloom (Prescott Campus) and Dr. Brad Sims (Worldwide Campus), for their continued support of UAS related activities across our university.

Cover picture: A fully 3-D printed UAV developed for Boeing in 2011.
# Table of Contents

**Engineering** ................................................................................................................................. 1  
  E1. Design, Development, and Validation .......................................................................................... 1  
  E2. Communications and Security .................................................................................................. 4  
  E3. Modeling and Simulation (M&S) ............................................................................................... 4  
  E4. Autonomy and Control ............................................................................................................. 6  
  E5. Propulsion and Power ............................................................................................................... 8  
  E6. Operational Environment ....................................................................................................... 9  

**Application** ................................................................................................................................... 10  
  A1. Regulation, Policy, and Ethics ................................................................................................ 10  
  A2. The Business Enterprise ......................................................................................................... 12  
  A3. Operational Employment ....................................................................................................... 12  
  A4. Remote Sensing with UAS ..................................................................................................... 13  
  A5. Education and Training .......................................................................................................... 14  
  A6. Human Performance and Machine Interaction ....................................................................... 16  

Unmanned Aircraft System (UAS) Capabilities Matrix ..................................................................... 19
Embry-Riddle Aeronautical University
Unmanned Aircraft System
Capabilities

Engineering
E1. 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)

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. (D29)

Aerodynamic Design considerations for UAS during Refueling Operations
This research investigates the aerodynamics associated with Unmanned Aerial Systems during refueling operations. (W05 & W06)

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, D22, & D23)

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, D28, D29 & D30)
**CFD analysis of Aerodynamic Surface Finishes**
This project involves CFD modeling of low speed boundary layer airflow on various UAS surface finishes. (W05 & W13)

**Design of Hunter-Killer UAV's using Morphing Aircraft Technology**
This project investigated the initial requirements for the USAF second generation of Hunter-Killer UAV’s as follow-on systems to the Predator and Reaper UAV’s. (W07)

**High-Fidelity Modeling of Gust-Airfoil Interactions for UAVs**
The project conducted in collaboration with WPAFB and Eglin AFB AFRL scientists over the past eight years employs 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, W13)

**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. (D23 & D24)
**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. (D28)

![Image of UAS on runway](image)

*Figure 3:* UAS of various classes and types each must be evaluated as part of the development and testing process.

**Qualification of Verification tools**

The project, sponsored by the FAA, dealt with the qualification of verification tools for airborne safety-critical software complying with DO-178. (D20 & D21)

**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)

**Software engineering process**

This project involved the evaluation of software engineering processes, software development tools with automatic code generation, software intensive system/software safety assessment, the testing of flight data processing software, and airborne systems certification with DO-178C and related guidance, software tools qualification. (D21)
TeamAIR
This project involved the design and building of a fixed-wing UAS for the Association of Unmanned Vehicle Systems International (AUVSI) Small UAS engineering competition. These UAS must be capable of autonomously searching a military airfield for static targets. (P02)

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, W11 & W13)

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 applications were applicable, needed re-interpretation, needed revision, or were missing. (D23 & D25)

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. What are the similarities and differences for secure communication – ground to air, air to satellite, ground to satellite, air to air. (P01)

E3. Modeling and Simulation (M&S)
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. (D29)

Considerations for the Development and Deployment of an Unmanned Systems Simulation Framework
This research represents a comparative literature review to identify the best practices, methods, and concepts associated with simulation and its potential use to support unmanned system design, evaluation, analysis, and demonstration within a distributed learning environment. (W03, W09 & W10)

Development of a fully 3-D Printed Fixed-Wing UAV
This is a Boeing sponsored project involving the development of tools and techniques for rapid parametric-based design and manufacture of UAV using 3-D printing technology. (D19, D28, D29 & D30)
**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, W09 & W10)

**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 project conducted in collaboration with WPAFB and Eglin AFB AFRL scientists over the past eight years employs 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)

**Human Computer Interfaces for Supervisory Control of Multi-mission, Multi-agent Autonomy (OSD12-HS1)**

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)

**Modeling and Simulation**

This project involves the modeling of the air traffic control environment, and human-in-the-loop simulation for NextGen. (D21)

**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, investigated the interaction between sensor sensitivity and Reinforcement Learning algorithm on agent performance for target search and identification. (D09)
**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)

**Use of Modeling and Simulation to Evaluate Unmanned Aerial System Asset Allocation and Assignment**

Modeling and simulation (M&S) can be used to support the assessment of UAS asset allocation and assignment to meet specific missions or tasks by providing the means to examine potential usage strategies (i.e., use cases) and effectiveness determination (in terms of cost and performance) of various UAS platforms or combination of platforms. The results of this research project may provide a framework for the development of a system to determine advantages and limitations of M&S use for UAS asset assignment evaluation, while identifying appropriate UAS platforms and flight profiles to obtain maximum mission effectiveness. (W03, W09 & W10)

**Using Simulation to Support Prototype Development Efforts**

This research examines the use, availability, and applicability of simulation tools and technology to support early prototype development efforts. Simulation has exhibited positive benefits for the testing and refinement of conceptual designs and theories of operation before physical prototypes are built. These tools provide an opportunity to better understand the early concept, design requirements, and considerations facilitating evolution and improvement before investing time and resources in design and construction of the physical prototype system. (W03, W09, & W10)

**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. (D23 & D25)

**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. (D29)

**Android Autopilot System**

In this project a flexible, cross-platform autopilot system capable of integrating advanced autonomy behaviors including obstacle avoidance, motion planning, and automatic task allocation is being developed. The system is designed to run on Android on Linux operating systems and will be demonstrated using an Android smartphone as a complete autopilot solution including sensors, processing, and payload capability. (D28)

**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**
This is a Boeing sponsored project involving the development of tools and techniques for rapid parametric-based design and manufacture of UAV using 3-D printing technology. (D19, D28, D29 & D30)

**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)

**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, D22, D23, & D27)

**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 & W09)

**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. (W09 & W10)

**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)
**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)

![Figure 4: Simulation for sense and avoid studies.](image)

**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, D22, D23 & 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 and thereby extending the range of UAVs. (D11)

**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)

**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)

---

**E5. Propulsion and Power**

**Development of a fully 3-D Printed Fixed-Wing UAV**

This is a Boeing sponsored project involving the development of tools and techniques for rapid parametric-based design and manufacture of UAV using 3-D printing technology. (D19, D28, D29 & D30)
**High-Fidelity Modeling of Gust-Airfoil Interactions for UAVs**

This project, conducted in collaboration with WPAFB and Eglin AFB AFRL scientists over the past eight years, employs DOD HPC and ERAU computer facilities to conduct high-fidelity, low-Reynolds number, 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)

**E6. Operational Environment**

![Image of UAS Competition and Demonstration at Wings over Houston](image)

**Figure 5: UAS Competition and Demonstration at Wings over Houston**

**Disaster response using UAS**

The use of multiple UASs to support disaster recovery and response activities will be explored using mixed-methods data collection and analysis, and simulation. This research features examination of occurrence of airport aviation emergencies, Aircraft Rescue and Fire Fighting (ARFF) processes, development of new strategies, optimization of response, improving situational awareness, and limiting conditions. (D09, W03, W04, W08, W09, W10 & W11)
**Image Processing In Support of “Sense-and-Avoid” 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, D22, D23, & D27)

**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 & W09)

**Integration of UAS in Airport Operations**
This study outlines best practices of integrating UAS at and in proximity to airports. This includes onsite consulting at the Fallon, NV airport. (D09, W03, & W10)

**Operational Environment**
This project provides a decision support system for air traffic system management, analysis and validation of the national airspace simulation models. (D21)

**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, & W10)

---

**Application**

**A1. Regulation, Policy, and Ethics**

**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 Administration regulations were assessed to determine which applications were applicable, needed re-interpretation, needed revision, or were missing. (D23 & D25)

**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. (D23 & D25)
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. Then, using House of Quality analysis, rules were written to determine aircraft requirements given mission, and alternatively mission envelop given aircraft. (D23)

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

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 & W09)

Integration of UAS in Airport Operations
This study outlines best practices of integrating UAS at and in proximity to airports. This includes onsite consulting at the Fallon, NV airport. (D09, W03, & W10)

Privacy and Unmanned Aerial Systems Integration into the National Airspace System
This study identified themes among 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 & W10)

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, & W10)

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, W09 & W10)

UAS Regulation, Policy, and Ethics
This research focuses on the non-military use of UAS technology and its ethical impact on privacy. (D02 & D05)
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). Additionally, this wiki proposes a potential solution path that will ameliorate these challenges. The wiki 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. (W14)

A2. The Business Enterprise

![Image of a quadcopter type UAS with various sensors]

**Figure 6:** 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.

*Integrating Unmanned Aircraft Systems into Airport Master Plans*
The purpose of the research is to establish best practices that will lead to a model for integrating UAS operations into airport master plans. This qualitative, observational, and multiple-case study will incorporate the evaluation of airport master plan development, UAS operations, and specific UAS airport integration issues. (W03, W09, W11, W12)

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

A3. Operational Employment

*CFD analysis of Aerodynamic Surface Finishes*
This project involves CFD modeling of low speed boundary layer airflow on various UAS surface finishes. (W05 & W13)
**Design of Hunter-Killer UAV’s using Morphing Aircraft Technology**
This project investigated the initial requirements for the USAF second generation of Hunter-Killer UAV’s as follow-on systems to the Predator and Reaper UAV’s. (W07)

**Hypersonic flight of UAV as a cargo vessel**
This project involved the computational fluid mechanics analysis of hypersonic flight parameters. (W02, W05, W13)

**Disaster response using UAS**
The use of multiple UAS to support disaster recovery and response activities will be explored using mixed-methods data collection and analysis, and simulation. This research features examination of occurrence of airport aviation emergencies, Aircraft Rescue and Fire Fighting processes, development of new strategies, optimization of response, improving situational awareness, and limiting conditions. (D09, W03, W04, W08, W09, W10 & W11)

**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, W11 & W13)

**UAS Operational Employment**
UAS designated instructor pilot in the Air Force’s largest formal training unit responsible for teaching both new instructors and inexperienced aviators the complexities of Unmanned Aircraft Systems operation. Test engineer for the Next Generation Airspace System Research; customs and Border Protection, and General Atomics, to test the use of ADS-B on a Medium Altitude Long Endurance UAS. (D05)

**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). Additionally, this wiki proposes a potential solution path that will ameliorate these challenges. The wiki 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. (W14)

**A4. Remote Sensing with UAS**

**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. (D29)

**Android Autopilot System**
In this project a flexible, cross-platform autopilot system capable of integrating advanced autonomy behaviors including obstacle avoidance, motion planning, and automatic task allocation is being developed. The system is designed to run on Android on Linux operating systems and will be demonstrated using an Android smartphone as a complete autopilot solution including sensors, processing, and payload capability. (D28)
**Application of Autonomous Soaring**
This 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)

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

**Development of a fully 3-D Printed Fixed-Wing UAV**
This is a Boeing sponsored project involving the development of tools and techniques for rapid parametric-based design and manufacture of UAVs using 3-D printing technology. (D19, D28, D29 & D30)

**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 & D27)

**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 focuses on new types of laser-based remote and short range sensors. (D26)

**Unmanned Aerial Systems for Agricultural Monitoring**
The project entails the development of a low-cost UAS and payload capable of monitoring water levels of agricultural fields using visible and near-infrared spectrum photography. (D27)

---

**A5. Education and Training**

*Figure 7:* UAS operators working within a common system control station.
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)

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, W03, W10 & D06)

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)

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)

This two-day, continuing education unit (CEU) course was created specifically for professionals and specialists seeking to expand their understanding of the application, operation, and support of unmanned aircraft systems (UAS), specifically in regards to the considerations, regulations, policies, business opportunities, and challenges of the industry. This course is developed and taught by Embry-Riddle Aeronautical University - Worldwide faculty with UAS operations and research experience. It is currently being offered at locations throughout the U.S. and being prepared for international locations. (W01 & W09)
**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. While partnered with URs Corporation 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. Research also involved initiating an extensive overhaul of the ERAU program’s curriculum to better align with regulatory demands and industry needs. 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. (D05)

**UAS ERAU Workshop**

The project involves a module on UAS Integration into the NAS. (D05, D07, & D08)

**UAS Operational Employment**

UAS designated instructor pilot in the Air Force’s largest formal training unit responsible for teaching both new instructors and inexperienced aviators the complexities of Unmanned Aircraft Systems operation. Test engineer for the Next Generation Airspace System Research; customs and Border Protection, and General Atomics, to test the use of ADS-B on a Medium Altitude Long Endurance UAS. (D05)

**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). Additionally, this wiki proposes a potential solution path that will ameliorate these challenges. The wiki 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. (W14)

---

**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, W09, & W10)

*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, W03, W10 & D06)

*Detect and Avoid (DAA)*

ERAU is participating with the RTCA SC228 workgroup to develop Minimum Operational Performance Standards (MOPS) for DAA. (D03)
**Disaster response using UAS**
The use of multiple UAS to support disaster recovery and response activities will be explored using mixed-methods data collection and analysis, and simulation. This research features examination of occurrence of airport aviation emergencies, Aircraft Rescue and Fire Fighting processes, development of new strategies, optimization of response, improving situational awareness, and limiting conditions. (D09, W03, W04, W08, W09, W10 & W11)

**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, W09 & W10)

**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 Computer Interfaces for Supervisory Control of Multi-mission, Multi-agent Autonomy (OSD12-HS1)**
In this project an 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)

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

**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**
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 design of an interface featuring vector/autopilot control would reduce operator attentional allocation, supporting the maintenance of localized situational awareness. (W09 & W10)
**NextGen Technology Evaluation to Support UAS in the National Airspace System**
This research effort assessed future technology and procedural requirements for uninhabited aircraft systems (UAS) flying in the national airspace system (NAS). Live UAS flight demonstrations and simulation studies were conducted by a multi-organization team that included ERAU human factors faculty and students. Results included recommendations for designing cockpit traffic displays and a backup communications system for UAS flight operations. (D10)

**NextGen UAS Human-Machine Interface (HMI) Evaluation**
This FAA project examined HMI certification requirements for uninhabited aircraft systems (UAS) and whether those requirements exist in current FAA regulations. To identify requirements, ERAU human factors researchers assessed the demands of UAS piloting and UAS HMI designs. (D10)

**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 sensor sensitivity on autonomous aerial vehicles, investigated the interaction between sensor sensitivity and Reinforcement Learning algorithm on agent performance for target search and identification. (D09)

**The Effect of Control and Display Lag on Unmanned Air System Manual Landing Performance**
Simulator-based landing performance was compared under conditions of ms, 250 ms, and 1000 ms of lag. (D10)

**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)
### Unmanned Aircraft System (UAS) Capabilities Matrix

<table>
<thead>
<tr>
<th>ID</th>
<th>PI Name</th>
<th>Aeronautical Sci</th>
<th>COA</th>
<th>PI Expertise</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>D01</td>
<td>Ted Beneigh</td>
<td>Dayton Beach</td>
<td>COA</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>D02</td>
<td>Daniel Friedenzohn</td>
<td>Dayton Beach</td>
<td>COA</td>
<td>Study 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>D03</td>
<td>Tom Haritos</td>
<td>Dayton Beach</td>
<td>COA</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>D04</td>
<td>Dan Macchiarella</td>
<td>Dayton Beach</td>
<td>COA</td>
<td>Media specialist due to issues of nondisclosure and security.</td>
<td>Nondisclosure and security</td>
</tr>
<tr>
<td>D05</td>
<td>Alex Mirot</td>
<td>Dayton Beach</td>
<td>COA</td>
<td>UAS Regulation, Policy, and Ethics, UAS Operations and Applications, Team work, Crew Resource Management and UAS Education, Training and Certification</td>
<td>Regulation, Policy, and Ethics Operations and Applications Team Work Crew Resource Management Education, Training and Certification</td>
</tr>
<tr>
<td>D06</td>
<td>Janet K. Marnane</td>
<td>Dayton Beach</td>
<td>COA</td>
<td>Crew Resource Management, Decision Making; Commerical Operations; Aviation Regulation/legislation</td>
<td>Decision Making Commercial Operations CRM Avaiton Regulation/Legislation</td>
</tr>
<tr>
<td>D07</td>
<td>Clyde Rinkinen</td>
<td>Air Traffic Mgmt</td>
<td>COA</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>
<tr>
<td>PI</td>
<td>Expertise</td>
<td>Keywords</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>-----------</td>
<td>----------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D08 Sarah Ochs</td>
<td>Manager of UAS Workshops/Short-Courses for Daytona Beach</td>
<td>Logistical Planner and Event Director</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dahai Liu</td>
<td>Human Machine Interface in UAS; Supervisory Control of UASs; Reinforcement Learning in Autonomous UAVs; Modeling and Simulation</td>
<td>Workload; Situation Awareness; Supervisory Control; Reinforcement Learning; HMI; Decision Support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kelly Neville</td>
<td>Research methods for studying human-machine interaction, teams, situation awareness and decision making in complex, operational environments; identifying human operator information and control requirements; training requirements analysis; training, team training, expertise, expertise acquisition, cognition and information processing; situation awareness; decision making; cognitive work; automation design; human-automation interaction; multi-tasking and attention; mental workload assessment, stress and fatigue effects on cognition and cognitive work</td>
<td>Human Machine interface evaluation &amp; assessment; Human-system integration; Training requirements analysis &amp; team training; Expertise, expertise acquisition; Cognition &amp; information processing; Situation awareness; Decision making; Cognitive work; Automation design; human-automation interaction; Multi-tasking and attention; Mental workload assessment; Stress &amp; fatigue effects on cognition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sergey V. Drakunov</td>
<td>Control algorithms design for autopilots for autonomous UAVs and multiple UAVs formations.</td>
<td>Autopilots for autonomous UAVs; Control for multiple autonomous UAVs formations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>William MacKunis</td>
<td>Feedback Tracking Control of an Unmanned Aerial Vehicle</td>
<td>Autopilots for autonomous UAVs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosemary Reynolds</td>
<td>Teamwork, shared mental models, coordination, virtual teams</td>
<td>Teamwork; Shared mental models; Coordination; Virtual teams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>Expertise</td>
<td>Keywords</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>-----------</td>
<td>----------</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Pat (Richard) Anderson  
Aerospace Eng  
Daytona Beach COE | Faculty Advisor for NASA UAS Challenge to create an optionally piloted UAS surrogate with sense-and-avoid capability. UAS Guidance navigation and control. | Optionally piloted vehicle guidance, navigation, and control (GNC) aircraft certification |
| Vladimir Golubev  
Aerospace Eng  
| Hever Moncayo  
Aerospace Eng  
| Richard Prazenica  
Aerospace Eng  
Daytona Beach COE | 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 |
| Dae Won Kim  
Aerospace Eng  
Daytona Beach COE | Smart materials and systems, structural health monitoring, | Smart Materials Smart Structures Adaptive Structures Morphing Wings Structural Health Monitoring |
| Billy Barott  
ECSSE  
Daytona Beach COE | RF engineering including passive radar. Sensors and Datalinks for the MSUASE program | RF engineering communications sensing radar passive radar sense-and-avoid |
| Brian Butka  
ECSSE  
Daytona Beach COE | Interested in how to sense UAVs with radar and acoustics, electrical system design | UAS sensing sense-and-avoid acoustics propulsion |
<table>
<thead>
<tr>
<th>PI</th>
<th>Expertise</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>D21 Andrew Kornecki ECSSE Daytona Beach COE</td>
<td>Familiarity with UAS concepts and operations, recent development on MOPS guidance as per RTCA Select Committee SC228, 14 CFR Sec. 11 FAA special conditions and exceptions, aviation systems safety and security (as per works of RTCA SC205 and SC216)</td>
<td>Tool Qualification for Complex Electronic Hardware Assessment of Software Development Tools Knowledge Based Methodology to support ATC Systems Analysis of ATC Sector</td>
</tr>
<tr>
<td>D22 Jianhua Liu ECSSE Daytona Beach COE</td>
<td>Faculty lead on radar 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>D23 Richard Stansbury ECSSE COE</td>
<td>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 UAS in NextGen ADS-B UAS sense-and-avoid</td>
</tr>
<tr>
<td>D24 Massood Towhidnejad ECSSE Daytona Beach COE</td>
<td>Gale UAS project</td>
<td>NextGen UAS NAS Integration</td>
</tr>
<tr>
<td>D25 Timothy Wilson ECSSE Daytona Beach COE</td>
<td>UAS NAS Integration studies with FAA tech Center (technology surveys and regulatory gap analyses)</td>
<td>UAS NAS Integration</td>
</tr>
<tr>
<td>D26 Susan Allen Mechanical Eng Daytona Beach COE</td>
<td>Have two patents (related) on laser sensors.</td>
<td>Lasers, remote sensing stand-off sensors laser-based sensors</td>
</tr>
<tr>
<td>D27 Eric Coyle Mechanical Eng Daytona Beach COE</td>
<td>Signal Processing, Computer Vision, UAS Platform and Payload Design</td>
<td>Sense-and-Avoid Multi-Spectral Imaging</td>
</tr>
<tr>
<td>PI</td>
<td>PI Name</td>
<td>Expertise</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>D28</td>
<td>Patrick Currier</td>
<td>System design and integration with respect to autonomous systems including novel applications of new technologies such as mobile processing devices and 3D printing. Research interests include 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>
</tr>
<tr>
<td>D29</td>
<td>Charles Reinholtz</td>
<td>Unmanned and Autonomous Vehicles; mechanism and robotics</td>
</tr>
<tr>
<td>D30</td>
<td>Heidi Steinhauer</td>
<td>Sent request for info on 11-5</td>
</tr>
<tr>
<td>P01</td>
<td>Jon Haass</td>
<td>UAS Cyber Security &amp; Intelligence</td>
</tr>
<tr>
<td>P02</td>
<td>Stephen Rayleigh (Adjunct)</td>
<td>Flight control system integration; teaches AS473 and AS220</td>
</tr>
<tr>
<td>W01</td>
<td>Teena Deering</td>
<td>UAS Professional Development Course</td>
</tr>
<tr>
<td>W02</td>
<td>Orin Godsey</td>
<td>Refueling of Unmanned Aerial Vehicles</td>
</tr>
<tr>
<td>PI</td>
<td>Expertise</td>
<td>Keywords</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W03 David Ison</td>
<td>Integrating 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</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 sUAS Legislation; regulation; privacy</td>
</tr>
<tr>
<td>W04 Adeel Khalid</td>
<td>Precision Agriculture Application and STEM Education; Real World Design Challenge</td>
<td>Precision Agriculture Application STEM Education Design</td>
</tr>
<tr>
<td>W05 Ian McAndrew</td>
<td>Drogue refueling of unmanned aircraft; Weibull analysis of docking probability of unmanned aircraft refueling</td>
<td>UAV refueling Weibull Analysis</td>
</tr>
<tr>
<td>W06 Kat Moran</td>
<td>Aerodynamic Design considerations for UAS during refueling operations</td>
<td>Refueling of UAS</td>
</tr>
<tr>
<td>W07 Brian Sanders</td>
<td>Precision Agriculture Application and STEM Education; Real World Design Challenge</td>
<td>Precision Agriculture Application STEM Education Design</td>
</tr>
<tr>
<td>W08 Todd Smith</td>
<td>Application and use of UAS in firefighting, emergency management, emergency response and disaster preparedness operations.</td>
<td>Safety Emergency management Emergency response Disaster preparedness</td>
</tr>
<tr>
<td>W09 Brent Terwilliger</td>
<td>Design, development, integration, test, application, and evaluation of unmanned systems and human-machine-interfaces; UAS regulatory and operational environment; Modeling and simulation (M&amp;S); Situational awareness; STEM education; Course/workshop development and execution; Documentation</td>
<td>Unmanned aircraft, system integration, UAS application, HMI, M&amp;S, STEM, UAS Workshops, documentation, sUAS</td>
</tr>
<tr>
<td>PI</td>
<td>Expertise</td>
<td>Keywords</td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W10</td>
<td>Dennis Vincenzi Worldwide COA</td>
<td>Unmanned systems including unmanned aerial systems (UAS), unmanned ground vehicles (UGV)s, and robotic systems; Situational awareness; Modeling and simulation (M&amp;S); System design, development, integration, and test; Application, operation, and support of unmanned systems; UAS regulatory environment; Human-machine-interface</td>
</tr>
<tr>
<td>W11</td>
<td>Ken Witcher Worldwide COA</td>
<td>Integrating UAS into Airport Master Plans; Refueling of unmanned aerial vehicles</td>
</tr>
<tr>
<td>W12</td>
<td>David Worrells Worldwide COA</td>
<td>Integrating UAS into Airport Master Plans; Integration of UAS in National Airspace System</td>
</tr>
<tr>
<td>W13</td>
<td>Elena Navarro Worldwide COAS</td>
<td>Mathematical Calculations</td>
</tr>
<tr>
<td>W14</td>
<td>Kelly George Worldwide COAS</td>
<td>Co-authored a Wiki on UAS for the DAS 735 course (ERAU Ph.D. in Aviation program)</td>
</tr>
</tbody>
</table>