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

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

Michael P. Hickey, Editor
University Dean of Research and Graduate Studies
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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.

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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 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 Mr. Alex Mirot, Drs. 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 Dr. Richard Heist, Senior Vice President for Academic Affairs and Research, Dr. Richard Bloom, Chief Academic Officer at Prescott and Dr. Brad L. Sims, Chancellor of Worldwide, for their continued support of UAS related activities across our university.

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

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### Project by Area Table

Unmanned Aircraft System (UAS) Capabilities Matrix: 18

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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)

CFD Analysis of Aerodynamic Surface Finishes
This project involves CFD modeling of low speed boundary layer airflow on various UAS surface finishes. (W05 & W13)
Figure 2: Boeing AerosPACE (Aerospace Partners for Advancement of Collaborative Engineering) 2013-14 Program. Blended Wing Body (BWB) UAS for Agricultural Surveillance Missions. Designed & Built by a Multi-University Team, including ERAU Prescott

**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)

**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)

**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)

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)

**UAS Clusters as a Source of Competitive Advantage**  
As UASs continue to evolve, it is important to remember that clusters have played an important role in the history of aerospace manufacturing. Although we don’t know exact numbers, we know the UAS industry will be huge, and we also know it will continue to play a crucial role in national defense. Given the enormous impact UAS could have on our country, the focus of this project is on leveraging innovative best practices that can accelerate our competitive advantage in UAS design, manufacturing, and lifecycle support. (W15)

**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**  
The details of this research are described under E1. Design, Development, and Validation. (D29)

**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, or system performance. (W01, W03, W08, W09, W10, & W11)
Development of a Fully 3-D Printed Fixed-Wing UAV
The details of this research are described under E1. Design, Development, and Validation. (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 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)
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)

**UAS-Aircraft Rescue Fire Fighting Response Conceptual and Application Analysis**
The application of UAS to support ARFF 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, W08, W09, W10 & W11)

![Figure 5: UAS Application Analysis – UAS ARFF Theory of Operation](image)

**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, 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*

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

The details of this research are described under *E1. Design, Development, and Validation.* (D19, D28, D29 & D30)

*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, 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

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)
**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**
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)

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**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, D28, D29 & D30)

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

**Unmanned System Attribute Performance Model Development**
The details of this research are described under *E3. Modeling and Simulation*. (W03, W09 & W10)

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**E6. Operational Environment**

**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, W03, W04, W08, W09, W10 & W11)

**Image Processing In Support of “Sense-and-Avoid” Operations**
The details of this research are described under *E4. Autonomy and Control*. (D17, D19, D22, D23, & D27)

**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 & W09)
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. (W03, W09, W11, W12)

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)
The details of this research are described under E2. Communications and Security. (D23 & D25)

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. (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 details of this research are described under E4. Autonomy and Control. (W03 & W09)

Integrating Unmanned Aircraft Systems into Airport Operations and Master Plans
The details of this research are described under E6. Operational Environment. (W03, W09, W11 & W12)

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)
The details of this research are described under E6. Operational Environment. (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 woman with a drone]

**Figure 8:** 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 Operations and Master Plans**
The details of this research are described under *E6. Operational Environment*. (W03, W09, W11, W12)

**The Business Enterprise**
In this project the development of a leasing market for UAS is researched. (D02)
**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. (W09)

A3. Operational Employment

**CFD Analysis of Aerodynamic Surface Finishes**
The details of this research are described under *E1. Design, Development, and Validation.* (W05 & W13)

**Design of Hunter-Killer UAV’s using Morphing Aircraft Technology**
The details of this research are described under *E1. Design, Development, and Validation.* (W07)

**Emergency Response using UAS**
The details of this research are described under *E6. Operational Environment.* (D09, W01, W03, W08, W09, W10 & W11)

**Hypersonic Flight of UAV as a Cargo Vessel**
The details of this research are described under *E1. Design, Development, and Validation.* (W02, W05, W13)

**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, W11 & 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, W08, W09, W10 & W11)

**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**
The details of this research are described under *A1. Regulation, Policy, and Ethics.* (W14)

A4. Remote Sensing with UAS

**Aerobiological Sampling Using UAVs**
The details of this research are described under *E1. Design, Development, and Validation.* (D29)

**Android Autopilot System**
The details of this research are described under *E4. Autonomy and Control.* (D28)
**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, 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 focusses on new types of laser-based remote and short range sensors. (D26)

**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. (D27)

A5. Education and Training

**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)

**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 & W09).
Figure 7: UAS operators working within a common system control station.

**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**
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. (W09)

**Wiki on UAS**
The details of this research are described under A1. Regulation, Policy, and Ethics. (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**
The details of this research are described under A5. Education and Training. (D04, D05, W03, W10 & D06)

**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, W09 & W10)

**Emergency Response using UAS**
The details of this research are described under E6. Operational Environment. (D09, W01, W03, W08, W09, W10 & W11)

**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 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**
The details of this research are described under *E4. Autonomy and Control.* (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**
The details of this research are described under *E3. Modeling and Simulation.* (D16)

**Reinforcement Learning of Imperfect sensor for autonomous aerial vehicles**
The details of this research are described under *E3. Modeling and Simulation.* (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)
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<tr>
<td>Vision-Aided Navigation</td>
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<td>Unmanned Systems Career</td>
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<tr>
<td>Opportunities, Educational</td>
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<td>Unmanned Systems Career</td>
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</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**
<table>
<thead>
<tr>
<th>PI</th>
<th>Expertise</th>
<th>Keywords</th>
</tr>
</thead>
</table>
| **D01** Ted Beneigh  
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 Professor  
Aeronautical Sciences  
Daytona Beach  
COA  
FRIEDEND@erau.edu | Study 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 and Chair  
Aeronautical Sciences  
Daytona Beach  
COA  
macchian@erau.edu | Media specialist due to issues of nondisclosure and security | Nondisclosure and security |
| **D05** Alex Mirot  
Assistant Professor  
Aeronautical Sciences  
Daytona Beach  
COA  
mirota@erau.edu | 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  
marnaneji@erau.edu | Crew Resource Management, Decision Making; Commercial Operations; Aviation Regulation/legislation | Decision Making  
Commercial Operations  
CRM  
Aviation  
Regulation/Legislation |
<table>
<thead>
<tr>
<th>PI</th>
<th>Expertise</th>
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</thead>
</table>
| Clyde Rinkinen  
Associate Professor  
Air Traffic Mgmt  
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 |
| Sarah Ochs  
Professional Programs  
Daytona Beach  
COA  
och839@erau.edu | Manager of UAS Workshops/Short-Courses for Daytona Beach | Logistical Planner and Event Director |
| Dahai Liu  
Professor  
Human Factors  
Daytona Beach  
COAS  
Liu89b@erau.edu | 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 |
| Kelly Neville  
Human Factors  
Daytona Beach  
COAS  
nevillek@erau.edu | 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 | Human Machine interface evaluation & assessment; Human-system integration; Training requirements analysis & team training; Expertise, expertise acquisition; Cognition & information processing; Situation awareness; Decision making; Cognitive work; Automation design; human-automation interaction; Multi-tasking and attention; Mental workload assessment, stress & fatigue effects on cognition |
| Sergey V. Drakunov  
Associate Dean for Research and Graduate Studies  
Daytona Beach  
COAS  
DRAKUNOV@erau.edu | Control algorithms design for autopilots for autonomous UAVs and multiple UAVs formations. | Autopilots for autonomous UAVs; Control for multiple autonomous UAVs formations |
| William MacKunis  
Assistant Professor  
Engineering Physics  
COAS  
MACKUNIW@erau.edu | Feedback Tracking Control of an Unmanned Aerial Vehicle | Autopilots for autonomous UAVs |
<table>
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<tr>
<th>PI</th>
<th>Expertise</th>
<th>Keywords</th>
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</table>
| Rosemarie Reynolds  
Mgmt, Marketing &  
Operations  
Daytona Beach  
COB  
reyno9bd@erau.edu | Teamwork, shared mental models, coordination, virtual teams | Teamwork  
Shared mental models  
Coordination  
Virtual teams |
| 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. UAS Guidance navigation and control. | Optionally piloted vehicle guidance, navigation, and control (GNC) aircraft certification |
| Vladimir Golubev  
Professor  
Aerospace Engineering  
Daytona Beach  
COE  
golubd1b@erau.edu | Unsteady Aerodynamics, Flow/Flight/Propulsion Control, Aeroacoustics, Aeroelasticity, Computational Fluid Dynamics | Synthetic Jet Actuators  
Gust-Airfoil Interactions  
Micro Air Vehicles  
Transitional Flows  
Flow-Acoustic Resonant Interactions |
| Hever Moncayo  
Assistant Professor  
Aerospace Engineering  
Daytona Beach  
COE  
moncayoh@erau.edu | Guidance, Navigation and Control, Flight dynamics Modeling and simulation. Aerospace Fault Tolerance | Unmanned systems  
Aviation Safety  
Navigation and control  
Fault Tolerance |
| Richard Prazenica  
Assistant Professor  
Aerospace Engineering  
Daytona Beach  
COE  
prazenir@erau.edu | 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  
Assistant Professor  
Aerospace Engineering  
Daytona Beach  
COE  
kimd3c@erau.edu | Smart materials and systems, structural health monitoring, | Smart Materials  
Smart Structures  
Adaptive Structures  
Morphing Wings  
Structural Health Monitoring |
| Billy Barott  
Associate Professor  
Electrical Engineering  
Daytona Beach  
COE  
barottw@erau.edu | RF engineering including passive radar. Sensors and Datalinks for the MSUASE program | RF engineering  
communications  
sensing  
radar  
passive radar  
sense-and-avoid |
<table>
<thead>
<tr>
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<tr>
<td>D20 Brian Butka</td>
<td>Interested in how to sense UAVs with radar and acoustics, electrical system design</td>
<td>UAS sensing, sense-and-avoid, acoustics, propulsion</td>
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<tr>
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<tr>
<td><a href="mailto:butkab@erau.edu">butkab@erau.edu</a></td>
<td></td>
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<tr>
<td>D21 Andrew Kornecki</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>Professor</td>
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<tr>
<td>Software Engineering</td>
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<tr>
<td><a href="mailto:kornecka@erau.edu">kornecka@erau.edu</a></td>
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<tr>
<td>D22 Jianhua Liu</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>
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<tr>
<td>Associate Professor</td>
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<tr>
<td><a href="mailto:liu620@erau.edu">liu620@erau.edu</a></td>
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<tr>
<td>D23 Richard Stansbury</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>
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<tr>
<td>Associate Professor</td>
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<tr>
<td><a href="mailto:stansbur@erau.edu">stansbur@erau.edu</a></td>
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<tr>
<td>D24 Massood Towhidnejad</td>
<td>Gale UAS project</td>
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<tr>
<td>Professor</td>
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<td><a href="mailto:towhid@erau.edu">towhid@erau.edu</a></td>
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<tr>
<td>D25 Timothy Wilson</td>
<td>UAS NAS Integration studies with FAA tech Center (technology surveys and regulatory gap analyses)</td>
<td>UAS NAS Integration</td>
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<tr>
<td>Chair and Professor</td>
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<tr>
<td>Software Engineering</td>
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<tr>
<td><a href="mailto:wilsonti@erau.edu">wilsonti@erau.edu</a></td>
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<tr>
<td>D26 Susan Allen</td>
<td>Have two patents (related) on laser sensors.</td>
<td>Lasers, remote sensing, stand-off sensors, laser-based sensors</td>
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<tr>
<td>Distinguished Professor</td>
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<tr>
<td>Mechanical Eng</td>
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<td><a href="mailto:ALLENS17@erau.edu">ALLENS17@erau.edu</a></td>
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<td>D27</td>
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<tr>
<td></td>
<td>Assistant Professor Mechanical Eng Daytona Beach COE <a href="mailto:COYEE1@erau.edu">COYEE1@erau.edu</a></td>
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| D28 | Patrick Currier | 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. | UAS integration autonomy 3D printing mobile devices student teams |
|     | Assistant Professor Mechanical Eng Daytona Beach COE CURRIERP@erau.edu | | |

| D29 | Charles Reinholtz | Unmanned and Autonomous Vehicles; mechanism and robotics | Unmanned and Autonomous Vehicles mechanism and robotics |
|     | Professor Mechanical Eng Daytona Beach COE reinholc@erau.edu | | |

| D30 | Heidi Steinhauser | Sent request for info on 11-5 | Fixed-wing UAV |
|     | Chair and Associate Professor Freshman Engineering Daytona Beach COE steinhah@erau.edu | | |

| P01 | Jon Haass | UAS Cyber Security & Intelligence | Cyber Security & Intelligence |
|     | Associate Professor Cyber Security and Intelligence Prescott COA HAASSJ@erau.edu | | |

<p>| P02 | Vince Pujalte | Flight control system integration; teaches AS473 and AS220 | Flight control system integration |
|     | Assistant Professor Applied Aviation Sci Prescott COA <a href="mailto:pujalo63@erau.edu">pujalo63@erau.edu</a> | | |</p>
<table>
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<tr>
<th>PI</th>
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</table>
| P03 | Sara Nilsson  
Assistant Professor  
Aeronautical Sci  
Prescott  
COA  
fishe5ca@erau.edu | UAS Law and Regulation | Law  
Regulation  
Policy |
| W01 | David Thirtyacre  
Assistant Professor  
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  
Worldwide  
COA  
godseyo@erau.edu | Refueling of Unmanned Aerial Vehicles | Refueling of UAV |
| W03 | David Ison  
Assistant Professor  
Worldwide  
COA  
isond46@erau.edu | 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 | 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 |
| W04 | Robert Deters  
Assistant Professor  
Worldwide  
COA  
DETERSR1@erau.edu | 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 | Drogue refueling of unmanned aircraft; Weibull analysis of docking probability of unmanned aircraft refueling | UAV refueling  
Weibull Analysis |
| W06 | Kat Moran  
Associate Professor  
Worldwide  
COA  
morank@erau.edu | Aerodynamic Design considerations for UAS during refueling operations | Refueling of UAS |
<table>
<thead>
<tr>
<th>W07</th>
<th>Brian Sanders</th>
<th>Full time Faculty Worldwide COA</th>
<th>Precision Agriculture Application and STEM Education; Real World Design Challenge</th>
<th>Precision Agriculture Application STEM Education Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Todd Smith</td>
<td>Assistant Professor Worldwide COA</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></td>
<td>Brent Terwilliger</td>
<td>Program Chair, MS in Unmanned Systems Worldwide COA</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; Curricula development and execution; Documentation</td>
<td>Unmanned aircraft, system integration, unmanned system application, HMI, M&amp;S, STEM, UAS curricula development, documentation, SUAS</td>
</tr>
<tr>
<td></td>
<td>Dennis Vincenzi</td>
<td>Department Chair Undergraduate Studies 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>
<td>Unmanned systems including UAS, UGVs, 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></td>
<td>Ken Witcher</td>
<td>Dean Worldwide COA</td>
<td>Integrating UAS into Airport Master Plans; Refueling of unmanned aerial vehicles</td>
<td>Integrating UAS into Airport Master Plans Refueling of UAV</td>
</tr>
<tr>
<td></td>
<td>David Worrells</td>
<td>Associate Professor Worldwide COA</td>
<td>Integrating UAS into Airport Master Plans; Integration of UAS in National Airspace System</td>
<td>Integrating UAS into Airport Master Plans Integration of UAS in National Airspace System</td>
</tr>
<tr>
<td></td>
<td>Elena Navarro</td>
<td>Instructor Worldwide COAS</td>
<td>Mathematical Calculations</td>
<td>Refueling of UAS</td>
</tr>
<tr>
<td>W14</td>
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<tr>
<td>Kelly George</td>
<td>Co-authored a Wiki on UAS for the DAS 735 course (ERAU Ph.D. in Aviation program)</td>
<td>Economics</td>
<td>Developing industries</td>
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<td>Worldwide</td>
<td>Monoetary &amp; fiscal policy</td>
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<td><a href="mailto:georged8@erau.edu">georged8@erau.edu</a></td>
<td></td>
<td>UAS Manufacturing Clusters</td>
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<tr>
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<td>Manufacturing Clusters and the UAS Industry</td>
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<td>Clusters as a Source of Competitive Advantage in the UAS Industry</td>
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<td>USA’s Role in UAS Manufacturing</td>
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<td>Leaders in UAS Design and Manufacturing</td>
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<td>Cluster Mapping and the UAS Industry</td>
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<td>Sustainability in UAS Manufacturing</td>
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<td>Repeat all the above for use with the acronym, UAV</td>
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<tr>
<td>Worldwide</td>
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<tr>
<td><a href="mailto:materc73@erau.edu">materc73@erau.edu</a></td>
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