The Research and Engineering Center for Unmanned Vehicles (RECUV) is a university, government, and industry partnership dedicated to the development and application of unmanned vehicle systems. RECUV research encompasses scientific experiments, commercial applications, mitigation of natural and man-made disasters, security, and national defense.

RECUV draws faculty and students from across the College of Engineering and Applied Science. We address technical challenges in a collaborative environment that integrates the traditional aerospace engineering disciplines of aerodynamics, structures, propulsion, navigation, control, and platform design with networking, telecommunications, robotics, and security.

The Goals of RECUV are to:
- Engineer new mobile sensing systems that integrate sensors and unmanned vehicles.
- Stimulate strategic discussions among local, national, and international leaders.
- Facilitate the adoption of these systems by working with regulatory agencies to lead the way to commercial development.
- Increase public awareness of unmanned vehicles and their applications.
- Educate and train a next generation of innovative and multidisciplinary engineers.
- The RECUV research program is supported by federal agency and industry support exceeding $1,500,000 per year.

Recent Highlights
- The Center for Unmanned Aircraft Systems (C-UAS) became an official operating center in March 2012 in the National Science Foundation (NSF) Industry/University Cooperative Research Centers (I/UCRC) program. The inaugural industry members of C-UAS include AFRL Aerospace Systems Directorate, AFRL Munitions Directorate, AAI-Textron, Boeing, Insitu, L-3 Communications, NASA Dryden Flight Research Center, the National Oceanic and Atmospheric Administration, United Technologies Research Center, and Utopia Compression. C-UAS is a collaborative effort between RECUV and Brigham Young University to address key technical challenges and provide superb training for future leaders in the unmanned aircraft systems industry.
- RECUV is part of the collaborative team selected for a two-year NASA project titled Investigations of Spatial and Temporal Variability of Ocean and Ice Conditions In and Near the Marginal Ice Zone (aka the Marginal Ice Zone Observations and Processes Experiment [MIZOPEX]). MIZOPEX will employ UAS to assess ocean and ice variability during the melt season, exploiting unique capabilities of multiple classes of unmanned systems (the NASA Sierra, Insitu ScanEagles, and the CU DataHawk) combined with UAS- and ship-deployed buoys and satellite observations. Flights will take place over the Beaufort Sea in summer 2013.

RECUV Partners and Sponsors
- AFOSR
- AFRL
- ARO
- ONR
- DARPA
- FAA
- NASA
- NSF
- Boeing
- United Technologies Research Center
- National Oceanic and Atmospheric Administration

RECUV Director: Associate Professor
Eric W. Frew

Dr. Eric W. Frew is an associate professor in the Aerospace Engineering Sciences Department and Director of the Research and Engineering Center for Unmanned Vehicles at the University of Colorado Boulder (CU). He received his B.S. in mechanical engineering from Cornell University in 1995 and his M.S. and Ph.D. in aeronautics and astronautics from Stanford University in 1996 and 2003, respectively. Dr. Frew’s research efforts focus on autonomous flight of heterogeneous unmanned aircraft systems, optimal distributed sensing by mobile robots; controlled mobility in ad-hoc networks; miniature self-deploying systems; and guidance and control of unmanned aircraft in complex atmospheric phenomena. He is currently the CU Site Director for the National Science Foundation Industry/University Cooperative Research Center (IUCRC) for Unmanned Aircraft Systems. He received the NSF Faculty Early Career Development (CAREER) Award in 2009 and was selected a member of the 2010 DARPA Computer Science Study Group.
Facilities, Unmanned Aircraft, Mobile Ground Station

- The Unmanned Vehicle Systems Integration Lab is located in the Engineering College’s Discovery Learning Center. Computing facilities, electronics work benches, and test equipment enable hardware/software integration and hardware-in-the-loop testing of mobile sensing systems.
- The Unmanned Systems Fabrication Lab, located in the Engineering Center, provides software design tools, machine, and power tools for unmanned vehicle design and construction.
- The Table Mountain Field Site and Radio Quiet Zone, owned and maintained by the US Dept. of Commerce, includes the RECUV UAS airfield, and a system of roads and a fiber optic network that interconnect various buildings and permanent antenna sites on a 2.5-mi × 1.5-mi mesa located about 10 miles north of the Boulder Campus. A high-speed router connects the test range communication system into the public internet. The facility is used to conduct RECUV mobile networking experiments and other flight tests.
- The mobile Ground Control Station (GCS) is a command, control, and communications (C3) center housed inside a customized 15-passenger van. The mobile GCS is equipped with VHF voice radios, a 900-MHz mechanical tracking antenna for direct UAS command and control, and a 2.4-GHz phased-array WiFi antenna to support the autonomy-enabling NetUAS C3 architecture.
- The RECUV Unmanned Aircraft Fleet consists of aircraft ranging in size and performance from the 1-lb, 36-inch wingspan DataHawk used for atmospheric sensing, to the 11-ft wingspan, 45-lb Platus P1-A that can carry up to 12 pounds of payload. With a 10 ft wingspan, the AresMax is the second generation of the original RECUV Ares UAS used in the first Ad Hoc UAS & Ground Network (AUGNet) experiments. Ten electric-powered NavSTAR UAS are the primary workhorses for current networking experiments. One of the four Tempest UAS, designed for in-situ sensing in severe thunderstorms, was the first UAS to penetrate and sample supercell thunderstorms.

Faculty

Dennis Akos
Associate Professor, Aerospace Engineering Sciences. GPS/GNSS satellite navigation systems, RFI/spoofing countermeasures, Software Defined Radios.

Brian M. Argrow
Professor, Aerospace Engineering Sciences. Unmanned aircraft systems, airspace integration, aero-gas dynamics.

Timothy Brown
Professor, Electrical, Computer, and Energy Engineering. Communication systems, networking, wireless systems, machine learning.

Eric W. Frew
Associate Professor, Director of RECUV, Aerospace Engineering Sciences. Networked heterogeneous unmanned aircraft systems, controlled mobility in ad-hoc networks, guidance and control of unmanned aircraft in complex atmospheric phenomena.

Harvey Gates
Associate Professor, Adjoint in Interdisciplinary Telecommunications and Aerospace Engineering Sciences. Commercial and defense related telecommunication initiatives.

Dale A. Lawrence
Professor, Aerospace Engineering Sciences. Small aircraft dynamics, guidance, and control, sensor and autopilot avionics, theory and applications of system identification and adaptive control.

James Maslanik
Research Professor, Aerospace Engineering Sciences. Remote sensing and climate modeling with emphasis on the Arctic, integration of field measurements, aircraft observations, and satellite-derived products, development of field instrumentation and remotely-piloted vehicles.

Scott Palo

Ryan Starkey
Assistant Professor, Aerospace Engineering Sciences. Multidisciplinary design optimization, high-speed unmanned systems, advanced propulsion systems, computational aerodynamics, and hypersonic systems.

More Information

Eric W. Frew
Director, Research and Engineering Center for Unmanned Vehicles
Associate Professor of Aerospace Engineering Sciences
University of Colorado Boulder
429 UCB, Boulder, CO 80309-0429
303-735-1285
eric.frew@colorado.edu

Kurt Maute
Associate Dean for Research
Joseph Negler Endowed Professor
College of Engineering and Applied Science
University of Colorado Boulder
422 UCB, Boulder, CO 80309-0422
303-735-2103
maute@colorado.edu

Jeffrey G. Scezchowski
Assistant Dean for Research Opportunities
College of Engineering and Applied Science
University of Colorado Boulder
422 UCB, Boulder, CO 80309-0422
303-492-2615
scezchowski@colorado.edu

RECUV Research Focus

The central integrative theme of RECUV is Cooperative Mobile Sensing Systems. Our research is focused into seven areas:

- **Mission-Derived Small UAS Design**
  RECUV focuses on the design of new UAS platforms for communication and sensing applications. Examples include the low-cost DataHawk for atmospheric boundary layer sensing, the Tempest UA for studying severe storms, and the AresMax which integrates a wireless communication antenna into the aircraft wing.

- **Mobile Ad-Hoc Communications**
  RECUV deploys delay-tolerant, ad-hoc protocols that allow unmanned aircraft systems (UAS) to operate in stressed or fractured networks. Cognitive radios are being developed that scan the RF spectrum to select frequencies with the best performance.

- **Cooperative UAS Teams**
  Teams of cooperating UAS can perform missions better, faster, and more efficiently than larger single aircraft systems. RECUV focuses on net-centric architectures and algorithms for autonomous control of multiple small unmanned aircraft.

- **Vehicle-Sensor Integration**
  Payloads that have been integrated into UAS by RECUV include a laser altimeter, synthetic aperture radar, wing-integrated antenna, IP-based video camera, ELINT package, in situ atmospheric state and turbulence sensors, phased array antenna, dropsonde, and gimbaled camera.

- **Robotic Sensor-Networks**
  This area combines work in networked unmanned systems, cooperative control, and controlled mobility in ad-hoc networks, and optimal distributed sensing to develop heterogeneous robot sensor networks for in situ science applications.

- **Advanced Propulsion Systems**
  RECUV develops small, efficient gas turbine based propulsion systems to enable high-speed UAS for advanced applications. This includes GoJett - the world’s first supersonic UAS – developed to facilitate low cost, high speed research.

- **Airspace Integration**
  Safety regulations designed by the FAA for large aircraft in populated areas are not appropriate for many UAS applications, RECUV works with the FAA to help them characterize UAS operation and to develop new safety technology for the aviation sector.