

Eric W. Frew

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RESEARCH INTERESTS:

My research interests are in the area of autonomous vehicles and field robotics, with an emphasis on unmanned aircraft systems (UAS). Primary focuses are autonomous flight of heterogeneous unmanned aircraft systems (UAS), guidance and control of unmanned aircraft in complex atmospheric phenomena, optimal distributed sensing by mobile robots, controlled mobility in ad-hoc sensor networks, miniature self-deploying systems, and vision-based control.

EMPLOYMENT:

Assistant Professor

2004-present

Aerospace Engineering Sciences Department, University of Colorado, Boulder

CITIZENSHIP: United States of America

PROFESSIONAL PREPARATION:

University of California, Berkeley

Postdoctoral Research Scientist, Center for Collaborative Control of Unmanned Vehicles (C3UV) July 2003-July 2004

Stanford University, Stanford, CA

Ph.D., Department of Aeronautics and Astronautics September 2003

M.S., Department of Aeronautics and Astronautics May 1996

Cornell University, Ithaca, NY

B.S., Sibley School of Mechanical and Aerospace Engineering, GPA 4.1 May 1995

AWARDS AND HONORS:

DARPA Computer Science Study Group, 2010

Provost's Faculty Achievement Award, 2009

NSF Faculty Early Career Development (CAREER) Award, 2009

The Chancellor's Award for Excellence in STEM Education, 2009-2010

Dean's Faculty Fellowship, Spring 2009

2006 Young Engineer of the Year, AIAA Rocky Mountain Section

ARCS Fellowship, 2003

Thomas V. Jones Stanford Graduate Fellowship, 1998 – 2001

Tau Beta Pi, Pi Tau Sigma

Cornell Tradition Fellowship, 1991-1993

TEACHING:

University of Colorado at Boulder

ASEN 2003 Introduction to Dynamics and Systems Spring 2006, 2007, 2008

ASEN 3128 Aircraft Dynamics Spring 2010, 2011

ASEN 4018/4028 Senior Projects, Project Advisory Board 2004 – 2005, 2008-2009

ASEN 4114/5114 Automatic Control Systems Fall 2005, 2006, 2007, 2008, 2009

ASEN 5014 Linear Control Systems Fall 2010

ASEN 5519-004 Unmanned Vehicle Systems and Control Spring 2005

ASEN 6519 ASTORM Graduate Project 2009-2010

ASEN 6519 Cooperative Control of Multi-Vehicle Systems Spring 2007, 2010

Stanford University, Substitute Lecturer

2000-2003

AA271A Dynamics and Control of Spacecraft and Aircraft

E206 Control System Design

STUDENT SUPERVISION:

Doctoral Theses, Supervisor

- [1] Cory Dixon, *Controlled Mobility of Unmanned Aircraft Chains to Optimize Capacity in Realistic Communication Environments*, Aerospace Engineering Sciences, PhD, August 2010.
- [2] Jack Elston, PhD candidate, Aerospace Engineering Sciences (passed thesis defense 12/09/10).
- [3] Maciej Stachura, PhD candidate, Aerospace Engineering Sciences (passed comprehensive exam 12/09).
- [4] Jason Durrie, PhD candidate, Aerospace Engineering Sciences (passed prelim 11/09).
- [5] Anthony Carfang, PhD candidate, Aerospace Engineering Sciences (passed prelim 11/09).
- [6] Neeti Wagle, PhD candidate, Computer Science (passed prelim exam 12/09).

Doctoral Theses, Reader

- [1] William Pisano, *The Development of an Autonomous Gust Insensitive Unmanned Aerial Vehicle*, University of Colorado, Boulder, May 2009.
- [2] Richard Power, *Track-Loss Detection in the Absence of Truth Data for Target Tracking in Clutter*, University of Colorado, Boulder, August 2007.

Masters Theses, Supervisor

- [1] Tristan Gerritsen, *Particle Filter for UAS Airfield Localization Using Passive Sensors in GPS-denied Environments*, July 2008. (Became project option due to AFRL public release policy)
- [2] Jennifer O'Brien, *Multi-vehicle Aerospace Simulation Environment*, May 2008.

Graduate Independent Study, Supervisor

- [1] Eric Brighton, Spring 2011
- [2] Holly Borowski, Fall 2010 – Spring 2011
- [3] Philip Holtzman, May 2010.
- [4] Spencer Riggs, Spring 2009.
- [5] Kimberly Kroh, Spring 2009.

REFEREED JOURNAL PUBLICATIONS: (* indicates students of mine)

- [1] Jack Elston* and Eric W. Frew. "Unmanned Aircraft Guidance for Penetration of Pre-Tornadic Storms." *AIAA Journal of Guidance, Control, and Dynamics*, 33(1):99–107, Jan.-Feb. 2010.
- [2] Jack Elston*, Eric W. Frew, Dale Lawrence, Peter Gray, and Brian Argrow. "Net-Centric Communication and Control for a Heterogeneous Unmanned Aircraft System." *Journal of Intelligent and Robotic Systems*, 56(1-2):199-232, Sept., 2009. (Published online May 22, 2009). <http://dx.doi.org/10.1007/s10846-009-9334-x>.
- [3] Eric W. Frew. "Information-Theoretic Integration of Sensing and Communication for Active Robot Networks." Invited to special issue of *Mobile Networks and Applications (MONET)*, 14(3):267-280 June 2009 (Published online Oct. 18, 2008). <http://dx.doi.org/10.1007/s11036-008-0103-z>
- [4] Cory Dixon* and Eric W. Frew. "Maintaining Optimal Communication Chains in Robotic Sensor Networks using Mobility Control." Invited to special issue of *Mobile Networks and Applications (MONET)*, 14(3):281-291 June 2009 (Published online Sept. 30, 2008). <http://dx.doi.org/10.1007/s11036-008-0102-0>.
- [5] Brian Argrow, Elizabeth Weatherhead, and Eric W. Frew. "Real-Time Participant Feedback from the Symposium for Civilian Applications of Unmanned Aircraft Systems." *Journal of Intelligent and Robotic Systems*, 54:87-103 March 2009. (Published online July 23, 2008). <http://dx.doi.org/10.1007/s10846-008-9259-9>
- [6] Eric W. Frew and Timothy X. Brown. "Networking Issues for Small Unmanned Aircraft Systems." *Journal of Intelligent and Robotic Systems*, 54:21-37, March 2009. (Published online July 17, 2008). <http://dx.doi.org/10.1007/s10846-008-9253-2>.
- [7] Eric W. Frew and Timothy X Brown, "Airborne Communication Networks for Small Unmanned Aircraft Systems." *Proceedings of the IEEE, Special Issue on Aviation Information Systems*, 96(12): 2008-2027, Dec. 2008.
- [8] Dale A. Lawrence, Eric. W. Frew, and William J. Pisano, "Lyapunov Vector Fields for Autonomous UAV Flight Control" *AIAA Journal of Guidance, Control, and Dynamics*, 31(5):1220–1229, Sept.-Oct. 2008.

- [9] Eric W. Frew. “Sensitivity of Cooperative Target Geolocalization to Orbit Coordination.” *AIAA Journal of Guidance, Control, and Dynamics*, 31(4):1028-1040, July-August 2008.
- [10] Eric W. Frew, Cory Dixon*, Jack Elston*, Brian Argrow, and Timothy X. Brown. “Networked Communication, Command, and Control of an Unmanned Aircraft System.” *AIAA Journal of Aerospace Computing, Information, and Communication*, 5(4):84–107, 2008.
- [11] Eric W. Frew, Dale A. Lawrence, and Stephen Morris. “Coordinated Standoff Tracking of Moving Targets using Lyapunov Guidance Vector Fields.” *AIAA Journal of Guidance, Control, and Dynamics*, 31(2):290–306, March-April 2008.

UNDER REVIEW OR IN PREPARATION

- [12] Cory Dixon* and Eric W. Frew, “Decentralized Mobility Control for Optimizing the Capacity of Linear Robotic Network Chains.” *IEEE Transactions on Robotics*, 2010, under revision (revision requested 07/08/10).
- [13] Maciej Stachura* and Eric W. Frew. “Cooperative Target Localization with a Communication Aware Unmanned Aircraft System.” *AIAA Journal of Guidance, Control, and Dynamics*, under review (revision submitted 11/23/10).
- [14] Anthony J. Carfang*, Eric W. Frew, and Timothy X Brown. “Effects of Communication Models on Ferry Routes for Sensor Network Data Collection.” *AIAA Journal of Aerospace Computing, Information, and Communication*, under review (submitted 07/23/10).
- [15] Eric W. Frew. “Providing Quality of Service of Information through Mobility.” *IEEE Transactions on Robotics*, 2010, under revision.
- [16] Jack Elston*, Jason Roadman, Maciej Stachura*, Brian Argrow, Adam Houston, and Eric W. Frew. “The Tempest Unmanned Aircraft System for In Situ Observations of Tornadic Supercells: Design and Flight Test Results.” *Journal of Field Robotics*, under review (revision submitted 01/14/11).
- [17] Jack Elston*, Brian Argrow, Eric W. Frew, Adam Houston, and Jerry Straka. “Evaluation of Unmanned Aircraft Systems for Severe Storm Sampling using Hardware-in-the-Loop Simulations” *AIAA Journal of Aerospace Computing, Information, and Communication*, under review (submitted 01/19/11).
- [18] Jason Roadman, Jack Elston*, Brian Argrow, and Eric Frew, “Performance of the Electric-Powered Tempest UAS in a Severe Storm Environment.” *AIAA Journal of Aircraft*, in preparation.
- [19] Maciej Stachura*, Jack Elston*, Cory Dixon*, Brian Argrow, and Eric W. Frew. “Obtaining FAA Certificates of Authorization for UAS Participation in VORTEX2.” *AIAA Journal of Aerospace Computing, Information, and Communication*, in preparation.
- [20] Jason Durrie*, Jack Elston*, Maciej Stachura*, Eric W. Frew, and Brian Argrow. “The Concept of Operations of a UAS Designed to Sample Severe Thunderstorms.” *Journal of Field Robotics*, in preparation.
- [21] Jack Elston*, Brian Argrow, and Eric W. Frew. “A Networked Avionics System for Unmanned Aircraft Systems Studying Severe Storms.” *Mobile Networks and Applications (MONET)*, in preparation.

BOOK CHAPTERS: (* indicates students of mine)

- [1] Cory Dixon* and Eric W. Frew. “Decentralized Extremum-Seeking Control of Nonholonomic Vehicles to Form a Communication Chain.” *Advances in Cooperative Control and Optimization*. Lecture Notes in Computer Science, Vol. 369, Michael J. Hirsch, Panos Pardalos, Robert Murphey, and Don Grundel, Eds. Springer-Verlag, Nov. 2007, pp. 311-322.
- [2] Timothy Brown, Brian Argrow, Eric Frew, Cory Dixon*, Daniel Henkel, Jack Elston*, and Harvey Gates. “Experiments Using Small Unmanned Aircraft to Augment a Mobile Ad Hoc Network.” *Emerging Technologies in Wireless LANs: Theory, Design, and Deployment*, Edited by Benny Bing, Ch. 28, p. 123-145, 2007.

CONFERENCE PUBLICATIONS: (* indicates students of mine)

- [1] Jack Elston*, Brian Argrow, Adam Houston, and Eric Frew. "Design and Validation of a System for Targeted Observations of Pre-Tornadic Supercells Using Unmanned Aircraft." In *2010 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Taipei, Taiwan, October 2010, 6 pages.
- [2] Maciej Stachura* and Eric W. Frew. "Cooperative Target Localization with a Communication Aware Active Sensor Network." In *AIAA Guidance, Navigation, and Control Conference*, Toronto, Canada, August 2010, 15 pages.
- [3] Anthony J. Carfang*, Eric W. Frew, and Timothy X Brown. "Improved Delay-Tolerant Communication by Considering Radio Propagation in Planning Data Ferry Navigation." In *AIAA Guidance, Navigation, and Control Conference*, Toronto, Canada, August 2010, 14 pages.
- [4] Neeti Wagle* and Eric W. Frew. "A Particle Filter Approach to WiFi Target Localization." In *AIAA Guidance, Navigation, and Control Conference*, Toronto, Canada, August 2010, 12 pages.
- [5] Jack Elston*, Brian Argrow, Eric W. Frew, and Adam Houston. "Evaluation of UAS Concepts of Operation for Severe Storm Penetration using Hardware-in-the-Loop Simulations." In *AIAA Guidance, Navigation, and Control Conference*, Toronto, Canada, August 2010, 15 pages.
- [6] Eric W. Frew and Brian Argrow. "Embedded Reasoning for Atmospheric Science Using Unmanned Aircraft Systems." In *AAAI 2010 Spring Symposium on Embedded Reasoning: Intelligence in Embedded Systems*, Palo Alto, CA, March 2010, 5 pages.
- [7] Eric W. Frew, Cory Dixon*, Jack Elston*, and Maciej Stachura*. "Active Sensing by Unmanned Aircraft Systems in Realistic Communication Environments." *IFAC Workshop on Networked Robotics*, Golden, CO, October 2009, 6 pages.
- [8] Jack Elston* and Eric W. Frew. "Reduction of Computational Complexity for Guidance of Unmanned Aircraft through Strong Wind Fields." In *AIAA Guidance, Navigation, and Control Conference*, Chicago, IL, August 2009, 6 pages.
- [9] Maciej Stachura*, Anthony Carfang*, and Eric W. Frew. "Cooperative Target Tracking with a Communication Limited Active Sensor Network." *International Workshop on Robotic Wireless Sensor Networks*, Marina Del Rey, CA, June 2009, 6 pages.
- [10] Eric W. Frew. "Providing Quality of Service of Information through Mobility." In *Proceedings 2009 American Control Conference*, St. Louis, MO, June 2009, pp. 2160-2165.
- [11] Eric W. Frew. "Combining Area Patrol, Perimeter Surveillance, and Target Tracking Using Ordered Upwind Methods." In *Proceedings of the 2009 IEEE International Conference on Robotics and Automation*, Kobe, Japan, May 12-17, 2009, pp. 3123-3128.
- [12] Jason Durrie*, Tristan Gerritsen*, Eric W. Frew, and Stephen Pledgie. "Vision-Aided Inertial Navigation on an Uncertain Map Using a Particle Filter." In *Proceedings of the 2009 IEEE International Conference on Robotics and Automation*, Kobe, Japan, May 12-17, 2009, pp. 4189-4194.
- [13] Jack Elston*, Maciej Stachura*, Eric W. Frew, and Ute C. Herzfeld. "Toward Model Free Atmospheric Sensing by Heterogeneous Aerial Robot Networks in Strong Wind Fields." In *Proceedings of the 2009 IEEE International Conference on Robotics and Automation*, Kobe, Japan, May 12-17, 2009, pp. 3090-3095.
- [14] Eric W. Frew. "Approximating Information Content for Active Sensing Tasks Using the Unscented Transform." In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Nice, France, Sept. 2008, pp. 2559-64.

- [15] Jack Elston* and Eric W. Frew. "Unmanned Aircraft Guidance for Penetration of Pre-Tornadic Storms." In *AIAA Guidance, Navigation, and Control Conference*, Honolulu, HI, August 2008, 14 pages.
- [16] Eric W. Frew, Tristan Gerritsen*, Stephen Pledge, Chris Brinton, Shivang Patel, and Bonnie Schwartz. "Vision-Based Navigation for Airfield Surface Operation." In *AIAA Guidance, Navigation, and Control Conference*, Honolulu, HI, August 2008, pp. 4189-94.
- [17] Brian Argrow, Elizabeth Weatherhead, and Eric W. Frew. "Real-Time Participant Feedback from the Symposium for Civilian Applications of Unmanned Aircraft Systems." In *International Symposium on Unmanned Aerial Vehicles*, Orlando, FL, June 2008, 13 pages.
- [18] Eric W. Frew and Timothy X. Brown. "Airborne Communication Networks for Small Unmanned Aircraft Systems." In *International Symposium on Unmanned Aerial Vehicles*, Orlando, FL, June 2008, 17 pages.
- [19] Eric W. Frew and Jack Elston*. "Target Assignment for Integrated Search and Tracking by Active Robot Networks." In *Proceedings of the 2008 IEEE International Conference on Robotics and Automation*, Pasadena, CA, May 2008, pp. 2354-2359.
- [20] Jack Elston* and Eric W. Frew. "Hierarchical Distributed Control for Search and Tracking by Heterogeneous Aerial Robot Networks." In *Proceedings of the 2008 IEEE International Conference on Robotics and Automation*, Pasadena, CA, May 2008, pp. 170-175.
- [21] Cory Dixon* and Eric W. Frew. "Maintaining Optimal Communication Chains in Robotic Sensor Networks using Mobility Control." In *Proceedings of the First International Conference on Robot Communication and Coordination (Robocomm)*, Athens, Greece, October 2007, 8 pages.
- [22] Eric W. Frew. "Information-Theoretic Integration of Sensing and Communication for Active Robot Networks." In *Proceedings of the First International Conference on Robot Communication and Coordination (Robocomm)*, Athens, Greece, October 2007, 8 pages.
- [23] Eric W. Frew, Jack Langelaan, and Maciej Stachura*. "Adaptive Planning Horizon Based on Information Velocity for Vision-Based Navigation." Invited to *AIAA Guidance, Navigation, and Control Conference*, Hilton Head, SC, August 2007, pp. 3822-3841.
- [24] Eric W. Frew. "Sensitivity of Cooperative Geolocalization to Orbit Coordination." *AIAA Guidance, Navigation, and Control Conference*, Hilton Head, SC, August 2007, pp. 3869-3892.
- [25] Dale A. Lawrence, Eric W. Frew, and William J. Pisano, "Lyapunov Vector Fields for Autonomous UAV Flight Control" *AIAA Guidance, Navigation, and Control Conference*, Hilton Head, SC, August 2007, pp. 78-99.
- [26] Cory Dixon* and Eric W. Frew. "Cooperative Electronic Chaining Using Small Unmanned Aircraft". In *AIAA Infotech@Aerospace*, Rohnert Park, CA, May 2007, pp. 339-346.
- [27] Jack Elston* and Eric W. Frew. "Net-centric Cooperative Tracking of Moving Targets." In *AIAA Infotech@Aerospace*, Rohnert Park, CA, May 2007, pp. 1931-1938.
- [28] Eric W. Frew, Dale A. Lawrence, Cory Dixon*, Jack Elston*, and William J. Pisano. "Lyapunov Guidance Vector Fields for Unmanned Aircraft Applications." Invited to *Proceedings 2007 American Control Conference*, New York, NY, June 2007, pp. 371-376.
- [29] Eric W. Frew. "Cooperative Stand-off Tracking of Uncertain Moving Targets using Active Robot Networks." *Proceedings of the 2007 IEEE International Conference on Robotics and Automation*, Rome, Italy, April 2007, pp. 3277 - 3282.
- [30] Eric W. Frew. "Receding Horizon Control under Uncertainty Using Optimal Input Design and the Unscented Transform." In *45th IEEE Conference on Decision and Control*, San Diego, CA, December 2006, 6 pages.
- [31] Cory Dixon* and Eric W. Frew. "Controlling the Mobility of Network Nodes using Decentralized Extremum Seeking." In *45th IEEE Conference on Decision and Control*, San Diego, CA, December 2006, pp. 1291-1296.

- [32] Cory Dixon*, Dan Henkel, Eric W. Frew, and Timothy X. Brown. "Phase Transitions for Controlled Mobility in Wireless Ad hoc Networks." *AIAA Guidance, Navigation, and Control Conference*, Keystone, CO, August 2006, pp. 3346-3356.
- [33] Cory Dixon* and Eric W. Frew. "Maintaining a Linked Network Chain Utilizing Decentralized Mobility Control." *AIAA Guidance, Navigation, and Control Conference*, Keystone, CO, August 2006, pp. 3338-3345.
- [34] Jack Elston*, Eric W. Frew, and Brian Argrow. "Networked UAV Communication, Command, and Control." *AIAA Guidance, Navigation, and Control Conference*, Keystone, CO, August 2006, pp. 3357-3365.
- [35] Eric W. Frew, Jack Langelaan, and Sungmoon Joo. "Adaptive Receding Horizon Control for Vision-Based Navigation of Small Unmanned Aircraft." Invited to *Proceedings 2006 American Control Conference*, Minneapolis, MN, June 2006, pp. 2160-2165.
- [36] Eric W. Frew. "Comparison of Lateral Controllers for Following Linear Structures Using Computer Vision." Invited to *Proceedings 2006 American Control Conference*, Minneapolis, MN, June 2006, pp. 2154-2159.
- [37] Eric W. Frew, Tim X. Brown, Cory Dixon*, and Dan Henkel. "Establishment and Maintenance of a Delay Tolerant Network through Decentralized Mobility Control." Invited to *IEEE International Conference On Networking, Sensing and Control (ICNSC)*, Ft. Lauderdale, FL, April 2006, pp. 584-589.
- [38] Cory Dixon*, Eric W. Frew, Brian Argrow. "Electronic Leashing of an Unmanned Aircraft to a Radio Source." *44th IEEE Conference on Decision and Control*, Seville, Spain, December 2005, pp. 3560-3565.
- [39] Eric W. Frew, Cory Dixon*, Brian Argrow, and Timothy Brown. "Radio Source Localization by a Cooperating UAV Team." Invited to *AIAA Infotech@Aerospace*, Arlington, VA, September 2005, pp. 10-20.
- [40] Cory Dixon*, Eric Frew, and Brian Argrow. "Radio Leashing Unmanned Aircraft." *AIAA Infotech@Aerospace*, Arlington, VA, September 2005, pp. 1093-1102.
- [41] Jack Elston*, Brian Argrow, and Eric Frew. "A Distributed Avionics Package for Small UAVs." *AIAA Infotech@Aerospace*, Arlington, VA, September 2005, pp. 733-742.
- [42] Eric W. Frew. "Receding Time Horizon Control Using Random Search for UAV Navigation with Passive, Non-cooperative Sensing." *AIAA Guidance, Navigation, and Control Conference*, San Francisco, CA, August 2005, pp. 553-565.
- [43] Eric W. Frew and Dale A. Lawrence. "Cooperative Stand-off Tracking of Moving Targets by a Team of Autonomous Aircraft." *AIAA Guidance, Navigation, and Control Conference*, San Francisco, CA, August 2005, pp. 4885-4895.
- [44] Eric W. Frew and Raja Sengupta. "Obstacle Avoidance with Sensor Uncertainty for Small Unmanned Aircraft." In *43rd IEEE Conference on Decision and Control*, Paradise Island, Bahamas, December 2004, pp. 614-619.
- [45] Eric Frew, Xiao Xiao, Stephen Spry, Tim McGee, ZuWhan Kim, Jack Tisdale, Raja Sengupta, and J. Karl Hedrick. "Flight Demonstrations of Self-Directed Collaborative Navigation of Small Unmanned Aircraft." *AIAA 3rd Unmanned Unlimited Technical Conference, Workshop, & Exhibit*, Chicago, IL, September 2004, 14 pages.
- [46] Eric Frew, Tim McGee, ZuWhan Kim, Xiao Xiao, Stephen Jackson, Michael Morimoto, Sivakumar Rathinam, Jose Padial, and Raja Sengupta. "Vision-Based Road Following Using a Small Autonomous Aircraft." In *Proceedings of the 2004 IEEE Aerospace Conference*, Big Sky, MT, March 2004, pp. 3006-3015.
- [47] Christopher M. Clark, Eric W. Frew, Henry L. Jones, and Stephen M. Rock. "An Integrated System for Command and Control of Cooperative Robotic Systems", In *Proceedings of the 11th International Conference on Advanced Robotics*, Portugal, June, 2003, pp. 459-464.
- [48] Eric W. Frew and Stephen M. Rock. "Trajectory Generation for Monocular Vision-Based Tracking of a Constant Velocity Target." In *Proceedings of the 2003 IEEE International Conference on Robotics and Automation*, Taipei, Taiwan, September 2003, pp. 461-465.

- [49] Andreas Huster, Eric W. Frew, and Stephen M. Rock. "Relative Position Estimation for AUVs by Fusing Bearing and Inertial Rate Sensor Measurements." In *Proceedings of the Oceans 2002 Conference*, Biloxi, MS, October 2002, pp. 1857-1864.
- [50] Eric W. Frew and Stephen M. Rock. "Exploratory Motion Generation for Monocular Vision-Based Target Localization." In *Proceedings of the 2002 IEEE Aerospace Conference*, Big Sky, MT, March 2002, 7:3633-3643.
- [51] Henry L. Jones, Eric W. Frew, Bruce R. Woodley, and Stephen M. Rock. "Human-Robot Interaction for Field Operation of an Autonomous Helicopter." In *Proc. SPIE, Mobile Robots XIII and Intelligent Transportation Systems*, Boston MA, November 1998, 3525:244-252.
- [52] Steve M. Rock, Eric W. Frew, Henry L. Jones, Bruce Woodley, and Ed LeMaster. "Combined CDGPS and Vision-Based Control of a Small Autonomous Helicopter." In *Proceedings 1998 American Control Conference*, Philadelphia, June 1998, 2:694-698.
- [53] Bruce Woodley, Henry Jones, Eric W. Frew, Ed LeMaster, and Dr. Stephen Rock. "A Contestant in the 1997 International Aerial Robotics Competition. Aerospace Robotics Laboratory Stanford University." In *AUVSI '97 Proceedings*, Orlando FL, July 1997, 8 pages.
- [54] Bruce Woodley, Hank Jones, Eric Frew, Ed LeMaster, and Dr. Stephen Rock. "A Contestant in the 1996 International Aerial Robotics Competition." In *AUVSI '96 Proceedings*, Orlando FL, July 1996, pp. 939-946.
- [55] Bruce Woodley, Henry L. Jones, Ed LeMaster, Eric W. Frew, and Dr. Stephen M. Rock. "Carrier Phase GPS and Computer Vision for the Control of an Autonomous Helicopter." In *Proceedings of the Institute of Navigation GPS-96 Conference*, Kansas City MO, September 1996, pp. 461-465.

CONFERENCE PRESENTATIONS: (* indicates students of mine)

- [1] Adam Houston, Brian Argrow, and Eric W. Frew. "Observing Supercells with Unmanned Aircraft: Results from the UAS Component of VORTEX-2." *American Geophysical Union Fall Meeting*, San Francisco CA, Dec. 2010.
- [2] Adam Houston, Brian Argrow, and Eric W. Frew. "Unmanned Aircraft in VORTEX2." *25th Conference on Severe Local Storms*, Denver CO, Oct. 2010.

DISSERTATION:

Trajectory Design for Target Motion Estimation Using Monocular Vision

August 2003

Advisor: Professor Stephen Rock

Reading Committee: Professor Robert Cannon, Professor Claire Tomlin

INVITED PRESENTATIONS:

- [1] Eric W. Frew, "Trajectory Design for Target Motion Estimation Using Monocular Vision." *Mechanical Engineering Seminar*, Case Western Reserve University, July 1, 2003.
- [2] Eric W. Frew, "Trajectory Design for Target Motion Estimation Using Monocular Vision." *Mechanical Engineering Seminar*, Yale University, July 8, 2003.
- [3] Eric W. Frew, "Self-directed Navigation of Small Unmanned Aircraft." *Aerospace Engineering Seminar*, University of Colorado at Boulder, March 29, 2004.
- [4] Eric W. Frew, "Self-directed Navigation of Small Unmanned Aircraft." *Aerospace Engineering Seminar*, Texas A&M University, April 15, 2004.
- [5] Eric W. Frew, "Stereo-Vision-Based Control of a Small Autonomous Aircraft Following a Road." *Second Annual Swarming Conference*, Crystal City, MD, June 2004.

- [6] Eric W. Frew, "Networked Communication, Command, and Control (C3) of a Team of Unmanned Aircraft." *Engineering Seminar*, Colorado School of Mines, Jan. 2005.
- [7] Eric W. Frew, "Networked Communication, Command, and Control (C3) of a Team of Unmanned Aircraft." *GNC Seminar*, Stanford University, Aug. 19, 2005.
- [8] Eric W. Frew, "Networked Communication, Command, and Control (C3) of a Team of Unmanned Aircraft." *System Engineering Seminar*, University of California, Berkeley, Aug. 20, 2005.
- [9] Eric W. Frew, "Networked Communication, Command, and Control (C3) of a Team of Unmanned Aircraft." United States Air Force Academy, Oct. 4, 2005.
- [10] Eric W. Frew, "Networked Communication, Command, and Control (C3) of a Team of Unmanned Aircraft." Cornell University, Aug. 16, 2006.
- [11] Eric W. Frew, "Networked Communication, Command, and Control (C3) of a Team of Unmanned Aircraft." Air Force Institute of Technology, Nov. 16, 2007.
- [12] Eric W. Frew, "Planning and Control of Unmanned Aircraft Systems in Realistic Communication Environments." *Electrical Engineering Department Seminar*, University of New Mexico, Nov. 14, 2008.
- [13] Eric W. Frew, "Planning and Control of Unmanned Aircraft Systems in Realistic Communication Environments." *Mechanical Engineering Department Seminar*, Tufts University, March 5, 2009.
- [14] Eric W. Frew, "Planning and Control of Unmanned Aircraft Systems in Realistic Communication Environments." MIT, March 6, 2009.
- [15] Eric W. Frew, "Control of Unmanned Aircraft Systems for Communication and Atmospheric Sensing Applications." *Aeronautics and Astronautics Department Seminar*, Stanford University, February 3, 2010.
- [16] Brian Argrow, Adam Houston, and Eric W. Frew, "VORTEX2 Unmanned Aircraft System (UAS)." *Hot Topics, AUVSI's Unmanned Systems North America 2010*, Denver, CO, August 23, 2010.
- [17] Eric W. Frew, "Sampling Tornadoic Supercell Thunderstorms Using Unmanned Aircraft Systems." University of Maryland, October 8, 2010.
- [18] Eric W. Frew, "Sampling Tornadoic Supercell Thunderstorms Using Unmanned Aircraft Systems." Rocky Mountain Chapter AUVSI, January 12, 2011.

SCIENTIFIC AND PROFESSIONAL SOCIETIES

- American Institute of Aeronautics and Astronautics (AIAA)
- Institute of Electrical and Electronic Engineers (IEEE)

INSTITUTIONAL AND PROFESSIONAL SERVICE

- Registration Chair, 2013 American Control Conference Operating Committee
- Member, International Program Committee, 2009 IFAC Workshop on Networked Robotics, October 6-8, 2009.
- Member, Program Committee, 2009 International Workshop on Robotic Wireless Sensor Networks, June 10, 2009.
- Member, Organizing Committee, 2nd International Symposium on Unmanned Aerial Vehicles, June 8-10, 2009.
- Member, AIAA Guidance, Navigation, and Control Technical Committee, Aug. 2008-present.
- Education Co-Chair, AIAA Guidance, Navigation, and Control Technical Committee, Aug. 2010-present.
- Vehicle Systems Focus Area lead, AES Department, 2008 – 2010.
- Member, Graduate Committee, Aerospace Engineering Sciences Department, 2005-present.
- Dynamics and Control Lead, Curriculum and Teaching Committee, AES Department, 2005-2008.
- AES Department Program Lead, CU High School Summer Honors Institute, 2006-2008.

- Associate Editor for 2008, 2009 American Control Conference (ACC).
- Associate Editor for 2010, 2011 International Conference on Robotics and Automation (ICRA).
- Journal reviewer: IEEE Trans. on Robotics; IEEE Trans. on Control System Technology; Trans. on Aerospace and Electronic Systems; AIAA Journal of Guidance, Control, and Dynamics; others.
- Review panelist NSF, AFOSR, NSSEFF.

FUNDED PROJECTS (\$1.9 M as PI; \$3.5M in total awards with \$2.4M as Frew's share)

A. In Progress

Exploiting Controlled Mobility in Aerial Communication and Surveillance Networks

Source of Support: DARPA Computer Science Study Group Phase 2; **Eric W. Frew (PI)**

Total Award Amount and Period Covered: \$100,000; 4/1/11 - 3/31/12

Forge FCMS

Source of Support: Forge Aeronautics; Brian Argrow (PI) and Eric W. Frew

Total Award Amount and Period Covered: \$9,600; 9/1/10 – 4/1/11

SQUAD: Smart Quad-Rotor Unmanned Autonomous Demonstrator

Source of Support: CU Engineering Excellence Fund (EEF); **Eric W. Frew (PI)**

Total Award Amount and Period Covered: \$8,000; 5/1/10 – 4/31/11

Control of Self-Deploying Robotic Systems

Source of Support: DARPA Computer Science Study Group; **Eric W. Frew (PI)**

Total Award Amount and Period Covered: \$100,000; 4/1/10 - 3/31/11

Collaborative Research: Planning Grant: IUCRC for Unmanned Aircraft Systems

Source of Support: NSF IUCRC; Brian Argrow (PI), Eric W. Frew, Dale Lawrence, and Tim Brown

Total Award Amount and Period Covered: \$10,000; 2/15/10 - 1/31/11

Frew's Share: \$2,500 (25%)

GAANN Fellowships in Aerospace Systems

Source of Support: DOE Graduate Assistance in Areas of National Need (GAANN) Program; George Born (PI) + 11

Total Award Amount and Period Covered: \$510,000; 8/15/2009 - 8/14/2012

Frew's Share: \$42,500 (8.33%)

CAREER: Mothership/Daughtership Architectures for In Situ Science by Robotic Sensor Networks

Source of Support: NSF CAREER; **Eric W. Frew (PI)**

Total Award Amount and Period Covered: \$558,589 (\$498,589 from NSF and \$60,000 matching from CU); 5/1/09-4/30/14

RI: Information-theoretic Control of Robotic Sensor Networks

Source of Support: NSF Robust Intelligence Cluster; **Eric W. Frew (PI)**

Total Award Amount and Period Covered: \$280,361 (\$11,875 through REU supplement); 9/1/07 – 8/31/10

B. Completed

Supplement to a Pilot Program for the Use of UAS in VORTEX2

Source of Support: Merage Foundation; Brian Argrow (PI) and Eric W. Frew

Total Award Amount and Period Covered: \$38,319; 1/1/2010 – 08/31/2010

Frew's Share: \$19,160 (50%)

A Pilot Program for the Use of UAS in VORTEX2

Source of Support: NSF Atmospheric Sciences; Brian Argrow (PI) and Eric W. Frew

Total Award Amount and Period Covered: \$289,566; 10/1/2008 – 09/31/2010

Frew's Share: \$144,783 (50%)

The Sky's the Limit: An Unmanned Aircraft Lab Module (Chancellor's Faculty Award for Excellence in STEM Education)

Source of Support: CU Innovation through Institutional Integration (I3); **Eric W. Frew (PI)**

Total Award Amount and Period Covered: \$9,600, 7/1/07 – 5/31/10

Unmanned Aerial Vehicle Ground Operations Positioning System

Source of Support: Phase I/II Air Force SBIR with Mosaic ATM; **Eric W. Frew (PI)**
Total Award Amount and Period Covered: \$228,000 (out of \$750,000 total); 6/1/06 – 5/31/09

An Integrated Framework for Controlled Mobility in Ad Hoc Networks

Source of Support: AFOSR – Software and System Program; **Eric W. Frew (PI)** and Tim Brown
Total Award Amount and Period Covered: \$450,000; 02/01/06 – 05/31/09

Networked System Test Bed Integration and Test Phase 1

Source of Support: L3 Concept / USAF; Tim Brown (PI), Brian Argrow, and Eric W. Frew
Total Award Amount and Period Covered: \$343,462; 10/01/07 – 03/27/09
Frew's Share: \$114,476 (33.33%)

Remote Management of a Heterogeneous UAV Team

Source of Support: Raytheon IIS; **Eric W. Frew (PI)**, Brian Argrow, and Dale Lawrence
Total Award Amount and Period Covered: \$135,000; 7/1/06 – 10/31/07

UAV Sensor Data Collection

Source of Support: L3 Concept / USAF; Tim Brown (PI), Brian Argrow, and Eric W. Frew
Total Award Amount and Period Covered: \$367,000; 09/22/05 – 09/30/07
Frew's Share: \$122,321 (33.33%)

Collaborative Tracking of Moving Targets by Teams of Autonomous Unmanned Air Vehicles

Source of Support: Phase I AFOSR STTR with MLB Company; **Eric W. Frew (PI)**
Total Award Amount and Period Covered: \$50,000; 11/1/04 – 7/30/05