Randal W. Beard

Professional Experience

Brigham Young University, Provo, Utah
> Professor, Electrical and Computer Engineering Department, 2007—Present
> Associate Professor, Electrical and Computer Engineering Department, 2002—2007
> Assistant Professor, Electrical and Computer Engineering Department, 1996—2002

Air Force Research Lab, Munitions Directorate, Eglin Air Force Base, Florida
> National Research Council Fellow, 2006-2007

Jet Propulsion Laboratory, Pasadena, California
> Summer Faculty Fellow in the Spacecraft Guidance and Control Division, 1997-1998

Rensselaer Polytechnic Institute, Troy, New York
> Research Assistant, Center for Intelligent Robotic Systems for Space Exploration, 1992-1995

Education

Rensselaer Polytechnic Institute, Electrical Engineering, PhD, 1995

Rensselaer Polytechnic Institute, Mathematics, MS, 1994

Rensselaer Polytechnic Institute, Electrical Engineering, MS, 1993

University of Utah, Electrical Engineering, BS (Magna Cum Laude), 1991

Research Focus

Unmanned Air Vehicles. Developing autonomous control technologies for real-time navigation, guidance, and control of unmanned air vehicles (UAVs). Developed path planning, trajectory generation, and trajectory tracking algorithms that require minimal computational resources. Directed the development of a light-weight, low-power autopilot for small (1-6 foot wingspan) UAVs. Developed an experimental testbed for small UAVs that has logged thousands of hours of successful flight tests.

Multiple Vehicle Coordination and Control. Developing coordination strategies for heterogeneous collections of autonomous vehicles. Platforms include uninhabited aerial vehicles, mobile robots, and spacecraft, with a particular emphasis on UAVs. Applications include coordinated formation maneuvers, coordinated rendezvous, coordinated timing, trajectory generation and autonomous landing. Developed a multiple UAV testbed capable of deploying five UAVs simultaneously. Also developed a multiple vehicle testbed including five differential drive mobile robots and ten omni-directional mobile robots.

Nonlinear Control. Developed practical algorithms to generate and improve the performance of feedback control laws for general classes of nonlinear systems. The Galerkin spectral method has been used to successively approximate the Hamilton-Jacobi-Bellman equation, which is at the foundation of nonlinear optimal control. The results also generate practical algorithms for solving nonlinear H-infinity (robust) control problems. Numerous application of the method have been explored including hydraulic actuators, underwater vehicles, power systems, and robotics.

Books

[4] Randal W. Beard, Timothy W. McLain, *Introduction to Feedback Control using Design Studies*, http://controlbook.byu.edu/
[3] Randal W. Beard, Timothy W. McLain, *Small Unmanned Aircraft: Theory and Practice,* Princeton University Press, 2012, ISBN: 978-06-911-4921-9.
[2] Kimon P. Valavanis, Randal W. Beard, Paul Oh, Anibal Ollero, Leslie Piegl, Hyunchul Shim, *Selected Papers from the 2nd International Symposium on UAVs*, Springer, 2010, ISBN: 978-90-481-8763-8.
[1] Wei Ren, Randal W. Beard, *Distributed Consensus in Multi-Vehicle Cooperative Control,* Communication and Control Engineering Series, Springer Verlag, New York, 2007, ISBN: 978-1-84800-014-8.
- Over 21,000 chapter downloads.

Journal Publications and Book Chapters

- Google Scholar h-index is 56, with 26,325 total citations.

[87] Parker C. Lusk, Patricia C. Glaab, Louis J. Glaab, Randal W. Beard, "Safe2Ditch: Emergency Landing for Small Unmanned Aircraft Systems," *AIAA Journal of Aerospace Information Systems* (in review).

[86] Jeffrey L. Ferrin, Randal W. Beard, Timothy W. McLain, "Estimation-Aware Model Predictive Control of a Ground Robot," *IEEE Transactions on Robotics* (in review).

[85] David O. Wheeler, Danial P. Koch, James S. Jackson, Gary J. Ellingson, Paul W. Nyholm, Timothy W. McLain, Randal W. Beard, "Relative Navigation of Autonomous GPS-Degraded Micro Air Vehicles," *Journal of Field Robotics* (to appear).

[84] He Bai, Randal W. Beard, "Relative Heading Estimation and its Application to Target Handoff in GPS-Denied Environments," *IEEE Transactions on Control Systems Technology,* vol. 27, no. 1, p. 74-85, 2019.

[83] Laith R. Sahawneh, Jared K. Wikle, A. Kaleo Roberts, Jonathan C. Spencer, Timothy W. McLain, Karl F. Warnick, Randal W. Beard, "Ground-Based Sense-and-Avoid for Small Unmanned Aircraft," *AIAA Journal of Aerospace Information Systems,* vol. 15, no. 8, pp. 501-517, August, 2018.

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[79] Joshua Y. Sakamaki, Randal W. Beard, Michael Rice, "Tracking Multiple Ground Objects Using a Team of Unmanned Air Vehicles," in *Sensing and Control for Autonomous Vehicles: Applications to Land, Water, and Air Vehicles,* Springer, ed. Thor I. Fossen, Kristin Y. Pettersen, Henk Nijmeijer, p. 249-268, 2017.

[78] Peter C. Niedfeldt, Kyle Ingersoll, Randal W. Beard, "A Comparison and Analysis of Recursive-RANSAC for Multiple Target Tracking," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 53, no. 1, p. 461-476, February, 2017.

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[20] Jonathan Lawton, Randal W. Beard, Tim McLain, "Successive Galerkin Approximation of Nonlinear Optimal Attitude Control," *American Control Conference*, San Diego, CA, June, 1999, p. 4373-4377.

[19] Jonathan Lawton, Randal W. Beard, Fred Y. Hadaegh, "An Adaptive Control Approach to Satellite Formation Flying with Relative Distance Constraints," *American Control Conference*, San Diego, CA, June, 1999, p. 1545-1549.

[18] Timothy W. McLain, Christopher A. Bailey, Randal W. Beard, "Synthesis and Experimental Testing of a Nonlinear Optimal Tracking Controller," *American Control Conference*, San Diego, CA, June, 1999, p. 2847-2851.

[17] Randal W. Beard, Fred Y. Hadaegh, "Finite Thrust Control for Satellite Formation Flying with State Constraints," *American Control Conference*, San Diego, CA, June, 1999, p. 4383-4387.

[16] Randal W. Beard, Fred Y. Hadaegh, "Fuel Optimized Rotation forSatellite Formations in Free Space," *American Control Conference*, San Diego, CA, June, 1999, p. 2975-2979.

[15] Randal Beard, Wynn Stirling and Rick Frost, "A Hierarchical Coordination Scheme for Satellite Formation Initialization," *AIAA Guidance, Navigation and Control Conference*, AIAA paper #98-4225, p. 677-685, Boston, MA, 1998.

[14] Timothy W. McLain, Randal W. Beard, "Nonlinear Optimal Control Design of a Missile Autopilot," *AIAA Guidance, Navigation and Control Conference*, AIAA paper #98-4321, p. 1209-1216, Boston, MA, 1998.

[13] Randal W. Beard, Timothy W. McLain, "A Practical Algorithm for Designing Nonlinear H-infinity Control Laws," *American Control Conference*, Philadelphia, PA, 3742-3743, June, 1998.

[12] John D. Kenney, Wynn Sterling, Randy Beard, "Set-Valued Nonlinear Estimation Using the Galerkin Approximation," *American Control Conference*, Philadelphia, PA, p. 3580-3584, June, 1998.

[11] Jonathan Lawton, Randal W. Beard, "Numerically Efficient Approximations to the Hamilton-Jacobi-Bellman Equation," *American Control Conference*, Philadelphia, PA, p. 195-199, June, 1998.

[10] Randal W. Beard, Timothy W. McLain, Fred Y. Hadaegh, "Fuel Equalized Retargeting for Separated Spacecraft Interferometry," *American Control Conference*, Philadelphia, PA, p. 1580-1584, June, 1998.

[9] Timothy W. McLain, Randal W. Beard, "Nonlinear Optimal Control of an Underwater Robotic Vehicle," *IEEE International Conference on Robotics and Automation*, Leuven, Belgium, p. 762-767, May 1998.

[8] Timothy W. McLain, Randal W. Beard, "Nonlinear Robust Control of an Electrohydraulic Positioning System," *International Mechanical Engineering Congress & Exposition*, The Fluid Power and Systems Technology Division FPST v. 5, Anaheim, CA, 1998.

[7] Randal W. Beard and Fred Y. Hadaegh, "Constellation Templates: An Approach to Autonomous Formation Flying," World Automation Congress, Anchorage, Alaska, ISIAC p. 177.1-177.6, 1998.*d*

[6] Timothy W. McLain and Randal W. Beard, "Nonlinear Optimal Control of a Hydraulically Actuated Positioning System," *International Mechanical Engineering Congress & Exposition*, The Fluid Power and Systems Technology Division FPST v. 4, p. 163-168, Dallas, TX, 1997.

[5] Jacob Gunther, Randal Beard, Jay Wilson, Travis Oliphant, Wynn Stirling, "Fast Nonlinear Filtering via Galerkin's Method," *American Control Conference*, Albuquerque, NM, 1997.

[4] Randal Beard, George Saridis, John Wen, "Sufficient Conditions for the Convergence of Galerkin Approximations to the Hamilton-Jacobi Equation," *IFAC World Congress*, Volume E, pp 347-352, San Francisco, 1996.

[3] Randal Beard, George Saridis, John Wen, "Computing Nonlinear Optimal Controls from Existing Stabilizing Controls," *Proceedings of the 4th IEEE Conference on Control Applications*, p. 1160-1161, Albany, NY, September, 1995.

[2] Randal Beard, George Saridis, John Wen, "An Iterative Solution to the Finite-Time Linear Quadratic Optimal Feedback Control Problem," *Proceedings of the American Control Conference*, p. 3921-3922, Seattle, WA, June 1995.

[1] Randal Beard, George N. Saridis, "A Cost Measure for Efficient Scheduling in Intelligent Machines," *Proceedings of the IEEE 8th International Symposium on Intelligent Control*, Chicago, Illinois, p. 52-57, August, 1993.

Peer Reviewed Video Presentations

[3] Joseph A. Jackson, Andrew M. Eldredge, Stephen R. Griffths, Jeffrey B. Saunders, Timothy W. McLain, Randal W. Beard, "Miniature Air Vehicle Obstacle Avoidance," *IEEE International Conference on Robotics and Automation*, Orlando, FL, May, 2006.

[2] Joseph A. Jackson, Andrew M. Eldredge, Derek R. Nelson, Stephen R. Griffths, Timothy W. McLain, Randal W. Beard, "Miniature Air Vehicle Cooperative Timing Missions," *IEEE International Conference on Robotics and Automation*, Orlando, FL, May, 2006.

[1] Andrew M. Eldredge, Stephen R. Griffiths, Timothy W. McLain, Randal W. Beard, "Recent Research Results using Miniature Air Vehicles," *AIAA Infotech@Aerospace Conference*, Arlington, VA, 2005. (Winner of grand prize for best overall video.)

Book Reviews

[1] R. W. Beard, "Soccer Robotics by Jong-Hwan Kim, Dong-Han Kim, Yong-Jae Kim, and Kiam-Tian Seow," *IEEE Control Systems Magazine*, vol. 25, no. 5, p. 93-95, October, 2005.

Research Contracts and Grants

Total funding is $7,746,928 + over $2,500,000 in funding from the NSF Center for Unmanned Aircraft Systems.

[40] Randal Beard (PI), "A Novel Algorithm for Tracking Multiple Targets with Significant Background Clutter," *Air Force Research Laboratory (RWK),* $230,000, 2013-2016.

[39] Randal Beard (PI), Tim McLain, "Long Endurance Vertical Takeoff and Landing Tier 2 Size UAV," *AFOSR SBIR Phase I & II with MLB Corporation,* $228,998, 2011-2015.

[38] Tim McLain (PI), Randal Beard, "Veracity Evaluation of non-Redundant Information in Flight Systems (VERACITY)," *AFOSR SBIR Phase I & II with SSCI*, $254,346, 2011-2013.

[37] Randal Beard (PI), Kevin Seppi, "Intelligent Controller Development for Cooperative UAV Missions," *AFOSR SBIR Phase I & II with Utopia Compression Corporation*, $185,000, 2012-2015.

[36] Randal Beard (PI), "Passive Collision Detection for UAV Sense and Avoid System," *DARPA SBIR Phase II with Utopia Compression Corporation*, $70,000, 2011-2012.

[35] Karl Warnick (PI), Randal Beard, "Non-GPS Dependent Method for Accurate UAS Navigation and Orientation Determination," *AFOSR, SBIR Phase I & II with ImSAR Technology,* $159,260, 2011-2013.

[34] Randal Beard (PI), "Miniature Self-Deploying Systems in Cluttered/Confined Environments," *AFRL Campus Challenge*, $150,000, 2011.

[33] Tim McLain (PI), Randal Beard, "Swarm/Agent Technology for Small Unit Scalable Effects," *Army, SBIR Phase I with Procerus Technology*, $38,537, 2009-2010.

[32] Tim McLain (PI), Randal Beard, "Robust Autonomous Maneuvering of Unmanned Air Systems in Challenging Environmental/Weather Conditions," *Navy, SBIR Phase I with Mosaic ATM*, $21,000, 2009-2010.

[31] Randal Beard (PI), Timothy W. McLain, Mark Colton, "Aerial Recovery of Micro Air Vehicles," *AFOSR, STTR Phase I & II with Procerus,* $509,987, 2008-2012.

[30] Randal Beard (PI), Timothy W. McLain, Bryan Morse, "Persistent Tactical Seeability through Integrated Sensor Guidance," *ARMY, SBIR Phase I & II with Mosaic ATM,*$251,755, 2008-2011.

[29] Randal Beard (PI), "Human Assisted UAV/UGV Cooperative Tracking of Urban Dismounts," *Air Force Research Laboratory, SBIR Phase II with SET Corporation,* $218,701, 2008-2010.

[28] Randal Beard (PI), "UAV/UGV Urban Tracking," *Air Force Research Laboratory, SBIR Phase I with SET Corporation,* $33,333, 2007.

[27] Tim McLain (PI), Randy Beard, Jerry Bowman, Michael Goodrich, Deryl Snyder, Clark Taylor, and Jim Archibald, "Miniature Air Vehicles Center of Excellence," *State of Utah*, $130,000, 2007-2008.

[26] Randal W. Beard (PI), Timothy W. McLain, "VAMAV: Visual Collision Detection and Avoidance for a Micro Air Vehicle," *Air Force Research Laboratory, SBIR with Scientific Systems Company Inc., Phase I & II*, $166,000, 2006-2008.

[25] Timothy W. McLain (PI), Randal W. Beard, "Rapid Deployment and Target Tracking for Micro Air Vehicles," *Idaho National Laboratory*, $75,984, 2006-2007.

[24] Deryl Snyder (PI), Randal W. Beard, Timothy W. McLain, "Aerodynamics and Control of Autonomous VTOL Micro-Air-Vehicles," *AFRL/MN*, $149,924, 2005-2006.

[23] Timothy W. McLain (PI), Randal W. Beard, "Center of Excellence in Unmanned Air Vehicle," *Utah Centers of Excellence Program*, $422,400, 2005-2007.

[22] Randal W. Beard (PI), Timothy W. McLain, "Coordinated Control of Multi-Agent Systems in Rapidly Varying Environments," *NASA (STTR Phase II)*, $329,681, 2005-2007.

[21] A. Lee Swindlehurst (PI), Randal W. Beard, Michael A. Jensen, Timothy W. McLain, Todd, K. Moon, "Distributed Communication and Control for Multiple Miniature Unmanned Air Vehicles," $1,124,191, *NSF*, $, 2004-2009.

[20] Randal W. Beard (PI), D.J. Lee, "Biologically Inspired Navigation and Control for Small Unmanned Air Vehicles," *NASA-Ames/JPL*, $66,068, 2004.

[19] Timothy W. McLain (PI), Randal W. Beard, "Cooperation and Consensus Seeking for Teams of Unmanned Air Vehicles," *AFOSR*, $342,043, 2004-2007.

[18] Randal W. Beard (PI), Timothy W. McLain, "Real-Time Trajectory Generation for Autonomous Nonlinear Flight Systems," *AFOSR (STTR Phase II)*, $299,799, 2004-2006.

[17] Randal W. Beard (PI), Timothy W. McLain, "Coordinated Control of Multi-Agent Systems in Rapidly Varying Environments," *NASA (STTR Phase I)*, $49,174, 2004.

[16] Randal W. Beard (PI), Timothy W. McLain, "Navigation and Control Technologies for Autonomous Micro Vehicles," *AFRL/MN*, $196,487, 2003-2004.

[15] Randal W. Beard (PI), "Development, Integration, and Testing of an Autopilot System for BATCAM," *AFRL/MN*, $38,250, 2003.

[14] Timothy W. McLain (PI), Randal W. Beard, "Automated Landing of an Unmanned Air Vehicle in a Non-Cooperative Environment," *NASA Ames Research Center*, $162,748, 2003-2006.

[13] Randal W. Beard (PI), Timothy W. McLain, "A Low-Cost Autopilot for Small Autonomous Air Vehicles," *BYU Technology Transfer Office*, $20,000, Jan. 2003-Dec. 2003.

[12] Michael A. Goodrich (PI), Dan R. Olson, Randal W. Beard, Timothy W. McLain, "Neglect Tolerant Interaction: Integrating Multi-Platform Interface Technology with Multiple Autonomy Levels," *DARPA*, $1.1 M, Sept. 2002-Aug. 2004.

[11] Randal W. Beard (PI), Timothy W. McLain, "Fast, Robust, Real-Time Trajectory Generation for Autonomous and Semi-Autonomous Nonlinear Flight Systems," *AFOSR (STTR Phase I)*, $49,850, Oct. 2002-Sept. 2003.

[10] Randal W. Beard (PI), "Precision Formation Flying for Deep Space Interferometry," *NASA/JPL*, $60,000, Sept. 2000-Nov. 2002.

[9] Randal W. Beard (PI), James K. Archibald, "Monitoring Hazardous Materials using Coordinated Control of Multiple Vehicles," *INEEL*, $20,000, Jan. 2001-Dec. 2004.

[8] Timothy W. McLain (PI), Randal W. Beard, "Coordinated Control of Unmanned Air Vehicles," *AFOSR*, $172,956, Jan. 2001-Dec. 2004.

[7] Randal W. Beard (PI), "A Practical Approach to Nonlinear Robust Control," *NSF*, $155,212, Sept. 1998-Aug. 2001.

[6] Randal W. Beard (PI), "Multiple Spacecraft Coordination and Control," *NASA/JPL*, $100,000, Sept. 1997-Aug. 2000.

[5] David Long (PI), Randal Beard, Kevin Smith, "QuikSCAT Calibration Ground Station Study," *NASA/JPL*, $25,959, Sept. 1998-Nov. 1998.

[4] Randal W. Beard (PI), Timothy W. McLain, "Coordinated Control of UAVs," *BYU College of Engineering and Technology*, $19,000, Jan. 2000-Dec. 2001.

[3] Randal W. Beard (PI), Wynn Stirling, Kevin Smith, James Archibald, Rick Frost, "The MAGICC Laboratory," *BYU College of Engineering and Technology*, $35,000, Jan. 1999-Aug. 2000.

[2] Rick Frost (PI), Jim Archibald, Randal Beard, Kevin Smith, Wynn Stirling, "Intelligent Autonomous Agents," *BYU College of Engineering and Technology*, $50,000, May 1998-May 1999.

[1] Randal W. Beard (PI), Timothy W. McLain, \A New Design Technique for Nonlinear Dynamic Systems," *BYU College of Engineering and Technology*, $35,285, Sept. 1996-Aug. 1997.

PhD Students

[15] David Wheeler, "Relative Navigation of Micro Air Vehicles in GPS-Degraded Environments," PhD, 2017.

[14] Matthew E. Argyle, "Modeling and Control of a Tailsitter with a Ducted Fan," PhD, 2016.

[13] Laith Sahawneh, "Airborne Collision Detection and Avoidance for Small UAS Sense and Avoid Systems," PhD, 2016.

[12] Eric B. Quist, "UAV Navigation and Radar Odometry," PhD, 2015.

[11] Peter C. Niedfeldt, "Recursive-RANSAC: A Novel Algorithm for Tracking Multiple Targets in Clutter," PhD 2014.

[10] Liang Sun, "Dynamic Modeling, Trajectory Generation and Tracking, Simulations and Experiements of Aerially Towed Cable Systems for Aerial Recovery of Miniature Aerial Vehicles," PhD 2012.

[9] John C. Macdonald Jr., "Efficient Estimation for Small Multi-Rotor Air Vehicles Operating in Unknown, Indoor Environments," PhD 2012.

[8] Rajnikant Sharma, "Bearing-only Cooperative Localization and Path Planning for Ground and Aerial Robots," PhD 2011.
[7] Huili Yu, "Vision-based Path Planning, Collision Avoidance, and Target Tracking for Unmanned Air and Ground Vehicles in Urban Environments," PhD, 2011.
[6] Jeff Saunders, "Obstacle Avoidance, Visual Automatic Target Tracking, and Task Allocation for Small Unmanned Air Vehicles," PhD, 2009.
[5] David Casbeer, "Decentralized Estimation Using Information Consensus Filters with a Multi-Static UAV Radar Tracking System," PhD, 2009.
[4] Derek Kingston, "Decentralized Control of Multiple UAVs for Perimeter and Target Surveillance," PhD, 2007.
[3] Wei Ren, "Consensus Seeking, Formation Keeping, and Trajectory Tracking in Multiple Vehicle Cooperative Control," PhD, 2004.
[2] J. Willard Curtis, "Satisficing Control for Nonlinear Systems," PhD, 2002.
[1] Jonathan Lawton, "A behavior-based approach for spacecraft formation flying," PhD, 2000.

MS Students

[28] Parker Lusk, "Vision-Based Emergency Landing of Small Unmanned Aircraft Systems," MS, 2018.
[27] Jae Hun Lee, "Nonlinear Control Framework for Gimbal and Multirotor in Target tracking," MS, 2018.
[26] Jeffrey D. Millard, "Multiple Target Tracking in Realistic Environments Using Recursive-RANSAC in a Data Fusion Framework," MS, 2017.
[25] Benjamin P. Lewis, "A Visual Return-to-Home System for GPS-Denied Flight," MS, 2016.
[24] Joshua Y. Sakamaki, "Cooperative Estimation for a Vision-Based Target Tracking System," MS, 2016.
[23] Patrick C. DeFranco, "Detecting and Tracking Moving Objects from a Small Unmanned Air Vehicle," MS, 2015.
[22] James K. Ingersoll, "Vision Based Multiple Target Tracking Using Recursive RANSAC," MS, 2015.
[21] Everett Bryan, "Cooperative Target Tracking Enhanced with the Sequence Memoizer," MS, 2013.
[20] Stephen Quebe, "Modeling, Parameter Estimation, and Gaze Control of Unmanned Indoor Quadrotor," MS, 2013.
[19] Kevin Meier, "Developing a Guidance Law for a Small-Scale Controllable Projectile Using Backstepping and Adaptive Control Techniques and a Hardware System Implementation for a UAV and a UGV to Track a Moving Ground Target," MS, 2012.
[18] Brandon Carroll, "Using Motion Fields to Estimate Video Utility and Detect GPS Spoofing," MS, 2012.
[17] Bryce S. Pincock, "Real-Time Target Following Using an Unmanned Rotorcraft with a Laser Rangefinder," MS, 2012.
[16] Caleb Chamberlain, "System Identification, State Estimation, and Control of Unmanned Aerial Robots," MS, 2011.
[15] Andrew Curtis, "Path Planning for Unmanned Air and Ground Vehicles in Urban Environments," MS, 2008.
[14] Joe Egbert, "Low-Altitude Road Following Using Strap-Down Cameras on Miniature Aerial Vehicles," MS, 2007.
[13] Stephen Osborne, "Transition Between Hover and Level Flight for a Tailsitter UAV," MS, 2007.
[12] Ryan Holt, "Three Enabling Technologies for Vision-Based Forest-Fire Perimeter Surveillance Using Multiple Unmanned Aerial Systems," MS, 2007.
[11] Brandon Call, "Obstacle Avoidance for Unmanned Air Vehicles," MS, 2006.
[10] David Johansen, "Video Stabilization and Object Localization using Feature Tracking with Small UAV Video," MS, 2006.
[9] Joshua Matthews, "Adaptive Control of Micro Unmanned Air Vehicles," MS, 2006.
[8] Walter H. Johnson, "Design and Implementation of the Kestrel Autopilot," MS, 2005.
[7] Reed Christiansen, "Design of an Autopilot for Small Unmanned Aerial Vehicles," MS, 2004.
[6] Joshua Hintze, "Autonomous Landing of a Rotary Unmanned Aerial Vehicle in a Non-Cooperative Environment Using Machine Vision," MS, 2004.
[5] Derek B. Kingston, "Implementation Issues of Real-Time Trajectory Generation of Small UAVs," MS, 2003.
[4] Erik Anderson, "Extremal Control and Unmanned Air Vehicle Trajectory Generation," MS, 2002.
[3] Jed Kelsey, "The MAGICC Mobile Robot Toolbox (MMRT): A Simulink-based Control and Coordination Toolbox for Multiple Robotic Agents," MS, 2001.
[2] J. Willard Curtis, "Nonlinear controller comparison on a benchmark system," MS, 2000.
[1] Brett Young, "Mobile robots: coordination and control," MS, 2000.

Technology Transfer

NSF I/UCRC Center for Unmanned Air Systems (C-UAS)
  BYU Site Director, 2012-Present.
Utah State Center of Excellence
  Co-Director, Center of Excellence for Small Unmanned Air Vehicles, 2004-2010.
Spin-off Companies
  Co-Founder, Procerus Technologies, January 2004.
  Procerus has licensed BYU's autopilot and video processing technologies. They manufacture the Kestrel autopilot, which is the smallest commercially available UAV autopilot. The Kestrel autopilot is currently used in the Air Force BATCAM and Night Hawk programs and the Army TAC-MAV program. It has been deployed for testing in Afghanistan and Iraq. In 2012 Procerus was acquired by Lockheed Martin.

  Technical Advisory Board, Flying Sensors, January 2006
  Flying Sensors utilizes BYU's UAV technology to provide aerial surveillance, videography, and mapping services in industrial and commercial applications. Since beginning operations, Flying Sensors has demonstrated their capabilities to numerous potential customers in a variety of applications. They recently secured a long-term surveillance contract as well as start-up funding from the State of Utah.
Patents
  Programmable Autopilot System for Autonomous Flight of Unmanned Aerial Vehicles, Randal W. Beard, Reid Christensen, Walter Johnson, and Timothy McLain, Patent no. 7,302,316, issued November 27, 2007.

  Aerial Recovery of Small and Micro Air Vehicles, Randal W. Beard, Patent No. 8,973,860. Issued March 10, 2015.

Invited Presentations

- Plenary speaker at the Mexican Control Conference, San Luis Potosi, Mexico, October, 2018
- Plenary speaker at the MarineUAS Winter School, Porto Portugal, January, 2018
- University of Nevada Reno, January 2018
- Georgia Tech, November, 2017
- Oklahoma State University, November 2017
- National Polytechnic Institute, Cinvestav, Mexico City, December, 2016.
- Plenary speaker at the Chinese Guidance Navigation and Control Conference, Nanjing, China, August, 2016.
- Invited tutorial speaker at the IEEE International Conference on Robotics and Automation, Stockholm, Sweden, May, 2016.
- Norwegian University of Science and Technology/AMOS, May, 2015.
- University of Washington, January, 2015.
- Naval Postgraduate School, November, 2014.
- University of Texas at Dallas, October, 2014.
- University of Illinois, Urbana-Champaign, March, 2014.
- Iowa State University, February, 2014.
- Missouri University of Science and Technology, November, 2013.
- Semi-Plenary Address, IFAC Symposium on Nonlinear Control Systems (NOLCOS), Toulouse, France, September, 2013.
- Texas A&M, Aerospace Engineering Department, November, 2012.
- Keynote speaker at the UAS Video Tracking Workshop and Challenge, Texas A&M, October, 2011.
- Plenary speaker at the International Conference on Unmanned Air Systems, Denver, CO, May, 2011.
- Harbin Institute of Technology, Harbin, China, April, 2011.
- University of California at Santa Barbara, January 2011.
- University of Porto, Porto, Portugal, May 2010.
- Short Course on Guidance and Control of MAVs, University of Porto, Portugal, May, 2010.
- Plenary speaker at the Seventh International Symposium on Mechatronics and its Applications, Sharjah, UAE, April, 2010.
- Short Course on Guidance and Control of MAVs, American University of Sharjah, UAE, April, 2010.
- Plenary speaker at the IFAC Workshop on Networked Robotics, Golden, Colorado, October, 2009.
- Royal Institute of Technology, Stockholm Sweden, March, 2009
- Plenary speaker at IEEE-Boeing Technologies Conference, Seal Beach, California, August, 2008.
- Plenary speaker at the Seventh International Conference on Autonomous Agents and Multiagent Systems (AAMAS), Estoril, Portugal, May, 2008.
- University of New Mexico, Albuquerque, New Mexico, November, 2007.

- University of Florida, Gainsville, Florida, October, 2007.
- Georgia Tech, Robotics Institute, Atlanta, GA, September, 2007.
- Georgia Tech, Aerospace Engineering Departments, Atlanta, GA, March, 2007.
- "Collision Detection and Avoidance Techniques for Micro Air Vehicles," Three hour invited workshop presentation at the Institute for Defense and Government Advancement, UAV Summit, February, 2007.
- Panel discussing future directions of Cooperative Control at the 2007 Conference on Cooperative Control and Optimization, Gainsville, Florida, January, 2007.
- University of Florida, REEF, Fort Walton Beach, Florida, January, 2007.
- University of Washington, Seattle, WA, January, 2006.
- Virginia Polytechnic and State University, Blackburg, VA, November 2005.
- University of Wyoming, Laromie, WY, November, 2005.
- Rensselaer Polytechnic Institute, Troy, NY, October, 2005.
- GRASP Lab, University of Pennsylvania, Philadelphia, PA, October, 2004.
- Raytheon, Tucson, AZ, March 2004.
- Utah State University, October 2003.
- Ohio State University, August 2003.
- AFRL/VA, WP AFB, Dayton, Ohio, August, 2003.
- INEEL, Idaho Falls, ID, August, 2003.
- AFRL/MN, Eglin AFB, Ft. Walton Beach, FL, June, 2003.
- UC Santa Barbara, May 2003.
- University of Nevada, Reno, 2002.
- Jet Propulsion Laboratory, 1998.
- INEEL, Idaho Falls, ID, 1997.
- Idaho State University, 1997.

Professional Activities

- Fellow of IEEE, 2015.
- Associate Fellow of AIAA, 2014.
- AIAA Unmanned Systems Program Committee, 2016-Present.
- Associate Editor, International Conference on Robotics and Automation, 2016.
- Scientific Advisory Board, Centre for Autonomous Marine Operations and Systems (AMOS), Norwegian University of Science and Technology, Tronheim, Norway, 2015-2016.
- Advisory Board, International Symposium on Mechatronics and Its Applications (ISMA), 2015.
- Program Committee, IEEE International Conference on Multisensor Fusion and Integration, 2015.
- Associate Editor, International Conference on Robotics and Automation, 2015.
- Exhibits Chair, American Control Conference, 2015.
- Awards Committee, IEEE Control Systems Society, 2015.
- Program Committee, Robotics and Science Systems, 2014.
- Associate Editor, International Conference on Robotics and Automation, 2014.
- Associate Editor, IEEE Transactions on Automatic Control, 2011-2013.
- IEEE Control Systems Society Conference Publication Chair, 2010-2013
- Publications Chair, American Control Conference, 2013.
- General co-Chair, International Conference on Unmanned Aircraft Systems, 2012.
- Publications Chair IEEE Conference on Decision and Control, 2012.
- Publications Chair, IEEE Conference on Decision and Control, 2011.
- Program Committee, Robotics: Science and Systems, 2011.
- Chair, IEEE Technical Committee on Aerospace Controls, 2011-Present.
- Program Committee, IEEE Conference on Decision and Control, 2010.
- Program Committee, Unmanned Vehicle Workshop, Istanbul, Turkey, 2010.
- Associate Editor, Journal of Intelligent and Robotic Systems, 2006-2010.
- Associate Editor, IEEE Control Systems Magazine, 2004-2009.
- Member of IEEE Technical Committee on Aerospace Controls, 2009-Present.
- Member of IEEE Technical Committee on Aerial Robotics, 2009-Present.
- Program Chair, Second International Symposium on Unmanned Aerial Vehicles, 2009.
- Program Committee, IFAC Workshop on Networked Robotics, 2009.
- Organizing Committee, First International Symposium on Unmanned Aerial Vehicles, 2008.
- Associate Editor, IEEE Control Systems Society Conference Editorial Board, 1999-2007.
- Vice Chair for Student Affairs, American Control Conference, 2007.
- Program Vice Chair, Mediterranean Conference on Control and Automation, 2007.
- Program Committee, IASTED International Conference on Control and Applications, 2005.

- Program Committee, American Control Conference, 2005.
- Program Committee, American Control Conference, 2004.
- Program Committee, IEEE Conference on Control Applications, 2002.

University Responsibilities

- University rank and status committee, 2017-present.
- University awards committee, 2015-2016.
- University rank and status appeals committee, 2011-2014.
- Chair, ECE undergraduate committee, 2012-2016.
- ECE rank and status committee, 2007-2016.
- Chair, ECE curriculum re-design committee, 2011-2013.
- Chair, ECE graduate committee, 2010-2011.
- Chair, ECE external relations committee, 2006-2010.
- ECE External relations committee, 2003-2006.
- ECE Undergraduate committee, 2001-2003.
- Chair, ECE faculty search committee, 2000-2001.
- ECE Faculty search committee, 1999-2000.
- ECE High School liason, 1995-2001.

Courses Taught

- ECEn 212 Introduction to Circuits
- ECEn 370 Probability Theory
- ECEn 380 Signals and Systems
- ECEn 483 Introduction to Feedback Control
- ECEn 490 Senior Design / Capstone (robot soccer, UAVs, quadrotors, laser guided munition)
- ECEn 671 Mathematics of Signals and Systems
- ECEn 674 Flight Control Systems
- ECEn 773 Linear Systems Theory
- ECEn 774 Nonlinear Systems Theory

Awards

- Karl G. Maeser Distinguished Faculty Lecturer Award, Brigham Young University, 2017.
- Cozzins Teaching and Learning Fellowship, Brigham Young University, 2012-2015.
- Karl G. Maeser Research and Creative Arts Award, Brigham Young University, 2009.
- Outstanding Researcher, College of Engineering and Technology, Brigham Young University, 2008.
- Thomson Scientific Essential Science Indicators Fast Breaking Paper, February 2007. [Paper published in IEEE Transactions on Automatic Control in May 2005 was identified in February 2007 to be one of the most cited recent papers in the field of Engineering.]
- National Research Council Fellowship, 2006-2007.
- Advised a student team that took first place at the 2nd US-European Competition for Micro Air Vehicles, November, 2006.
- Advised a student team that took second place at the AUVSI Undergraduate Student Competition for Autonomous Fixed Wing Aircraft, June, 2006.
- Technology Transfer Award, Brigham Young University, 2006
- Advised a student team that won the Grand Prize for Best Overall Video at the Infotech@Aerospace Conference, 2005
- Young Scholar Award, Brigham Young University, 2004
- Finalist, Stoel Rives Innovation Award, 2004
- Voted Outstanding Teacher by graduating seniors, BYU Electrical and Computer Engineering Department, 2004
- Outstanding Faculty Award, BYU Electrical and Computer Engineering Department, 2002
- Advised an undergraduate student who won the best undergraduate student paper award at the 2002 International Telemetry Conference.
- Advised a graduate student who won the best graduate student paper award at the 2002 International Telemetry Conference.
- Advised a graduate student who was a finalist in the Best Student Paper Competition at the 2001 American Control Conference.

- Voted Outstanding Teacher by graduating seniors, BYU Electrical and Computer Engineering Department, 1998
- Outstanding Senior, University of Utah Electrical Engineering Department, 1991.