

ROBERT C. LEISHMAN, PH.D.

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EDUCATION

Brigham Young University, Provo, UT June 2013

Ph.D. in Mechanical Engineering

Thesis Title: *A Vision-based Relative Navigation Approach for Autonomous Multirotor Aircraft*

Advisors: Dr. Timothy W. McLain and Dr. Randal W. Beard

Brigham Young University, Provo, UT June 2009

M.S. in Mechanical Engineering

Thesis Title: *Applications of Variation Analysis Methods to Automotive Mechanisms*

Advisor: Dr. Kenneth Chase

Utah State University, Logan, UT August 2006

B.S. in Mechanical Engineering

Cum Laude

ACADEMIC RESEARCH/TEACHING EXPERIENCE

Air Force Institute of Technology, ENG December 2016 - Present

Research Assistant Professor of Autonomy, Full Time

WPAFB, OH

- ◇ Directing autonomy-related research for the Autonomy and Navigation Technology (ANT) Center.
- ◇ Co-created and directed novel fellowship for top MS graduates with DIUx in Silicone Valley.
- ◇ Principle Investigator for over \$583k in research funds in FY17 and FY18.
- ◇ Co-Principle Investigator for over \$645k in research funds in FY18.
- ◇ Teaching and currently redesigning EENG 586 Feedback Systems course.

BYU MAGICC Lab/Center for Unmanned Systems September 2009 - May 2013

Graduate Student, Full-time

Provo, UT

- ◇ Co-led a new research effort in GPS-denied aerial UAS autonomy for the MAGICC lab that is now one of the fundamental lab efforts.
- ◇ Co-developed a new approach for aerial vehicle GPS-denied navigation that employs relative information for stability of the UAS but enables a backend globally centric map.
- ◇ Developed a novel approach to correctly utilize accelerometers in estimating quadrotor motion.
- ◇ Developed and implemented on quadrotor hardware advanced algorithms for visual odometry, feedback control, state estimation and sensor fusion.
- ◇ Mentored several undergraduate and masters students, who continued the project .

Dept. of Mechanical Engineering, Brigham Young University April 2012 - June 2012

Lecturer, 20 hrs/week

Provo, UT

- ◇ Taught MeEn 363 Elementary Instrumentation.
- ◇ Prepared and gave lectures, laboratory assignments, homework and exams.
- ◇ Outlined and oversaw development of a new set of course laboratory experiments.
- ◇ Course topics included: concepts of measurement, characteristics of signals, probability and uncertainty analysis, system behavior, and digital and analog measurements.

PROFESSIONAL EXPERIENCE

Air Force Research Laboratory, Systems Technology Office September 2009 - December 2016
Project Engineer, Full-time *WPAFB, OH*

- ◇ Planned and simultaneously executed six different research and development projects, with a total value in the tens-of-millions of dollars, that included ground and flight tests and modeling and simulation efforts.
- ◇ Co-lead an effort that redefines how a community understood and approached solving a specific, large and complex problem.
- ◇ Co-wrote a standards document and oversaw tool development to facilitate this problem redefinition.
- ◇ Planned, directed, coordinated, and evaluated work of multiple contractor teams.
- ◇ Routinely presented technical results to diverse audiences.
- ◇ Published and reviewed technical reports in a community library system.

Independent UAV Consultant July 2013 - April 2014
Software Developer, 10-15 hrs/week *Beavercreek, OH*

- ◇ Designed and developed real-time control software for quadrotor UAS for use within Motion Analysis motion capture systems.
- ◇ Developed software product now provided to customers interested in UAS and robotics research.
- ◇ Developed documentation and training materials for flying quadrotors and using provided software, then trained Motion Analysis personnel.
- ◇ Demonstrated the complete system in several UAS and robotic trade shows.

USAF 506th Combat Sustainment Squadron August 2006 - August 2009
Program Engineer, Full-time *Hill AFB, UT*

- ◇ Program engineer for sustainment of all USAF ammunition from .22 caliber through 20mm, as well as hand and 40mm grenades.
- ◇ Instituted statistical-based testing program to eliminate “Case-neck Separation” in 20mm ammunition manufacturing.
- ◇ Developed, organized and supervised new life-cycle testing for the USAF stockpile of small-caliber munitions.
- ◇ Led investigations to resolve incidents when ammunition did not function properly.
- ◇ Reviewed technical data and coordinated with other members of a multi-disciplined sustainment team.

FUNDED PROPOSALS

Support for PNT Modeling and Simulation, US Army CERDEC, \$50k, May 2018, 1 year, **Co-Principle Investigator** (25%)

PNT-Focused Distance Learning, US Army CERDEC, \$80k, May 2018, 1 year, **Co-Principle Investigator** (25%)

Robust Back-end Navigation Techniques, AFRL/Ryat, \$50k, May 2018, 1 year, **Principle Investigator** (100%)

PNT-Focused Distance Learning, 746 Test Squadron, \$40k, May 2018, 1 year, **Co-Principle Investigator** (25%)

Navigation for A2AD, Long Range, Over Water, AFRL/Rywn, \$400k/year, April 2018, 3 years, **Co-Principle Investigator** (30%)

Autonomy Framework Design and Development, US Army CERDEC, \$302k, December 2017, 1 year, **Principle Investigator** (50%)

Morphing Wing Aircraft Control, Integration and Flight Test, AFRL/RQVS, \$150k, November 2017, 18 months, **Principle Investigator** (70%)

Support for PNT Modeling and Simulation, US Army CERDEC, \$75k, October 2017, 1 year, **Co-Principle Investigator** (25%)

Robust Navigation for Small UAVs, AFRL/RV, \$30k, August 2017, 1 year, **Principle Investigator** (100%)

Relative Navigation for Autonomous Fixed-wing Unmanned Aerial Vehicles, AFOSR Research Development Funds, \$26,790, March 2017, 1 year, **Principle Investigator** (80%)

Robust, Back-end Navigation Techniques, AFRL/RVAT Research Grant, \$25,000, March 2017, 1 year, **Principle Investigator** (100%)

AWARDS

The Presidents Volunteer Service Award - Silver Category	2017
US DoD SMART Scholarship	Sept 2009 - May 2013
BYU Department of Mechanical Engineering Research Fellowship	Sept 2009 - May 2010
USAF PALACE Acquire Scholarship	Sept 2006 - Sept 2009
Utah State NSF Diversity and Retention Engineering Scholarship	Aug 2004 - May 2006
Utah State Department of Engineering Scholarship	Aug 2004 - May 2005
Eagle Scout	May 2000

PUBLICATIONS

Peer-reviewed Journal Articles

- [1] Robert C. Leishman and Timothy W McLain. “A Multiplicative Extended Kalman Filter for Relative Rotorcraft Navigation”. In: *Journal of Aerospace Information Systems* (2015). DOI: [10.2514/1.I010236](https://doi.org/10.2514/1.I010236).
- [2] Robert C. Leishman et al. “Quadrotors & Accelerometers: State Estimation with an Improved Dynamic Model”. In: *Control Systems Magazine* 34.1 (2014), pp. 28–41. ISSN: 1066033X. DOI: [10.1109/MCS.2013.2287362](https://doi.org/10.1109/MCS.2013.2287362).
- [3] Robert C. Leishman, Timothy W. McLain, and Randal W. Beard. “Relative Navigation Approach for Vision-Based Aerial GPS-denied Navigation”. In: *Journal of Intelligent and Robotic Systems* 47.1 (2014), pp. 97–111. DOI: [10.1007/s10846-013-9914-7](https://doi.org/10.1007/s10846-013-9914-7).
- [4] John Macdonald et al. “Analysis of an Improved IMU-Based Observer for Multirotor Helicopters”. In: *Journal of Intelligent & Robotic Systems* May (2013). DOI: [10.1007/s10846-013-9835-5](https://doi.org/10.1007/s10846-013-9835-5).
- [5] Robert C. Leishman and Kenneth W. Chase. “Direct Linearization Method Kinematic Variation Analysis”. eng. In: *Journal of Mechanical Design* 132.7 (2010), pp. 0710031–0710039. ISSN: 1050-0472. DOI: [10.1115/1.4001531](https://doi.org/10.1115/1.4001531). URL: <http://cat.inist.fr/?aModele=afficheN%7B%5C%7Dcpsid=23086999>.

Peer-reviewed Conference Proceedings

- [1] R. C. Leishman et al. “Utilization of UAV autopilots in vision-based alternative navigation”. In: *30th International Technical Meeting of the Satellite Division of the Institute of Navigation, ION GNSS 2017*. Vol. 4. Portland, OR: Institute of Navigation, 2017. ISBN: 9781510853317.

- [2] Robert C. Leishman et al. “Robust visual motion estimation using RGB-D cameras”. In: *AIAA Infotech @ Aerospace Conference*. Boston, MA, USA, 2013.
- [3] Robert C. Leishman, Timothy W. McLain, and Randal W. Beard. “Relative Navigation Approach for Vision-Based Aerial GPS-Denied Navigation”. In: *Intl. Conference on Unmanned Aircraft Systems*. Vol. 47. 1. Atlanta, GA: IEEE, 2013, pp. 343–352. ISBN: 9781479908172. DOI: [10.1109/ICUAS.2013.6564707](https://doi.org/10.1109/ICUAS.2013.6564707).
- [4] Brandon Cannon, Robert C Leishman, and Timothy W McLain. “Non-Redundant Sensor Fault Detection for Autonomous Rotorcraft using an Improved Dynamic Model”. In: *AIAA Guidance Navigation and Control*. Boston, MA, USA, 2013.
- [5] Robert Leishman et al. “Relative navigation and control of a hexacopter”. In: *IEEE Intl. Conf. on Robotics and Automation*. St. Paul, MN, USA, May 2012, pp. 4937–4942. ISBN: 978-1-4673-1405-3. DOI: [10.1109/ICRA.2012.6224983](https://doi.org/10.1109/ICRA.2012.6224983).
- [6] Robert C Leishman et al. “Utilizing an Improved Rotorcraft Dynamic Model in State Estimation”. In: *IEEE Intl. Conf. on Intelligent Robots and Systems*. San Francisco, Sept. 2011, pp. 5173–5178. ISBN: 9781612844541. DOI: [10.1109/IRROS.2011.6048591](https://doi.org/10.1109/IRROS.2011.6048591).
- [7] J. Ferrin et al. “Differential Flatness Based Control of a Rotorcraft For Aggressive Maneuvers”. In: *IEEE Int. Conf. Intelligent Robots and Systems*. 2011. ISBN: 9781612844541. DOI: [10.1109/IRROS.2011.6048861](https://doi.org/10.1109/IRROS.2011.6048861).
- [8] Robert C Leishman and Kenneth W Chase. “A New Tool for Design and Analysis of Optimized Rack and Pinion Steering Mechanisms”. In: *Non-Conference Specific Technical Papers*. SAE, 2009. DOI: [10.4271/2009-01-1675](https://doi.org/10.4271/2009-01-1675). URL: <http://papers.sae.org/2009-01-1675>.
- [9] Robert C Leishman and Kenneth W Chase. “Variation Analysis of Position, Velocity, and Acceleration of Two-Dimensional Mechanisms by the Direct Linearization Method”. In: *ASME Conference Proceedings*. Vol. 2009. 49026. ASME, 2009, pp. 1067–1079. DOI: [10.1115/DETC2009-86236](https://doi.org/10.1115/DETC2009-86236). URL: <http://link.aip.org/link/abstract/ASMECP/v2009/i49026/p1067/s1>.
- [10] Robert C Leishman and Kenneth W Chase. “Rack and Pinion Steering Linkage Synthesis Using an Adapted Freudenstein Approach”. In: *ASME Conference Proceedings*. Vol. 2009. 49033. ASME, 2009, pp. 849–856. DOI: [10.1115/DETC2009-86350](https://doi.org/10.1115/DETC2009-86350). URL: <http://link.aip.org/link/abstract/ASMECP/v2009/i49033/p849/s1>.

INVITED PRESENTATIONS (PRESENTER IN BOLDFACE)

Leishman, R. C., Gray, J., and Raquet, J., ” Utilization of UAV Autopilots in Vision-Based Alternative Navigation”, in ION GNSS+, Portland, OR, September 2017

Leishman, R. C., “A Relative Navigation Framework for Robust Autonomous Aircraft Flight”, presented at University of Cincinnati Graduate Seminar, Cincinnati, OH, April 2017

Leishman, R. C., “A Vision-based Relative Navigation Approach for Autonomous Multirotor Aircraft”, presented at AFIT/ENG Introduction to Autonomy course, Dayton, OH, December 2016

Leishman, R. C., “A Vision-based Relative Navigation Approach for Autonomous Multirotor Aircraft”, presented at AFIT ANT Center, Dayton, OH, June 2016

Leishman, R. C., “Autonomy Technologies and Algorithms for Multirotor Aircraft”, presented at Kitty Hawk Aero, Mountain View, CA, May 2016

PRESENTATIONS (PRESENTER IN BOLDFACE)

Nelson, K., Leishman, R. C., ” Alternative Methods for Optical Flow and Visual Odometry” in COUNT, Columbus, OH, April 2018

Berhold, M., Leishman, R. C., ”Aircraft Specific Visual Identification using Convolution Neural Networks” in COUNT, Columbus, OH, April 2018

Leishman, R. C., Taylor, C., "Robust Navigation for Autonomous Fixed-wing Unmanned Aerial Vehicles", in ION GNSS+, Portland, OR, September 2017

Cannon, B., Leishman, R. C., & McLain, T. W. "Non-Redundant Sensor Fault Detection for Autonomous Rotorcraft using an Improved Dynamic Mode". In AIAA Guidance Navigation and Control. Boston, MA, August 2013.

Leishman, R. C., **Koch, D. P.**, McLain, T. W., & Beard, R. W. "Robust visual motion estimation using RGB-D cameras" In AIAA Infotech at Aerospace Conference, August 2013

Leishman, R. C., McLain, T. W., & Beard, R. W. "Relative navigation approach for vision-based aerial GPS-denied navigation" Int. Conf. on Unmanned Aircraft Systems, ICUAS May 2013

Leishman, R. C., Macdonald, J., Beard, R. W., & McLain, T. "Relative navigation and control of a hexacopter" IEEE Intl. Conf. on Robotics and Automation St. Paul, MN, May 2012

Ferrin, J., **Leishman, R. C.**, Beard, R., & McLain, T. "Differential Flatness Based Control of a Rotorcraft For Aggressive Maneuvers". In IEEE Int. Conf. Intelligent Robots and Systems, September 2011

Leishman, R. C., Ferrin, J., McLain, T., MacDonald, J., Quebe, S., & Beard, R. "Utilizing an improved rotorcraft dynamic model in state estimation" In IEEE Int. Conf. Intelligent Robots and Systems, September 2011

RECENT ACADEMIC SERVICE

Technical Program Chair, ION CASSCA Conference, January 2019

Faculty Advisor, AFIT Innovation Fellowship, August 2017 - June 2018

Vice President, Dayton ION Section, June 2017 - June 2018

Session Chair, ION International Technical Meeting in Reston, VA, January, 2018

Session Chair, ION GNSS+ Conference in Portland, OR, September 2017

Technical Reviewer Reviewing papers for IEEE, ION, AIAA, etc. 2-4 hrs/month since Jan 2009

RECENT VOLUNTEER EXPERIENCE

FIRST Lego Robotics League Assistant Coach Mentoring youth ages 9-12 in Engineering and Robotics, 5 hrs/week Sept-Dec 2016 & 2017

Board of Directors Interfaith Hospitality Network Directing non-profit corporation, assisting in fund-raising efforts and service 5 hrs/month since Apr 2017

Boy Scouts of America Mentor teenage boys in Scouting/life 5 hrs/week since Jan 2007, currently serving as Scoutmaster.

LDS Church Served in various positions, about 8 hrs/week since Apr 2003