

**PENINA AXELRAD**

Joseph T. Negler Professor of Aerospace Engineering Sciences  
 Colorado Center for Astrodynamics Research  
 Ann and H.J. Smead Aerospace Engineering Sciences  
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**Research Interests**

Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) technology and applications for position, navigation and timing; satellite orbit and attitude determination; GNSS reflections for remote sensing; GNSS multipath characterization and mitigation; satellite timing systems; space applications of quantum technology.

**Education**

Ph.D. in Aeronautics and Astronautics, 1991, Stanford University, Stanford, CA  
 Dissertation: "A Closed-Loop GPS-Based Orbit Trim System for Gravity Probe B."  
 S.M. in Aeronautics and Astronautics, 1986, Massachusetts Institute of Technology, Cambridge, MA, Master's thesis: "Near-Earth Orbit Determination and Rendezvous Navigation Using GPS."  
 S.B. in Aeronautics and Astronautics (Avionics Option), 1985, Massachusetts Institute of Technology, Cambridge, MA.

**Professional Experience**

2020-present	Distinguished Professor, Ann and H.J. Smead Aerospace Engineering Sciences, University of Colorado Boulder.
2005-2020	Professor, Ann and H.J. Smead Aerospace Engineering Sciences, University of Colorado Boulder.
2017-2018	NRC Senior Research Associate, AFRL/RVEP Space Experiments and Programs, Albuquerque, NM.
2012-2017	Chair, Ann and H.J. Smead Dept. of Aerospace Engineering Sciences, University of Colorado Boulder.
2008-2009	Visiting Scientist COSMIC Program Office, University Corporation for Atmospheric Research (UCAR).
2007-2008	Acting Chair, Department of Aerospace Engineering Sciences, University of Colorado Boulder.
2005-2007	Associate Chair, Department of Aerospace Engineering Sciences, University of Colorado Boulder.
1999-2005	Associate Professor, Colorado Center for Astrodynamics Research, Department of Aerospace Engineering Sciences, University of Colorado Boulder.
1992-1999	Assistant Professor, Colorado Center for Astrodynamics Research, Department of Aerospace Engineering Sciences, University of Colorado Boulder.
1991-2011	Instructor, Navtech Seminars, Inc., Arlington, VA.
1991-1992	Lecturer, Department of Aeronautics and Astronautics, Stanford University.
1990-1992	Member of the Technical Staff and Program Manager, GPS Systems Organization, Stanford Telecommunications Inc., Santa Clara, CA.
1986-1990	Graduate Research Assistant, Gravity Probe B, Stanford University.
1985-1986	Systems Engineer, Space and Communications Group, Hughes Aircraft Co., El Segundo, CA.

**Honors and Awards**

University of Colorado Distinguished Professor (2020)  
 Smead Aerospace Outstanding Faculty Award for Research (2020)  
 Member of the National Academy of Engineering (2019)  
 Joseph T. Negler Professor of Aerospace Engineering Sciences (2018-Present)  
 University of Colorado Excellence in Leadership Award (2017)  
 National Research Council (NRC) Senior Research Associate, Air Force Research Laboratory (AY2017-2018)

Women in Aerospace Educator Award (2015)  
 Institute of Navigation Samuel Burka Award (2011)  
 American Institute of Aeronautics and Astronautics Summerfield Book Award (2011)  
 University of Colorado, College of Engineering and Applied Science, Max S. Peters Faculty Service Award (2009)  
 Institute of Navigation Johannes Kepler Award (2009)  
 Fellow, American Institute of Aeronautics and Astronautics (2008)  
 Institute of Navigation Outstanding Service Award (2005)  
 Fellow, Institute of Navigation (2004)  
 University of Colorado, Subaru Educator Spotlight (2004)  
 Senior Member, Institute of Electrical and Electronics Engineers (2003)  
 Institute of Navigation Tycho Brahe Award (2003)  
 AIAA Lawrence Sperry Award (1996)  
 AAS/AIAA Space Flight Mechanics Meeting Best Paper Award (1996)  
 Naval Research Laboratory Alan Berman Annual Research Publications Award (1995, 2000)  
 AIAA Rocky Mountain Section, Young Engineer of the Year (1995)  
 AIAA Guidance, Navigation and Control Conference Best Paper Award (1993)  
 Stanford University Graduate Fellowship (1986)  
 Hughes Aircraft Company Graduate Fellowship (1986)  
 James Means Award for Leadership in Aerospace Design (1985)  
 Member Sigma Xi and Tau Beta Pi

**Research Funding** – Award Total: \$16.5M (Axelrad share \$13M), Award Total as PI: \$12.4M

### **Professional Activities**

#### Current External Service and Committee Memberships

2020-Present	National Research Council Space Technology Industry-Government-University Roundtable (STIGUR)
2013-Present	National Space-Based Positioning, Navigation and Timing (PNT) Advisory Board
1994-Present	Member of the Draper Corporation
1993-Present	Associate Editor, Navigation

#### Past External Service and Committee Memberships

2016-2019	NASA Advisory Council Member at Large
2019	Panel Member Purdue University Amelia Earhart Summit, September 2019
2019	Panel Member MIT-Stanford-CU Women in Aerospace Symposium, May 2019
2017	CU-MIT-Stanford Women in Aerospace Symposium Organizer and Host, May 30- Jun 1 <a href="https://www.colorado.edu/aerospace/wias">https://www.colorado.edu/aerospace/wias</a>
2016	International Committee on Global Navigation Satellite Systems (ICG-10) Organizing Committee Member
2014-2018	AIAA Publications Ethics Subcommittee
2013-2015	Institute of Navigation (ION) Awards Chair
2013, 2019, 2020	AIAA Fellow Peer Reviewer
2013-2014	Astrodynamics Collaboration Environment Working Group (AFRL)
2012-2016	Member of the Board of eSpace: The Center for Space Entrepreneurship
2009	Keck Institute for Space Studies External Advisory Committee
2007-2010	Program Co-Chair, ION/IEEE PLANS
2005-2006	NASA ST9 Precision Formation Flying Technology Review Board
2004-2005	Institute of Navigation (ION) President
2003-2004	Institute of Navigation (ION) Executive Vice President

2002-2012	Member of the Massachusetts Institute of Technology, Department of Aeronautics and Astronautics Visiting Committee
2000-2002	Institute of Navigation (ION) Chair, Satellite Division
1998-2000	Institute of Navigation (ION) Vice-Chair, Satellite Division
1997	General Chair, ION GPS-97
1996	Program Chair, ION GPS-96
1995	General Chair, ION National Technical Meeting
1994-1995	Member, National Research Council Committee on the Future of the Global Positioning System
1994-1996	Institute of Navigation (ION) Secretary, Satellite Division
1994-1995	Institute of Navigation (ION) Vice President, Western Region
1994	Technical Program Chair, ION National Technical Meeting
1993-1996	Faculty Advisor, University of Colorado Student Chapter Institute of Navigation (ION)
1993-1994	Institute of Navigation (ION) Chair, Student Awards Committee
1992-1994	Institute of Navigation (ION) Council Space Representative
1993	Institute of Navigation (ION) Technical Chair, ION GPS-93
1993	Institute of Navigation (ION) Chair, Rocky Mountain Section
1991-1992	Institute of Navigation (ION) Western Region Council Member at Large
1988-1989	Institute of Navigation (ION) Chair, Annual Satellite Division Student session

#### University of Colorado (CU) Service Activities

2019-Present	Smead Aerospace Graduate Committee, Astrodynamics and Satellite Navigation Focus Lead
2018-Present	College of Engineering First Level Review Committee
2018-Present	Smead Aerospace Executive Committee
2005-2019	Faculty Teaching Excellence Faculty Associate and Advisory Board Member
2016-2017	Aerospace Building Design Committee
2012-2017	Chair CU AeroSpace Ventures Executive Committee
2016-2017	Provost's Chairs Committee (Ad hoc)
2016	College of Engineering and Applied Science Dean's Search Committee
2014-2015	CU Grand Challenge Steering Committee
2014-2015	Internal Review Committee – Continuing Education
2014-2015	CU Libraries Dean's Review Committee
2011-2012	Internal Review Committee - Geography
2006-2007	University of Colorado Emerging Leaders Program Fellow
2005-2007	College of Engineering First Level Review Committee
2005-2007	Aerospace Engineering Sciences Coop Program Faculty Advisor
2004-2006	CRCW Committee
2003-2005	LEAP Program Coach
2002-03, 04-05	Aerospace Engineering Sciences Department, Search Committee Chair
1999-2008	Faculty Teaching Excellence Program Advisory Board
1998-2002	CU, College of Engineering Summer Success Institute
1994-2002	Lab Demonstrations for Women in Engineering Program High School Career Day

## Journal Publications

Names of Dr. Axelrad's students are underlined.

1. Parkinson, B.W. and P. Axelrad, "Autonomous GPS Integrity Monitoring Using the Pseudorange Residual," *NAVIGATION*, Vol. 35, No. 2, p. 255-274, 1988.
2. Axelrad, P. and B.W. Parkinson, "Closed Loop Navigation and Guidance for Gravity Probe B Orbit Insertion," *NAVIGATION*, Vol. 36, No. 1, p. 45-61, 1989.
3. Green, G.B. and P. Axelrad, "Space Applications of GPS," *NAVIGATION*, Vol. 36, No. 3, p. 239-251, 1989.
4. Kee, C., B.W. Parkinson, P. Axelrad, "Wide Area Differential GPS," *NAVIGATION*, Vol. 38, No. 2, p. 123-146, 1991.
5. Born, G.H., M.E. Parke, P. Axelrad, K.L. Gold, J. Johnson, K.W. Key, D.G. Kubitschek, E.J. Christensen, "Calibration of the TOPEX altimeter using a GPS buoy," *Journal of Geophysical Research*, Vol. 99, No. C12, p. 24,517-24,526, 1994.
6. Adams, L.J., P. Axelrad, et al., *The Global Positioning System - A Shared National Asset, A Report by the Committee on the Future of the Global Positioning System*, National Academy Press, 264 pages, 1995.
7. Axelrad, P., C.J. Comp, P.F. MacDoran, "SNR Based Multipath Error Correction for GPS Differential Phase," *IEEE Transactions on Aerospace & Electronic Systems*, Vol. 32, No. 2, p. 650-660, April 1996.
8. Axelrad, P. and L.M. Ward, "Spacecraft Attitude Estimation Using the Global Positioning System: Methodology and Results for RADCAL," *Journal of Guidance, Control and Dynamics*, Vol. 19, No. 6, p. 1201-1209, November-December 1996.
9. Melvin, P.J., L.M. Ward, P. Axelrad, "The Analysis of GPS Attitude Data From a Slowly Rotating, Symmetrical Gravity Gradient Satellite," *Journal of the Astronautical Sciences*, Vol. 44, p. 515-539, October-December 1996.
10. Axelrad, P. and C.P. Behre, "Attitude Estimation Algorithms for Spinning Satellites Using GPS Phase Data," *Journal of Guidance, Control and Dynamics*, Vol. 20, No. 1, p. 164-169, January-February 1997.
11. Ward, L.M. and P. Axelrad, "A Combined Filter for GPS-Based Attitude and Baseline Estimation," *NAVIGATION*, Vol. 44, No. 2, p. 195-213, 1997.
12. Comp, C.J. and P. Axelrad, "Adaptive SNR-Based Carrier Phase Multipath Mitigation Technique", *IEEE Transactions on Aerospace & Electronic Systems*, Vol. 34, No. 1, p. 264-276, January 1998.
13. Irish, K., K. Gold, G. Born, A. Reichert, P. Axelrad, "Precision Orbit Determination for the Geosat Follow-On Satellites," *Journal of Spacecraft and Rockets*, Vol. 35, No. 3, p. 336-341, May-June 1998.
14. Garrison, J.L., P. Axelrad, N.J. Kasdin, "Ill-Conditioned Covariance Matrices in the First-Order Two-Step Estimator," *Journal of Guidance, Control and Dynamics*, Vol. 21, No. 5, p. 754-760, September-October 1998.
15. Axelrad, P., and C.P. Behre, "Satellite Attitude Determination Based on GPS Signal-to-Noise Ratio," (Invited Paper) *Proceedings of the IEEE*, Vol. 87, No. 1, p. 133-144, January 1999.
16. Komjathy, A., V.U. Zavorotny, P. Axelrad, G.H. Born, J.L. Garrison, "GPS Signal Scattering from Sea Surface: Wind Speed Retrieval Using Experimental Data and Theoretical Model," *Journal of Remote Sensing of Environment*, Vol. 73, p. 162-174, August 2000.
17. Moreau, M., P. Axelrad, J.L. Garrison, A. Long, "GPS Receiver Architecture and Expected Performance for Autonomous Navigation in High Earth Orbits," *NAVIGATION*, Vol. 47, No. 3, p. 191-204, 2000.
18. Bauer, F.H., P. Axelrad, et al., "Enabling Spacecraft Formation Flying in Any Earth Orbit Through Spaceborne GPS and Enhanced Autonomy Technologies," *Space Technology*, Vol. 20, No. 4, p. 175-185, 2001.
19. Reichert, A.K. and P. Axelrad "Carrier-Phase Multipath Corrections for GPS-Based Satellite Attitude Determination," *NAVIGATION*, Vol. 48, No.2, p. 77-88, 2001.
20. Goldstein, D., G. Born, P. Axelrad "Real-time, Autonomous, Precise Orbit Determination Using GPS," *NAVIGATION*, Vol. 48, No. 3, p. 155-168, 2001.

21. Thompson, B., M.C. Meek, K.L. Gold, P. Axelrad, G.H. Born, D.G. Kubitschek, "Orbit Determination for the QuikSCAT Spacecraft," *Journal of Spacecraft and Rockets*, Vol. 39, No. 6, p. 852-858, November-December 2002.
22. Madhani, P.H., P. Axelrad, K. Krumvieda, J. Thomas, "Application of Successive Interference Cancellation to the GPS Pseudolite Near-Far Problem," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 39, No.2, p. 481-489, April 2003.
23. Komjathy, A., M. Armatys, D. Masters, P. Axelrad, V.U. Zavorotny, S.J. Katzberg, "Retrieval of Ocean Surface Wind Speed and Wind Direction Using Reflected GPS Signals," *Journal of Atmospheric and Oceanic Technology*, Vol.21, No.3, p. 515-526, March 2004.
24. Mickler, D., G.H. Born, P. Axelrad "Using GPS Reflections for Satellite Remote Sensing," *Acta Astronautica*, Vol. 55:1, p. 39-49, 2004.
25. Masters, D., P. Axelrad, S. Katzberg, "Initial Results of Land-Reflected GPS Bistatic Radar Soil Moisture Measurements in SMEX02," *Remote Sensing of Environment*, Vol. 92:4 p. 507-520, 2004.
26. Choi, K., A. Bilich, K.M. Larson, P. Axelrad, "Modified Sidereal Filtering: Implications for High-Rate GPS Positioning," *Geophys. Res. Lett.*, Vol. 31, No. 22, 2004.
27. Weiss, J.P., S. Anderson, P. Axelrad, "Development of Multipath Error Budgets for JPALS Ground Station Receivers," *NAVIGATION*, Vol. 52, No. 3, p. 145-154, 2005.
28. Lane, C. and P. Axelrad, "Formation Design in Eccentric Orbits Using Linearized Equations of Relative Motion," *Journal of Guidance, Control, and Dynamics*, Vol. 29, No. 1, p. 146-160, 2006.
29. Meek, M.C., G.H Born, P. Axelrad, "Automated Operational Orbit Determination for the Ice Cloud and Land Elevation Satellite Mission," *Journal of Spacecraft and Rockets*, Vol. 43, No. 5, p. 1048-1053, Sept-Oct 2006.
30. Belmonte-Rivas, M., J. Maslanik, J. Sonntag, P. Axelrad, "Sea Ice Roughness from Airborne Lidar Profiles," *IEEE Transactions on Geoscience and Remote Sensing*, Volume 44, Issue 11, p. 3032 – 3037, 2006.
31. Lane, C. and P. Axelrad, "Analysis of Relative Navigation in High Earth Orbits," *Journal of the Astronautical Sciences*, Vol. 55, No 1, Jan-Mar 2007, p. 23-52.
32. Larson, K., A. Bilich, P. Axelrad, "Improving the precision of high-rate GPS," *Journal of Geophysical Research*, 112, B05422, DOI:10.1029/2006JB004367, 2007.
33. Lane, C. and P. Axelrad, "Relative Semimajor Axis Uncertainty in High Earth Orbits," *Journal of Guidance, Control, and Dynamics*, Vol. 30, No. 6, p. 1827-1830, 2007.
34. Weiss, Jan P., P. Axelrad, S. Anderson, "A GNSS Code Multipath Model for Semi-Urban, Aircraft, and Ship Environments," *NAVIGATION*, Vol. 54, No.4, p. 294-307, 2007.
35. Larson, K. M., E. E. Small, E. Gutmann, A. Bilich, P. Axelrad, J. Braun, "Using GPS multipath to measure soil moisture fluctuations: initial results," *GPS Solutions*, Vol 12 (3), p. 173-177, DOI:10.1007/s10291-007-0076-6, July 2008.
36. Bilich, A., K. M. Larson, P. Axelrad, "Modeling GPS Phase Multipath with SNR: Case study from Salar de Uyuni, Bolivia," *Journal of Geophysical Research*, 113, B04401, DOI:10.1029/2007JB005194, 2008.
37. Jah, M.K., M.E. Lisano, G.H. Born, P. Axelrad, "Mars Aerobraking Spacecraft State Estimation by Processing Inertial Measurement Unit Data," *Journal of Guidance, Control, and Dynamics*, Vol. 31, No. 6, p. 1802-1813, 2008.
38. Belmonte Rivas, M., J. Maslanik, P. Axelrad, "Bistatic scattering of GPS signals off Arctic Sea Ice," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 48, No. 3, p. 1548-1553, doi: 10.1109/TGRS.2009.2029342, 2010.
39. Vinande, E., P. Axelrad, D. Akos, "Mounting Angle Estimation for Personal Navigation Devices," *IEEE Transactions on Vehicular Technology*, Vol.59, No. 3, p. 1129-1138, March 2010.
40. Tombasco, J., P. Axelrad, M. Jah, "Analysis of Specialized Coordinate Representation for Dynamic Modeling and Orbit Estimation in the Geosynchronous Regime," *Journal of Guidance, Control, and Dynamics*, Vol. 33, No. 6, p. 1824-1836, 2010.

41. Axelrad, P., "Global Navigation Satellite Systems," in *Encyclopedia of Aerospace Engineering*, R. Blockley and W. Shyy (eds). John Wiley & Sons Ltd., Chichester, UK, p. 3167-3178, 2010.
42. Tombasco, J.M. and P. Axelrad, "A Study of the Achievable Geosynchronous Angles-Only Orbit Estimation Accuracy," *Journal of Astronautical Sciences*, Vol. 58, No. 2, April-June 2011, pp. 275-290.
43. Axelrad, P., B.K. Bradley, J. Donna, M. Mitchell, S. Mohiuddin, "Collective Detection and Direct Positioning Using Multiple GNSS Satellites," *NAVIGATION*, Vol. 58, No. 4, p. 305-321, 2011.
44. L.B. Cornman, R.K. Goodrich, P. Axelrad, E. Barlow, "Progress in turbulence detection via GNSS occultation data," *Atmospheric Measurement Techniques*, 5, 789-808, DOI:10.5194/amt-5-789-2012, 2012.
45. Tombasco, J.M. and P. Axelrad, "Along-Track Separation Uncertainty Modeling Given Space-Based Angles-Only Tracking," *Journal of Guidance, Control, and Dynamics*, Vol. 35, No. 3, p. 732-739, DOI: 10.2514/1.56240, 2012.
46. Tombasco, J.M. and P. Axelrad, "Observability of Relative Hybrid Elements Given Space-Based Angles-Only Observations," *Journal of Guidance, Control, and Dynamics*, Vol. 35, No. 5, p. 1681-1686, DOI: 10.2514/1.54981, 2012.
47. Pratt, J., P. Axelrad, K.M. Larson, B. Lesage, R. Gerren, N. DiOrio, "Satellite clock bias estimation for iGPS," *GPS Solutions*, 17(3): 381-389, doi: 10.1007/s10291-012-0286-4, 2013.
48. Bradley, B.K., B.A. Jones, G. Beylkin, K. Sandberg, P. Axelrad, "Bandlimited Implicit Runge-Kutta Integration for Astrodynamics," *Celestial Mechanics and Dynamical Astronomy*, 119:143-168, doi: 10.1007/s10569-014-9551-x, 2014.
49. Bradley, B.K., A. Sibois, P. Axelrad, "Influence of ITRF/GCRF Implementation for Astrodynamics: Coordinate Transformations" *Advances in Space Research*, Vol. 57, Issue 3, p. 850-866, doi: 10.1016/j.asr.2015.11.006, 2016.
50. Mashburn, J., P. Axelrad, S. T. Lowe, K. M. Larson, "An Assessment of the Precision and Accuracy of Altimetry Retrievals for a Monterey Bay GNSS-R Experiment," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 9, no. 10, pp. 4660-4668, doi: 10.1109/JSTARS.2016.2537698, 2016.
51. Gehly, S., B. Jones, P. Axelrad, "Sensor Allocation for Tracking Geosynchronous Space Objects," *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 41, No. 1, pp. 149-163, doi 10.2514/1.G000421, 2018.
52. Strandjord, K.L. and P. Axelrad, "Improved Prediction of GPS Satellite Clock Sub-Daily Variations Based on Daily Repeat," *GPS Solutions*, 22:58, doi: 10.1007/s10291-018-0723-0, 2018.
53. Mashburn, J., P. Axelrad, S. Lowe, K.M. Larson, "Global Ocean Altimetry with GPS Reflections from TechDemoSat-1," *IEEE Trans. on Geoscience and Remote Sensing*, 56(7) doi: 10.1109/TGRS.2018.2823316, 2018.
54. Gehly, S., B. Jones, P. Axelrad "Search-Detect-Track Sensor Allocation for Geosynchronous Space Objects" *IEEE Trans. on Aerospace and Electronic Systems*, Vol. 54, No. 6, pp. 2788-2808, doi: 10.1109/TAES.2018.2830578, 2018.
55. Schumacher, P.W, J. Gaebler, C. Roscoe, M. Wilkins, P. Axelrad, "Parallel Initial Orbit Determination Using Angles-Only Observation Pairs," *Celestial Mech and Dynamical Astronomy*, 130(60), doi: 10.1007/s10569-018-9852-6, 2018.
56. Klein, V, P. Axelrad, "Advanced multipath modeling and validation for GPS onboard the International Space Station," *NAVIGATION*, Vol. 66, pp. 559- 575, <https://doi.org/10.1002/navi.327>, 2019.
57. Mutschler, S., P. Axelrad, T. Matsuo, "A Partially Orthogonal EnKF approach to atmospheric density estimation using orbital debris," *Advances in Space Research*, 65(8), pp. 1965-1980, <https://doi.org/10.1016/j.asr.2020.01.021>, 2020.
58. Mashburn, J., P. Axelrad, C. Zuffada, E. Loria, A. O'Brien, B. Haines, "Improved GNSS-R Ocean Surface Altimetry with CYGNSS in the Seas of Indonesia," in *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 58, No. 9, pp. 6071-6087, doi: 10.1109/TGRS.2020.2973079, Sept. 2020.
59. Strandjord, K.L., P. Axelrad, S. Mohiuddin, "Improved Urban Navigation with Collaborative Shadow Matching and Specular Matching in Formation," *NAVIGATION*, 67:547-565, <https://doi.org/10.1002/navi.378>, 2020.
60. Gaebler, J., P. Axelrad, P. Schumacher, "CubeSat Cluster Deployment Track Initiation via a Radar Admissible Region Birth Model," *Journal of Guidance, Control, and Dynamics*, Vol. 43, No. 10, p. 1927-1934, doi.org/10.2514/1.G005139, October 2020.

61. Gaebler, J. and P. Axelrad, "Identity Management of Clustered Satellites with a Generalized Labeled Multi-Bernoulli Filter," *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 43, No. 11, p. 2046-2057, doi.org/10.2514/1.G004725, November 2020.
62. Rybak, M. P. Axelrad, J. Seubert, T. Ely, "Chip Scale Atomic Clock–Driven One-Way Radiometric Tracking for Low-Earth-Orbit CubeSat Navigation," *AIAA Journal of Spacecraft and Rockets*, doi.org/10.2514/1.A34684, Online October 2020.
63. VanBuren, D., P. Axelrad, S. Palo, "A Low Complexity Smoothing Algorithm for Improved GPS Point Solutions On Board LEO Spacecraft," In press, *NAVIGATION*, doi: 10.1002/navi.410, 2021.

### Manuscripts in Progress or in Review

64. VanBuren, D., P. Axelrad, S. Palo, "Design of a High Stability Heterogeneous Clock System for Small Satellites in LEO," Revision in review, *GPS Solutions*, November 2020.

### Books and Book Chapters

1. Axelrad, P. and R.G. Brown, "GPS Navigation Algorithms," in *Global Positioning System: Theory and Applications*, Ed. by B.W. Parkinson, J.J. Spilker, Assoc. Ed. P. Axelrad and P. Enge, Progress in Astronautics and Aeronautics, Vol. 163 , Chapt 9, American Institute of Aeronautics and Astronautics, 409-433, 1996.
2. *Global Positioning System: Theory and Applications*, Ed. by B.W. Parkinson, J.J. Spilker, Assoc. Ed. P. Axelrad and P. Enge, Progress in Astronautics and Aeronautics, Volumes 163 and 164, American Institute of Aeronautics and Astronautics, 1394 pages, 1996.

### Conference Proceedings

NOTE: ION conference papers are selected for presentation and inclusion in the proceedings based on an abstract. AIAA/AAS Papers are selected for presentation and inclusion in the proceedings based on a draft of the paper. All items listed here include actual papers as well as presentation material.

1. Axelrad, P. and J.F. Kelley, "Near Earth Orbit Determination and Rendezvous Navigation Using GPS," *IEEE PLANS*, p. 184-191, Las Vegas, NV, November 1986.
2. Parkinson, B.W. and P. Axelrad, "Simplified GPS Integrity Checking with Multiple Satellites," *ION National Technical Meeting*, Dayton, OH, p. 78-83, January 1987.
3. Parkinson, B.W. and P. Axelrad, "A Basis for the Development of Operational Algorithms for Simplified GPS Integrity Checking," *ION Satellite Division Meeting*, Colorado Springs, CO, p. 269-276, September 1987.
4. Parkinson, B.W. and P. Axelrad, "A Practical Algorithm for Autonomous Integrity Verification Using the Pseudo Range Residual," *ION National Technical Meeting*, Santa Barbara, CA, p. 254-260, January 1988.
5. Parkinson, B.W. and P. Axelrad, "Closed Loop Orbit Trim Using GPS," *40th International Astronautical Congress*, Malaga, Spain, IAF-89-393, 14 pages, October 1989.
6. Kee, C., B.W. Parkinson, P. Axelrad, "Wide Area Differential GPS," *ION- GPS 90*, Colorado Springs, CO, p. 587-598, September 1990.
7. Axelrad, P., R.H. Vassar, B.W. Parkinson, "Gravity Probe B Orbit Modeling and Injection Requirements," *AAS/AIAA Spaceflight Mechanics Meeting*, Houston, TX, AAS 91-164, February 1991.
8. Hanson, P., P. Axelrad, T. Hayashi, T. Ishizaki, "A Real-Time GPS Kinematic Survey System (GKSS)," *ION- GPS 92*, Albuquerque, NM, p. 1005-1013, September 1992.

9. Axelrad, P. and B.C. Chesley, "Performance Testing of a GPS Based Attitude Determination System.," *AIAA Guidance, Navigation, and Control Conference*, Monterey, CA, p. 809-819, August 1993. (Received award for best paper presented at the conference.)
10. Axelrad, P. and L.M. Ward, "On-Orbit GPS Based Attitude and Antenna Baseline Estimation," *ION National Technical Meeting*, San Diego, CA, p. 441-450, January 1994.
11. Chesley, B.C. and P. Axelrad, "An Integrated GPS Attitude Determination System for JAWSAT," *ION-GPS 94*, Salt Lake City, UT, p. 1251-1261, September 1994.
12. Axelrad, P., C.J. Comp, P.F. MacDoran, "Use of Signal-to-Noise Ratio for Multipath Error Correction in GPS Differential Phase Measurements," *ION-GPS 94*, Salt Lake City, UT, p. 655-666, September 1994. (Received award for best paper out of eight in the session.)
13. Park, M., G. Born, P. Axelrad, K. Gold, K. Key, D. Kubitshek, T. Kelecy, J. LaMance, C. Rocken, J. Johnson, "The Use of GPS Buoys to Calibrate Altimetric Satellites," *ION-GPS 94*, Salt Lake City, UT, p. 221-230, September 1994.
14. Lawrence, D.A., T.E. Holden, F. Padiou, P. Axelrad, M. Malone, "Disturbance Learning Control for Small Satellites," *American Control Conference*, Baltimore, MD, p. 2882-2886, 1994.
15. Ward, L.M. and P. Axelrad, "Spacecraft Attitude Estimation Using GPS: Methodology and Results for RADCAL," *ION National Technical Meeting*, Anaheim, CA, p. 813-825, January 1995.
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123. Boylston, A., J.A. Gaebler, and P. Axelrad, "Extracting CubeSat Relative Motion Using In Situ Deployment Imagery," *Proceedings of the 42<sup>nd</sup> AAS Rocky Mountain Section Guidance and Control Conference 2019*, Advances in the Astronautical Sciences, Vol. 169, Breckenridge, CO, AAS 19-016, pp. 59-68, February 3, 2019.
124. Loria, E., J. Mashburn, A. O'Brien, P. Axelrad, C. Zuffada, Z. Li, and B. Haines, Towards an Ocean Altimetry Product Using CYGNSS," *Proceedings of IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, Yokohama, Japan, pp. 8700-8702, July 2019.
125. Gaebler, J.A. and P. Axelrad, "Track Initiation for CubeSat Cluster Deployment Tracking," *2019 AAS/AIAA Astrodynamics Specialist Conference*, Portland, ME, AAS 19-862, 11 pages, August 2019.
126. Van Buren, D., S. Palo, P. Axelrad, "Simulation of a High Stability Reference Clock for Small Satellites with Modeled GPS Timing Errors," *Proceedings of the AIAA/USU Conference on Small Satellites*, SSC19-XII-03, 11 pages, <http://digitalcommons.usu.edu/smallsat/2019/all2019/159>, August 2019.
127. Mutschler, S., P. Axelrad, T. Matsuo, E. Sutton, "Physics-based Approach to Density Estimation and Prediction using Orbital Debris Tracking Data," *AMOS – Advanced Maui Optical and Space Surveillance Technologies Conference*, Maui, HI, September 17-20, 2019.
128. Strandjord, K.L., P. Axelrad, D.M. Akos, S. Mohiuddin, "Improved Urban Navigation with Direct Positioning and Specular Matching," *Proceedings of the 2020 International Technical Meeting of The Institute of Navigation*, San Diego, CA, pp. 787-800, January 21-24, 2020.
129. Rybak, M.M., P. Axelrad, J. Seubert, T. Ely, "Estimation of Thermal and Stochastic Variations of Chip Scale Atomic Clocks for Navigation of a Lunar CubeSat," *Proceedings of the 51<sup>st</sup> Precise Time and Time Interval Systems Meeting*, San Diego, CA, pp. 221-233, <https://doi.org/10.33012/2020.17302>, January 21-24, 2020.
130. Khatri, Y., A. Aboaf, D. Dowd, C. Flood, H. Dixon, P. Axelrad, "CSAC Flight Experiment to Characterize On-Orbit Performance," *Proceedings of the AIAA/USU Conference on Small Satellites*, SSC20-XIII-03, <https://digitalcommons.usu.edu/smallsat/2020/all2020/46/>, August 2020.
131. Conrad, A., P. Axelrad, C. Zuffada, B. Haines, A. O'Brien, E. Loria, "Improved Orbit Determination of the CyGNSS Satellites and Its Application to GNSS-R Ocean Altimetry", forthcoming *IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, September 27 – October 2, 2020 (Virtual).
132. Conrad, A., P. Axelrad, C. Zuffada, B. Haines, A. O'Brien, E. Loria, "Improved Single Frequency Orbit Determination for the CYGNSS Spacecraft," *Proceedings of the 33rd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2020)*, pp. 3875-3887, September 2020.

**Other Publications**

1. Axelrad, P., Near-Earth Orbit Determination and Rendezvous Navigation Using GPS, Master's Thesis, MIT, 1986.
2. Parkinson, B.W. and P. Axelrad, "Techniques for Autonomous GPS Integrity Monitoring," AGARDograph No. 314, *Analysis, Design and Synthesis Methods for Guidance and Control Systems*, p. III-1-18, 1990.
3. Axelrad, P., *A Closed-Loop GPS-Based Orbit Trim System for Gravity Probe B*, Ph. D. Dissertation, Stanford University, 1990.
4. Axelrad, P., Invited essay for "Directions'96" Issue of *GPS World Magazine*, p. 50, December, 1995.
5. Online : "Ten Lessons on Navigation" Authored by Jeffery White, Matt Lippis, Mindy Schaefer Zarske, Penina Axelrad, Janet Yowell. <http://www.ion.org/satdiv/education.cfm>
6. Axelrad, P. and K.M. Larson, "GNSS Solutions: Is it true that the GPS satellite geometry repeats every day shifted by 4 minutes?" *InsideGNSS Magazine*, p. 16-17, July/August 2006.
7. Axelrad, P., J. Donna, M. Mitchell, S. Mohiuddin, "Collective Detection - Enhancing GNSS Receiver Sensitivity by Combining Signals from Multiple Satellites," *GPS World Magazine*, p. 58-64, January 2010.
8. Axelrad, P. AIAA Member Spotlight Interview, November 2015.
9. Axelrad, P. and J. Gaebler, "Specialized FISST-based Estimation Methods to Enhance Space Situational Awareness in MEO and GEO Orbits," Technical Report AFRL-RV-PS-TR-2016-0114, August 2016.
10. Strandjord, K.L., P. Axelrad, D. Akos, S. Mohiuddin, "Going Direct: Improved Accuracy from Reflected Signals and Path Predictions," *Inside GNSS Magazine*, <https://insidegnss.com/strandjord/>, April 6, 2020.

**Invited Talks, Seminars and Colloquia (since 2000)**

1. Invited speaker at the Institute for Mathematics and Its Applications, University of Minnesota, IMA "HOT TOPICS" workshop on Mathematical Challenges in Global Positioning System, "Retrieval of Ocean and Land Surface Characteristics Using Measurements of Reflected GPS Signals," August 18, 2000.
2. Invited lecture at Stanford University, "Remote Sensing of Ocean Surfaces Using Bistatic GPS," February 14, 2001.
3. University of Colorado, Faculty Teaching Excellence Program, "Establishing a Teaching Portfolio," March 2001.
4. University of Colorado, College of Engineering and Applied Science Orientation, Faculty Keynote Address, August 23, 2006.
5. Invited speaker for ZONTA Foothills Club, Amelia Earhart Dinner, "On encouraging young women to study science, math, and engineering," Broomfield, CO, January 28, 2007.
6. Invited tutorial seminar "Introduction to Global Navigation Satellite Systems," at 32st Annual Time and Frequency Metrology Seminar, NIST, Boulder, CO, June 14, 2007.
7. "GNSS Applications for Science and the Environment," 2<sup>nd</sup> International Summer School on GNSS, Berchtesgaden, Germany, July 30, 2008.
8. Invited speaker for Stanford University Department of Aeronautics and Astronautics 50<sup>th</sup> Anniversary Symposium, "Challenges and Opportunities in Aerospace Education," Palo Alto, CA, May 10, 2008.
9. Invited speaker for National Academy of Engineering / Chinese Academy of Sciences GNSS Workshop, "Application of GNSS to Environmental Studies," Shanghai, China, May 2011.
10. Invited speaker for 2<sup>nd</sup> Smead Fellow Workshop, "GPS Collective Detection – a new approach for making a little signal go a long way," Vail, CO, May 10, 2012.
11. Invited speaker Georgia Institute of Technology, "How GPS Changes Everything," January 31, 2013.
12. Invited speaker at NASA JPL, "University of Colorado Boulder (CU) Overview of Research & Educational Programs in Aerospace Engineering and Sciences," December 17, 2013.
13. Keynote Speaker, GNSS Futures in the Asia-Pacific Region Workshop at UNSW Australia, July 8, 2014.

14. Invited speaker University of Kansas, “How GPS Changes Everything,” February 9, 2015.
15. Invited speaker University of Michigan, “How GPS Changes Everything,” February 26, 2015.
16. Invited speaker Texas A&M, “How GPS Changes Everything,” April 9, 2015.
17. Invited speaker International Technical Symposium on Navigation and Timing (ITSNT), “Space Applications of GNSS,” ENAC, Toulouse, November 15, 2016.
18. Invited speaker University of Illinois Urbana-Champaign, “GPS Reflections,” November 28, 2016.
19. Invited Panel Member, EDU-01: Panel Session. Educating the Engineer of the 2030. Wednesday, AIAA SciTech, January 11, 2017.
20. Invited luncheon speaker for ZONTA Foothills Club, “How GPS Changes Everything,” Boulder, CO, January 28, 2017.
21. Invited plenary lecture 59<sup>th</sup> Israel Annual Conference on Aerospace Sciences (IACAS), “Scientific Applications of Global Navigation Satellite Systems,” Tel Aviv, Israel, March 6, 2019.
22. Invited speaker University of Texas Austin, “GNSS Reflections – Modeling multipath for space applications and utilizing reflections for remote sensing,” Austin, TX, January 30, 2020.

#### Conference & Workshop Presentations and Posters (*without papers*)

1. Burkert, J., P. Axelrad, L. Cornman, K Goodrich, Scott Palo, Andrew Weekley, "Turbulence Estimation Techniques for COSMIC Occultation Data," Fourth FORMOSAT-3/COSMIC Data Users Workshop, Boulder, CO, 28 October, 2009.
2. Mashburn, J., P. Axelrad, S. T. Lowe, K. M. Larson, V. Zlotnicki, “An Assessment of the Accuracy of Altimetry Retrievals for the Monterey Bay GNSS+R Experiment”, *GNSS+R 2015 Workshop*, Potsdam, Germany.
3. Mashburn, J., P. Axelrad, K. Larson, S. Lowe, “TechDemoSat-1 Land Altimetry and Sea Ice Boundary Detection,” USNC-URSI National Radio Science Meeting, Boulder, CO, January 4, 2017.
4. Mashburn, J., P. Axelrad, S. Lowe, and K.M. Larson, “TDS-1 Global Ocean Altimetry and Sea Ice Boundary Zone Detection,” *GNSS+R 2017 Workshop*, Ann Arbor, MI, May 25, 2017.
5. Strandjord, K. and P. Axelrad, “Improved Prediction of GPS Satellite Clock Variations Based on Daily Repeat,” *ION Joint Navigation Conference*, Dayton, OH, June 6, 2017.
6. Mashburn, J., P. Axelrad, S. T. Lowe, C. Zuffada, D. Masters, "Ocean Surface Altimetry with CYGNSS: A Case Study in Indonesia", *Ocean Surface Topography Science Team Meeting*, poster, Miami, FL, October 23-27, 2017.
7. Mashburn, J., P. Axelrad, S. Lowe, C. Zuffada, D. Masters, “Ocean Surface Altimetry with CyGNSS: An Updated Case Study in Indonesia,” American Meteorological Society Annual Meeting, Austin, TX, January 10, 2018.
8. Axelrad, P. and J. Gaebler, “CubeSat Deployment Tracking,” FAA COE/CST RA1 Workshop on Space Traffic Management and Space Environment,” McLean, VA, February 6, 2018.
9. Mashburn, J., P. Axelrad, K. Larson, C. Zuffada, S. Lowe, “Ocean Surface Altimetry with GNSS-R utilizing data from CyGNSS,” 4<sup>th</sup> International Conference on GPS Radio Occultation, Taipei, Taiwan, April 16, 2018.
10. Mashburn, J., P. Axelrad, C. Zuffada, S. Lowe, G. Hajj, B. Haines, R. Shah, A. O’Brien, E. Loria, “Ocean Surface Altimetry with GNSS-R utilizing data from CyGNSS,” CYGNSS Science Team Meeting, Ann Arbor, MI, June 2018.
11. Mutschler, S., P. Axelrad, T. Matsuo, J. Anderson, “An Ensemble Kalman Filtering Approach for Atmospheric Density Estimation Using Orbital Debris,” 42nd COSPAR Scientific Assembly, Pasadena, CA, July 2018.
12. E. Loria, J. Mashburn, A. O’Brien, P. Axelrad, and C. Zuffada, “Assessment of a CYGNSS Ocean Altimetry Product Using a Full DDM Approach,” 2019 IEEE Specialist Meeting on Reflectometry using GNSS and other Signals of Opportunity, Benevento, Italy, 20-22 May 2019.
13. Mutschler, S., P. Axelrad, T. Matsuo, E. Sutton, “Physics-based Approach to Density Estimation and Prediction using Orbital Debris Tracking Data,” (Poster), CEDAR Workshop, Santa Fe, NM, June 2019.



14. Conrad, A., P. Axelrad, C. Zuffada, B. Haines, L. Sparks, A. O'Brien, E. Loria, "CYGNSS Altimetry with Improved Orbits, Re-tracking, and Delay Offsets," CYGNSS Science Team Meeting, Pasadena, CA, January 21, 2020.

**Courses Taught** (*most recent year shown*)

Introduction to Dynamics and Systems ASEN2003 (University of Colorado, 2020)

Sophomore core course on 2-D dynamics, vibrations, and systems. Includes experimental and design laboratories, group problem solving, traditional lecture, and interactive learning classes (5 credits).

Orbital Mechanics and Attitude Dynamics ASEN3200 (University of Colorado, 2020)

Junior core course on two body orbits, attitude dynamics and control. Includes experimental and design laboratories, group problem solving, traditional lecture, and interactive learning classes (4 credits).

Introduction to Global Navigation Satellite Systems ASEN 5090 (University of Colorado, 2020)

Graduate level course introducing key technologies of GPS to Aerospace, Electrical, Civil Engineering and Physics students.

Spacecraft Attitude Dynamics and Control ASEN 5010 (University of Colorado, 2012)

Graduate level course covering attitude representations and estimation, kinematics, dynamics, and control of 3D rigid body motion.

Aerospace Senior Projects ASEN4018/4028 (University of Colorado, 2019)

Senior capstone design course member of Project Advisory Board or Project Sponsor  
AY18-19 VANTAGE Team Sponsor - 2<sup>nd</sup> prize in Frank J. Redd Student Paper Competition  
AY19-20 VISION Team Sponsor

Aerospace Graduate Projects ASEN5018/6028 (University of Colorado, AY2020-2021)

Spring 2019-present – Satellite Timing System Testbed, Funded by AFRL Space Vehicles Directorate

Aerospace Electronics and Communications ASEN3300 (University of Colorado, 2003)

Junior core course introducing basics of analog and digital electronics, computer interfacing, and communications, focusing on hands-on learning and use of laboratory instruments. Includes experimental laboratories, traditional lecture, and interactive learning classes (4 credits).

First Year Engineering Projects GEEN1400 (University of Colorado, 1996)

General Engineering freshman level course providing hands-on experiences in analysis, design, and technical writing.

Radio and Inertial Navigation (University of Colorado, Stanford University, 1995)

Graduate level course on technologies and algorithms for navigation and positioning.

### Ph.D. Graduates, University of Colorado Boulder

1. Bruce C. Chesley, 1995 – Boeing Network and Space Systems, El Segundo, CA  
Dissertation – *An Integrated GPS Attitude Determination System for Small Satellites*
2. Lisa M. Ward, 1996 – Ball Aerospace, Boulder, CO  
Dissertation – *Spacecraft Attitude Estimation Using GPS: Methodology and Results*
3. Christopher J. Comp, 1996 – Digital Globe, Longmont, CO  
Dissertation – *GPS Carrier Phase Multipath Characterization and a Mitigation Technique Using the Signal-to-Noise Ratio*
4. James L. Garrison, 1997 – Professor of Aeronautics and Astronautics, Purdue University, West Lafayette, IN  
Dissertation – *Recursive Nonlinear Estimation for Relative Navigation in Elliptical Orbits*
5. Charles P. Behre, 1997 – ITT, Los Angeles, CA  
Dissertation – *GPS Based Attitude Algorithms for Low Cost Satellite Missions*
6. Angela (Reichert) Dorsey, 1999 – Jet Propulsion Laboratory, Pasadena, CA  
Dissertation – *Correction Algorithms for GPS Carrier Phase Multipath Utilizing the Signal-to-Noise Ratio and Spatial Correlation*
7. Franklin Ascarunz, 1999 – Founder SpectraDynamics Inc, Louisville, CO  
Dissertation – *Timing Errors in Two-Way Satellite Time and Frequency Transfer Using Spread Spectrum Modulation*
8. Dolan Highsmith, 2000 – Aerospace Corporation, Chantilly, VA  
Dissertation – *Precise Satellite-to-Satellite GPS Time Transfer in Near Real-Time*
9. Michael Armatys, 2001 – Rockwell Collins, Cedar Rapids, IA  
Dissertation – *Estimation of Sea Surface Winds Using Reflected GPS Signals*  
*NASA GSRP, 1998-2000*
10. Michael Moreau, 2001 – NASA Goddard Space Flight Center, Greenbelt, MD  
Dissertation – *GPS Receiver Architecture for Autonomous Navigation in High Earth Orbits*  
*NASA Graduate Student Research Program Fellowship, 1997-2000*
11. Premal Madhani, 2002 – Master Engineer with Broadcom, San Jose, CA  
Dissertation – *GPS Receiver Algorithms for Suppression of Narrowband and Structured Wideband Interference*
12. Dallas Masters, 2004 – GNSS-R Product Manager, Spire Global Inc, Boulder, CO  
Dissertation – *Surface Remote Sensing Applications of GNSS Bistatic Radar : Soil Moisture and Aircraft Altimetry*  
*John A. Vise Student Excellence Award 2003, NASA GSRP 2000-2004*
13. Maria Belmonte Rivas, 2007 – Research Scientist, TU Delft, Netherlands  
Dissertation – *Bistatic Scattering of Global Positioning System Signals from Arctic Sea Ice*  
*Zonta Foundation Amelia Earhart Fellowship 2004/2005, NASA Earth Systems Graduate Researcher 2004 - 2007*
14. Jan-Peter Weiss, 2007 – UCAR Cosmic Program, Boulder, CO  
Dissertation – *Modeling and Analysis of Multipath in Global Navigation Satellite System Ranging Signals*  
*John A. Vise Student Excellence Award 2007, NSF East Asia and Pacific Summer Institute Fellowship, 2006*
15. Christopher Lane, 2007 – Enterprise Architect, Chick-fil-A, Atlanta, GA  
Dissertation – *Formation Design and Relative Navigation in High Earth Orbits*  
*AIAA Graduate Student Researcher Award 2006*
16. Jill (Tombasco) Seubert, 2011 – Space Navigator, Jet Propulsion Laboratory, Pasadena, CA  
Dissertation – *Orbit Estimation of Geosynchronous Objects Via Ground-Based and Space-Based Optical Tracking*  
*Zonta International Foundation Amelia Earhart Fellowship 2010, National Defense Science and Engineering Graduate Fellowship 2007-2010, John A. Vise Student Excellence Award 2011, AIAA Orville and Wilbur Wright Graduate Award 2011, College of Engineering and Applied Science Distinguished Recent Alumni Award 2017*
17. Ben K. Bradley, 2015 – Jet Propulsion Laboratory, Pasadena, CA  
Dissertation - *Numerical Algorithms for Precise and Efficient Orbit Propagation and Positioning*  
*National Defense Science and Engineering Graduate Fellowship 2010-2012, eSpace Entrepreneurship Award 2012, CU-Boulder Summer Dissertation Fellowship 2014*

18. Steven Gehly, 2016 – Research Scientist in Space Surveillance, University of New South Wales, Canberra, Australia  
Dissertation - *Estimation of Geosynchronous Space Objects Using Finite Set Statistics Filtering Methods*
19. Jake R. Mashburn, 2019 - Senior Navigation Algorithms Engineer, Draper, Cambridge, MA  
Dissertation – *Analysis of GNSS-R Observations for Altimetry and Characterization of Earth Surfaces*  
Co-Advised with Kristine Larson  
*UCAR Student Travel Grant 2018*
20. John Gaebler, 2020 – Research Aerospace Engineer, Air Force Maui Optical & Supercomputing Site  
Dissertation – *CubeSat Cluster Deployment Tracking*  
*AFRL Space Scholar Summers 2016, 2017, 2019, CU Boulder Graduate Student Travel Grant 2017, GAANN Fellowship Fall 2019.*
21. Viliam Klein, 2020 – Southwest Research Institute  
Dissertation - *Advanced GPS Multipath Modeling for Receivers On-Board the International Space Station*  
*ION GNSS+ 2020 Best Presentation in Session Award*
22. Kirsten Strandjord, 2020 - Postdoctoral Research Associate CU Boulder  
Dissertation – *Urban Navigation with Global Satellite Navigation Systems*  
*Draper Fellow 2018-current, John A. Vise Graduate Student Excellence Award 2019, Lockheed Martin Corporation Endowed Graduate Fellowship 2019*
23. Damon VanBuren, 2020 (co-advised with Prof Scott Palo)- Consultant  
Dissertation – *Techniques for Precise Timing Onboard Small Satellites*

#### **M.S. Graduates (With thesis), University of Colorado Boulder**

1. Anne Theurkauf, 2020 (co-advised by Dana Anderson, Physics), January 2019, Thesis Defense 4/10/20  
*Draper Fellow 2018-current*

#### **M.S. Graduates (Research but no thesis), University of Colorado Boulder**

1. Jiyun Lee, 1999 - Associate Professor, Korea Advanced Institute of Science and Technology
2. Eden (Denton) Speed, 2001 – Lockheed Martin, Boulder, CO
3. Lisa (Reeh) Turner, 2002 – Lockheed Martin, Denver, CO
4. Cove Sturtevant, 2004 – NSF Neon, Boulder, CO
5. Lin Song Stowe, 2006 – MIT Lincoln Laboratory, MA
6. Steven Brown, 2008 – Infinity Systems Engineering, Colorado Springs, CO
7. Julian Greene, 2009 – Blue Origin, Seattle, WA
8. James Burkert, 2010 – Lockheed Martin, Denver, CO  
*NASA GSRP 2008-2010*
9. Bruno Lesage, 2012 – Lockheed Martin, Valley Forge, PA
10. Jeanette Veldman, 2016 – Ball Aerospace, Boulder, CO
11. Jeff Jenkins 2019 – Rincon Research Inc, Tucson, AZ

#### **Other Graduate Research Students, University of Colorado Boulder**

1. Jonah Kisesi, 2010-2012 – GNSS occultations for sensing ionospheric turbulence  
*NSF GK-12 Fellowship AY2011-12*
2. Stephen Phillips, 2012-2013 – Modeling of autonomous rendezvous and docking
3. John Pratt, PhD 2010-2012 – Clock estimation for iGPS
4. Heather LoCrao, 2013-2014 - Autonomous rendezvous and docking for commercial space transportation
5. Elliot Barlow, 2009-2016 – GPS radio occultation satellites  
*Department of Education, Graduate Assistantship in Areas of National Need (GAANN) Fellowship 2010-2011, ION Best Presentation Award 2014.*
6. Eric Barron, 2016-2017 – Satellite clock modeling

### Undergraduate Research Students, University of Colorado Boulder

1. Samantha Krenning, 2009 – Undergraduate research assistant, Weak Signal Acquisition
2. Jordan Gomez, 2010 – Undergraduate research assistant, Weak Signal Acquisition
3. Jacob Varey, 2010-2011 - Discovery Learning Apprentice and Undergraduate Research Opportunity
4. Nicholas DiOrio, 2011-2012 – Undergraduate research assistant and Discovery Learning Apprentice
5. Zachary Cuseo 2012-2013 – BS/MS Student, Discovery Learning Apprentice and undergraduate research assistant
6. Alex Mault, Spring 2013 - Undergraduate research assistant, GPS acquisition software
7. Isaac Hayden, summer 2013 - Undergraduate research assistant, Picosat positioning
8. David Thomas, summer 2013 - Undergraduate research assistant, Multipath modeling
9. Thomas Green, 2013-2014 - Undergraduate research assistant, GPS bistatic radar data analysis
10. Caleb Lipscomb, 2013-2014 – Undergraduate Discovery Learning Assistant, Image processing for autonomous rendezvous and docking
11. Davis Peterson, 2015-2016 - Undergraduate Discovery Learning Assistant, Long term GPS orbit evolution
12. Michael Greene, Spring 2017 – Undergraduate research assistant, ArcGIS
13. Diana Mata, Summer 2018 – CU Summer Program for Undergraduate Research (SPUR), Simulating Space Object Measurements for Space Situational Awareness
14. Adam Boylston, Summer-Fall 2018 – Undergraduate research assistant, CubeSat image processing for relative position estimation after deployment, *2019 AAS Breckenridge Conference Student Session 2<sup>nd</sup> Place Award*
15. Connor Ott, 2018-2019 - Undergraduate Discovery Learning Assistant, Visualization tools for space environment situational awareness

### Visiting Students, University of Colorado Boulder

1. Estel Cardellach Gali – Visiting PhD student from Institut d'Estudis Espacials de Catalunya (IEEC-CSIC), 2003
2. Lennox Thompson – RESESS Program (UNAVCO), Undergraduate at Coppin State University, Baltimore, MD, 2006
3. Michael Williams – SMART Program, Undergraduate at UC Irvine, 2004
4. Johan Bejeryd – Visiting MS student from the Institute of Technology of Linkoping University, Sweden, 2008
5. Joseph Meilen – Visiting High School intern, 4 weeks, Summer 2009
6. Antonella Albuja – SMART Program, Undergraduate at University of Iowa, 2010
7. Fabien Gachet – Visiting MS student from Institut Supérieur de l'Aéronautique et de l'Espace, France, 2011
8. Rene van Aken – MS thesis student from the University of the Federal Armed Forces Munich, 2013
9. Nicholas Sweet – Visiting undergraduate student from Concordia University, Canada, 2013
10. Javier Garcia – Fulbright Fellowship PhD student from National University of La Plata, Argentina, 2014-2015
11. Santiago Ozafrain – Fulbright Fellowship PhD student from National University of La Plata, Argentina, Fall 2018

### Current Students

1. Shaylah Mutschler – PhD Candidate, August 2015, Preliminary Exam 9/2017, Comprehensive Exam 12/2019  
*H.J. Smead Scholar 2015-current, AFRL Space Scholar Summer 2016, 2017, NSF Graduate Research Fellowship Program 2017 (Selected but declined), National Defense Science and Engineering Graduate Fellowship 2017-2020, Zonta International Foundation Amelia Earhart Fellowship 2020*
2. Margaret Rybak – PhD Candidate, January 2016, Preliminary Exam 9/2017, Comprehensive Exam 4/2020  
*NASA Education Aeronautics Scholarship and Advanced STEM Training and Research (AS&ASTAR) Harriet Jenkins Fellowship, 2016-present, Aerospace Engineering Sciences Outstanding Teaching Assistant AY2016-2017*
3. Alex Conrad – PhD Student, June 2019, Preliminary Exam 8/2020
4. Henry Dixon – MS Student (Mechanical Engineering), January 2019
5. Christopher Flood – PhD Student, August 2019, Preliminary Exam 8/2020  
*CU College of Engineering and Applied Science Dean's Assistantship AY19-20*
6. Luciana Schement – MS Student, June 2020
7. Laura Davies – PhD Pre-candidate, August 2020
8. Caroline Dixon – Undergraduate research assistant, September 2020
9. Stephen Albert – Discovery Learning Assistant, August 2020

**PhD and MS Thesis Committee Memberships (not tracked prior to 2010)**

1. Eric Vinande - Ph.D. AES, 2010, Prof. Akos, *CU Boulder*
2. James McDonald - Ph.D. ECE, 2010, Prof. Filipovic, *CU Boulder*
3. Ravi Inampudi – Ph.D. AES, 2010, Prof. Schaub, *CU Boulder*
4. Marcus Holzinger - Ph.D. AES, 2011, Prof. Scheeres, *CU Boulder*
5. Nicholas Pedatella - Ph.D. AES, 2011, Prof. Larson, *CU Boulder*
6. Robin Blendan – M.S. AES, 2011, Prof. Schaub, *CU Boulder*
7. Samantha Krenning – M.S. AES, 2011, Prof. Schaub, *CU Boulder*
8. Carl Seubert - Ph.D. AES, 2011, Prof. Schaub, *CU Boulder*
9. Erez Falkenstein – Ph.D. ECE, 2011, Prof. Popovic, *CU Boulder*
10. Kohei Fujimoto – Ph.D. AES 2013, Prof. Scheeres, *CU Boulder*
11. Stephanie Jones – M.S. AES, 2013, Prof. Schaub, *CU Boulder*
12. Jian Yao – Ph.D. Physics, 2014, Prof. Levine, *CU Boulder*
13. Rui Sun – Ph.D. Aerospace Engineering, 2014, Prof. Dr. E. Gill, *Technical University of Delft*
14. Erin Griggs – Ph.D. AES, 2015, Prof. Akos, *CU Boulder*
15. Steven O’Keefe – Ph.D. AES, 2015 Prof. Schaub, *CU Boulder*
16. John Pratt – Ph.D. AES, 2015, Prof. Larson, *CU Boulder*
17. Chen Cao – Ph.D. AES, 2016, Prof. Chu, *CU Boulder*
18. Ryan Handzo – Ph.D. Student AES, Prof. Parker, Comprehensive Exam 11/1/13, *CU Boulder*
19. Daniel (Stu) Bryant – Ph.D. AES, 2017 Prof. Jones, *CU Boulder*
20. Jeroen Geeraert – Ph.D. AES, 2017, Prof. McMahon, *CU Boulder*
21. Erin Kahr – Ph.D. Geomatics Engineering, 2017, Prof. K. O’Keefe, *University of Calgary*
22. Sara Hrbek – Ph.D. AES 2019, Prof. Akos, *CU Boulder*
23. Manuel Eichelberger – Ph.D. External Examiner, 2019, Prof. Dr. R. Wattenhofer, *ETH Zurich*
24. William McGrew – Ph.D. Physics 2020, Dr. S. Diddams, *CU Boulder*
25. Joanna Fulton – Ph.D. AES 2020, Prof. Schaub, *CU Boulder*
26. Andrew French – Ph.D. AES 2020, Prof. McMahon, *CU Boulder*
27. Damian Miralles – Ph.D. Candidate AES, Prof. Akos, Comprehensive Exam 12/12/18, *CU Boulder*
28. Brian Breitsch – Ph.D. Candidate AES, Prof. Morton, Comprehensive Exam 4/3/20, *CU Boulder*
29. Marielle Pellegrino – Ph.D. Candidate AES, Prof. Scheeres, Comprehensive Exam 6/19/20, *CU Boulder*
30. Yang Wang – Ph.D. Candidate AES, Prof. Morton, Comprehensive Exam 8/4/20, *CU Boulder*
31. Yunxiang (Leo) Liu – Ph.D. Candidate AES, Prof. Morton, Comprehensive Exam 8/12/20, *CU Boulder*
32. Ian Collett – Ph.D. Candidate AES, Prof. Morton, Comprehensive Exam 10/16/20, *CU Boulder*