Ethan R. Burnett

Email: ethanryan.burnett (at) polimi.it U.S. Citizen

EDUCATION

Ph.D., Aerospace Engineering Sciences Aug 2018 – Oct 2021
University of Colorado, Boulder
Advisor: Dr. Hanspeter Schaub
Dissertation topic: Guidance and control for spacecraft formation flying and rendezvous (PDF link)

M.S., Aerospace Engineering Aug 2016 – May 2018
University of Arizona
Advisor: Dr. Eric Butcher

B.S., Aerospace Engineering and *Minor*, Physics Aug 2012 – May 2016
University of Arizona

SPECIALIZATION

An interdisciplinary researcher with interests in spaceflight and space science, my work history spans from aerospace vehicle guidance & control (particularly for spacecraft rendezvous) to planetary science. In my current project I am developing computationally efficient methods for autonomous spacecraft guidance.

SELECTED AWARDS

Accepted research funding:
- Marie Skłodowska-Curie Actions Postdoc Fellowship, European Commission, €172750 / 2 yr 2022
- DoD National Defense Science and Engineering Graduate Fellowship (NDSEG), $161066/ 3 yr 2018

Declined research funding:
- NRC Postdoc Fellowship, U.S. Air Force Science & Technology Fellowship Program $79542/yr 2022
- National Science Foundation Graduate Research Fellowship Program (GRFP) $32000/yr × 3 2018

Academic / Travel / other:
- Travel Award, International Workshop on Satellite Constellations & Formation Flying, £500 2019
- Dean's Fellowship, Department Scholarship (CU Boulder), total of $9000 2018
- Theodore H. Troller Memorial Scholarship (University of Arizona), $1759 2017
- Third Place, AAS Student Team Competition: Mission Design to Asteroid 2016 HO3, $500 2017
- National Merit Scholar (Top 0.5% of scores in PSAT national standardized test), $16000/yr×4 2012

EXPERIENCE

Marie Skłodowska-Curie Postdoctoral Fellow, July 2023 – present
Politecnico di Milano Dipartimento di Scienze e Tecnologie Aerospaziali (DAER)
- Funded by the European Commission, and hosted in Prof. Francesco Topputo's DART Lab
- MSCA is the European Union's flagship fellowship program for excellent research
- Project: FAAST, On-board orbit guidance for interplanetary CubeSats
- Additional collaboration re: tidal modeling in binary asteroid systems; Hera Science Working Group 3

Engineer - Avionics, Instruments & GNC II, April 2022 – July 2023
Blue Origin Space Systems Development
- ADP Flight Sciences - Guidance and Control group - supporting Advanced Technology (2022)
- Space Systems Development - Guidance/RPOD group - on loan to Lunar Transportation (2023)
- Project: Robust drift-safe spacecraft rendezvous guidance (LEO and NRHO); linear covariance applications, uncertainty quantification
- Technical interchanges with NASA Johnson Space Center under a Space Act agreement

Planetary Science Affiliate, May 2022 – present
Laboratory for Atmospheric and Space Physics (LASP) SCI/Planetary
- Sponsor: Paul Hayne
- Research topics: Europa tectonics, geology, tidal dissipation, and spin-orbit coupling

INTERNSHIPS & EARLY CAREER

NASA Jet Propulsion Laboratory Summers 2020, 2021
Section 347D: Robotics Modeling and Simulation Visiting Researcher
- Guidance and Control for ADEPT drag device for SmallSat aerocapture, using DSENDS

Planetary Science Summer School Participant
- Simulated pre-phase A design study for New Frontiers Enceladus mission, org. by JPL Team X.
- Propulsion design, Science team (co-developed 1 of 4 science goals), Engineering team.

U.S. Air Force Research Laboratory Summers: 2016, 2017, 2018
Space Vehicles Directorate, Kirtland AFB, Albuquerque, NM Space Scholar, SFFP
- Novel techniques for spacecraft formation/orbit control and estimation.
- Supervisors: Dr. Andrew Sinclair (2017 & 2018), Dr. T. Alan Lovell (2016)

Apollo Robotic Systems May 2015 – May 2016
Startup Office, Tucson, AZ Robotics Engineer
- Tech startup. Developed programs and hardware for autonomous UAV landing control.

JOURNAL PAPERS

Profiles: Google Scholar | ORCID Daggers† differentiate planetary science articles from engineering

(J11) **E. Burnett** and F. Topputo, "Rapid nonlinear convex guidance using a monomial method". Journal of Guidance, Control, and Dynamics. *Submitted May 2024. Under review.*
https://arxiv.org/abs/2403.19324v2

(J10) S. Albert, **E. Burnett**, H. Schaub, P. D. Burkhart, and A. Austin, "Energy Reference Guidance for Drag-Modulated Aerocapture". Advances in Space Research. Accepted 09/16/2023.
https://doi.org/10.1016/j.asr.2023.09.034

†(J9) **E. Burnett** and P. Hayne, "Spin-Orbit Coupling of Europa's Ice Shell and Interior," Icarus (2023) 115731. Online 08/02/2023.
https://arxiv.org/abs/2302.13226 https://doi.org/10.1016/j.icarus.2023.115731

†(J8) K. Marshall Seaton, Szilárd Gyalay, Gaia Stucky de Quay, **E. Burnett**, C. Adeene Denton, Bryce Doerr, Kamak Ebadi, Stephanie Eckert, Ian T. W. Flynn, Casey I. Honniball, Shayna Hume, Corbin L. Kling, Julian C. Marohnic, Julia Milton, Claire A. Mondro, Raquel G. Nuno, Caoimhe M. Rooney, Beck E. Strauss, Alfred Nash, and Jennifer E. C. Scully, "Astrobiology eXploration at Enceladus (AXE): A New Frontiers Mission Concept Study," Planetary Science Journal. Published 06/29/2023.
https://doi.org/10.3847/PSJ/acd119

(J7) **E. Burnett** and H. Schaub, 'Spacecraft Relative Motion Dynamics and Control Using Fundamental Modal Solution Constants". Journal of Guidance, Control, and Dynamics. Online 08/31/2022.
https://arxiv.org/abs/2112.02678 https://doi.org/10.2514/1.G006603

(J6) **E. Burnett** and H. Schaub, "Approximating Orbits in a Rotating Gravity Field with Oblateness and Ellipticity Perturbations," Celestial Mechanics and Dynamical Astronomy. Online 01/20/2022.
https://arxiv.org/abs/2108.09607 https://doi.org/10.1007/s10569-022-10061-z

(J5) **E. Burnett** and H. Schaub, "Geometric Perspectives on Fundamental Solutions in the Linearized Satellite Relative Motion Problem," Acta Astronautica 190 (2022), pp. 48-61. Online 10/06/2021.
https://arxiv.org/abs/2108.09608 https://doi.org/10.1016/j.actaastro.2021.09.028

†(J4) **E. Burnett** and P. Hayne, "Europa's Hemispheric Color Dichotomy as a Constraint on Non-synchronous Rotation," Icarus 364 (2021) 114438. Online 03/29/2021.
https://arxiv.org/abs/2003.06680 https://doi.org/10.1016/j.icarus.2021.114438

(J3) **E. Burnett** and H. Schaub, "Spacecraft Formation and Orbit Control Using Attitude-Dependent Differential Solar Radiation Pressure," Advances in Space Research 67 (2021), 3396-3408. Online 04/12/2020.
https://doi.org/10.1016/j.asr.2020.03.047

(J2) **E. Burnett** and H. Schaub, "Study of Highly Perturbed Spacecraft Formation Dynamics via Approximation," Advances in Space Research 67 (2021), 3381-3395. Online 03/21/2020.
https://doi.org/10.1016/j.asr.2020.02.030

(J1) **E. Burnett**, A. J. Sinclair, and C. C. Fisk, "Unit Sphere-Constrained and Higher Order Interpolations in Laplace's Method of Initial Orbit Determination," Journal of Astronautical Sciences 67 (2020), 1116-1138. Online 11/11/2019.
https://doi.org/10.1007/s40295-019-00196-x

CONFERENCES – FULL PROCEEDINGS

For a partial repository: https://hanspeterschaub.info/conferences.html (Search "Burnett")

(C19) A. W. Berning, **E. Burnett**, and S. Bieniawski, "Chance-Constrained, Drift-Safe Guidance for Spacecraft Rendezvous", Blue Origin work, 2023 AAS Rocky Mountain GNC Conference. https://arxiv.org/abs/2401.11077

(C18) **E. Burnett**, S. Albert, and H. Schaub, "A New Guidance Technique for Discrete-Event Drag Modulation for Aerocapture Missions," 2022 AAS Rocky Mountain GNC Conference.

(C17) **E. Burnett** and H. Schaub, "Spacecraft Relative Motion Dynamics and Control Using Fundamental Solution Constants," 2022 AIAA SciTech Forum: Spaceflight Mechanics Group. https://doi.org/10.2514/6.2022-2462

(C16) M. J. Grace, **E. Burnett** and J. McMahon, "Quasi-Initial Conditions as a State Representation for Aerocapture," 2022 AIAA SciTech Forum: Hypersonic and Spacecraft Flight Mechanics Group. https://doi.org/10.2514/6.2022-1652

(C15) A. J. Sinclair, Scott Norrix, **E. Burnett**, and E. A. Butcher, "Coordinate-Invariant Kalman Filtering," 2022 U.S. National Congress on Theoretical and Applied Mechanics.

(C14) **E. Burnett** and H. Schaub, "Satellite Relative State Uncertainty Dynamics in the Vicinity of a Poorly Tracked Target Object," 2021 AAS Astrodynamics Specialist Conference.

(C13) **E. Burnett** and H. Schaub, "Modal Decomposition of Spacecraft Relative Motion in Quasi-Periodic Orbits," AAS 20-506, 2020 AAS Astrodynamics Specialist Conference

(C12) **E. Burnett** and H. Schaub, "Analytic Approximations of Orbit Geometry in a Rotating Higher Order Gravity Field," AAS 19-684, 2019 AAS Astrodynamics Specialist Conference

(C11) **E. Burnett**, A. Harris, and H. Schaub, "Desensitized Optimal Spacecraft Rendezvous Control with Poorly Known Gravitational and Solar Radiation Pressure Perturbations," AAS 19-685, 2019 AAS Astrodynamics Specialist Conference

(C10) A. Harris, **E. Burnett**, and H. Schaub, "Desensitized Optimal Attitude Guidance for Differential-Drag Rendezvous," AAS 19-651, 2019 AAS Astrodynamics Specialist Conference

(C9) **E. Burnett** and H. Schaub, "Spacecraft Formation and Orbit Control Using Attitude-Dependent Solar Radiation Pressure," IWSCFF 19-28, 2019 International Workshop on Satellite Constellations and Formation Flying

(C8) **E. Burnett** and H. Schaub, "Study of Highly Perturbed Spacecraft Formation Dynamics via Approximation," IWSCFF 19-27, 2019 International Workshop on Satellite Constellations and Formation Flying

(C7) **E. Burnett**, A. J. Sinclair, and E. A. Butcher, "Coordinate-Invariant Linear Quadratic Control," GAMM 2019, 90$^{\text{th}}$ Annual Meeting of the International Association of Applied Mathematics and Mechanics

(C6) **E. Burnett** and E. A. Butcher, "Linearized Relative Motion Dynamics in a Rotating Second Degree and Order Gravity Field," AAS 18-232, 2018 AAS Astrodynamics Specialist Conference

(C5) **E. Burnett**, E. A. Butcher, A. J. Sinclair, and T. A. Lovell, "Linearized Relative Orbital Motion Model About an Oblate Body Without Averaging," AAS 18-218, 2018 AAS Astrodynamics Specialist Conference

(C4) **E. Burnett** and A. J. Sinclair, "Interpolation on the Unit Sphere in Laplace's Method," AAS 17-793, 2017 AAS Astrodynamics Specialist Conference

(C3) K. Drozd, **E. Burnett**, E. Sahr, D. McNeely, V. Franzese, N. R. Morón, "Block-Like Explorer of a near-Earth Body by achieving Orbital Proximity (BEEBOP)," AAS 17-846, 2017 AAS Astrodynamics Specialist Conference

(C2) E. A. Butcher, **E. Burnett**, J. Wang, and T. A. Lovell, "A New Time-Explicit J2-Perturbed Nonlinear Relative Orbit Model with Perturbation Solutions," AAS 17-758, 2017 AAS Astrodynamics Specialist Conference

(C1) E. A. Butcher, **E. Burnett**, and T. A. Lovell, "Comparison of Relative Orbital Motion Perturbation Solutions in Cartesian and Spherical Coordinates," AAS 17-202, 2017 AAS Spaceflight Mechanics Meeting

CONFERENCES – PEER-REVIEWED ABSTRACTS

Daggers† differentiate planetary science items

†(A5) **E. Burnett**, I. Fodde, and F. Ferrari (2024), "Numerical inference of viscoelastic properties in tidal models of rubble pile asteroids." General Assembly of the European Geosciences Union (EGU), Vienna, Austria. Abstract EGU24-17927

†(A4) **E. Burnett** and P. Hayne (2023), "Dynamical Study of the Tidal Locking of Europa." 54th Lunar and Planetary Science Conference (LPSC), The Woodlands, Texas, USA. Abstract 2804

†(A3) **E. Burnett** and P. Hayne (2022), "Tides and the Spin States of the Icy Ocean World Europa." 53rd Lunar and Planetary Science Conference (LPSC), The Woodlands, Texas, USA. Abstract 1723

†(A2) K. M. Seaton, **E. Burnett**, C. A. Denton, B. Doerr, K. Ebadi, S. Eckert, I. T. W. Flynn, S. Gyalay, C. I. Honniball, S. Hume, C. L. Kling, J. C. Marohnic, J. Milton, C. A. Mondro, R. G. Nuno, C. M. Rooney, B. E. Strauss, G. Stucky de Quay, A. Nash, and J. Scully (2022), "Science Objectives for a Mission Concept to Enceladus: The Astrobiology Exploration at Enceladus (AXE)." 53rd Lunar and Planetary Science Conference (LPSC), The Woodlands, Texas, USA. Abstract 2152

†(A1) K. M. Seaton, **E. Burnett**, C. A. Denton, B. Doerr, K. Ebadi, S. Eckert, I. T. W. Flynn, S. Gyalay, C. I. Honniball, S. Hume, C. L. Kling, J. C. Marohnic, J. Milton, C. A. Mondro, R. G. Nuno, C. M. Rooney, B. E. Strauss, G. Stucky de Quay, A. Nash, and J. Scully (2022), "Mission Implementation for a New Frontiers Mission Concept: The Astrobiology Exploration at Enceladus (AXE)." 53rd Lunar and Planetary Science Conference (LPSC), The Woodlands, Texas, USA. Abstract 2168

CONFERENCES – ATTENDANCE AND TALKS

Daggers† differentiate planetary science conferences, and stars* denote conferences where I gave a talk

†*15. 2024 European Geosciences Union General Assembly, April 14 - 19, 2024, Vienna, Austria

†*14. 54th Lunar and Planetary Science Conference, March 13 - 17, 2023, The Woodlands, TX

13. AAS Guidance, Navigation, and Control Conference, February 2023, Breckenridge, CO

†*12. 53rd Lunar and Planetary Science Conference, March 6 - 11, 2022, The Woodlands, TX

*11. AAS Guidance, Navigation, and Control Conference, February 2022, Breckenridge, CO

*10. AIAA SciTech Forum, January 3 - 7, 2022, San Diego, CA

†*9. 53rd Annual Meeting of the Division for Planetary Sciences, October 3 - 8, 2021, virtual

*8. AAS Astrodynamics Specialist Conference, August 8 - 12, 2021, virtual

*7. AAS Astrodynamics Specialist Conference, August 9 - 12, 2020, virtual

*6. AAS Astrodynamics Specialist Conference, August 11 - 15, 2019, Portland, ME

*5. International Workshop on Satellite Constellations and Formation Flying, July 16 - 19, 2019, Glasgow, Scotland

4. 90th Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), February 18 - 22, 2019, Vienna, Austria

*3. AAS Astrodynamics Specialist Conference, August 19 - 23, 2018, Snowbird, UT

2. AAS Astrodynamics Specialist Conference, August 20 - 24, 2017 Stevenson, WA

*1. 27th AAS/AIAA Spaceflight Mechanics Meeting, February 5 - 9, 2017, San Antonio, TX

INVITED TALKS

Daggers† differentiate planetary science talks

5. E. Burnett, "Astrodynamics", invited lecture at *Georgia Institute of Technology* for undergrad course AE 4342, October 11, 2022, Atlanta, GA

4. E. Burnett, "Frontiers in Spaceflight and Space Science," presented at *Georgia Institute of Technology*, February 3, 2022, Atlanta, GA

†3. E. Burnett, "Europa's Hemispheric Color Dichotomy as a Constraint on Non-Synchronous Rotation," presented at *NASA JPL Europa Clipper Lecture Series*, October 15, 2021 (virtual)

2. E. Burnett, "Novel Formulations for Modern Multi-Spacecraft Proximity Operations and Rendezvous", presented to *U.S. Air Force Office of Scientific Research* and *2018 NDSEG Fellows Class*, in *2nd Annual NDSEG Conference*, July 19, 2021 (virtual)

†1. E. Burnett, "Europa's Hemispheric Color Dichotomy as a Constraint on Non-Synchronous Rotation," presented to *Exploration of Planetary Ices and Climates (EPIC) Group*, in *Laboratory for Atmospheric and Space Physics (LASP), CU Boulder*, April 5, 2021, Boulder, CO (virtual)

TEACHING EXPERIENCE

Tutor, "I Have a Dream" Foundation of Boulder County — June 2019 – May 2021

- Calculus and Physics (university level), January – May 2021
- Algebra and Geometry (high school level), June 2019 – March 2020

Teaching Assistant, University of Arizona — August 2016 – May 2018

- Advanced Engineering Mathematics I & II (graduate courses), 2017, 2018
- Vibrations (undergraduate course), 2017
- Fluid Mechanics (undergraduate course), 2017
- Introduction to MATLAB (undergraduate course), 2016, 2017

MENTORING EXPERIENCE

MS Thesis Co-Supervision, Politecnico di Milano — February 2024 – present

1. **Omar Regantini**, "Use of State Transition Tensors in Onboard Guidance", 2024 (in progress). Supervisors and co-supervisors: E. Burnett, A. Morselli
2. **Marco Baldetti**, "Apophis Flyby Modeling using GRAINS", 2024 (in progress). Supervisors and co-supervisors: I. Fodde, F. Ferrari, E. Burnett

Technical Lead, New Grad Rotation Program project at Blue Origin — Spring 2023

- Four month internal research project (path-constrained indirect trajectory optimization) completed by an engineer in the competitive New Grad Rotation (NGR) Program at Blue Origin
- Mentee: **Josh Stoffel**

Graduate Mentor, CU Boulder "Discovery Learning Apprenticeship" Program — Fall 2021

- One-year undergrad research project on aerocapture guidance and trajectory design
- Mentee: **Sam Alvis**

PROFESSIONAL SERVICES

Peer Reviewer — 2020 – present

Acta Astronautica · Advances in Space Research · Celestial Mechanics and Dynamical Astronomy · Journal of Guidance, Control, and Dynamics (Awarded "Excellent Reviewer" Oct 2021 - 2022) · International Journal of Aerospace Engineering · IEEE Access · The Planetary Science Journal

Volunteer Tutor — 2019 – 2021
"I Have a Dream" Foundation of Boulder County

HIGHLIGHTED SKILLS BY DISCIPLINE

Guidance and Control | Optimal control theory · Linear control theory · Nonlinear methods · Differential algebra and state transition tensors · Optimization (direct and indirect methods) · Convex optimization · Linear covariance methods for stochastic guidance

Astrodynamics | Orbital mechanics · Orbital perturbations · Formation flying and rendezvous · Orbit regulation and control · Three-body problems · Computing periodic/quasi-periodic orbits and manifolds · Orbital transfers and three-body trajectories · Aerocapture and atmospheric entry guidance · Filtering & initial orbit determination methods · Attitude dynamics & control

Applied mathematics | Perturbation theory (Straightforward, Lindstedt-Poincaré, harmonic balance, etc) · Lyapunov-Floquet theory · Periodic and quasi-periodic systems · Differential algebra · Hamiltonian and Lagrangian formulation · Geometric mechanics

Planetary Science | Icy ocean worlds · Tidal theory · Natural satellites · Binary asteroid systems

Computer and numerical skills | Programming (primarily Python and MATLAB) · Numerical integration and modeling · Shell scripting · Optimization tools (e.g. CVXPY, scipy.optimize, fmincon, cvx) · Differential algebra tools (e.g. pyaudi) · macOS and linux · Mathematica · LaTeX