# Chad R. Frost

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## Subjects of interest

My current areas of research and application interest include architecture of multi-spacecraft missions and vehicle swarms; command and control of heterogenous mixtures of vehicle types and classes; advanced manufacturing technologies for small and nanospacecraft; and new mission design methodologies including optimization approaches. Through Raven Lab LLC, I provide consulting, advisory and analytical services to commercial and government space organizations.

#### Professional experience

Feb 2024 - present	CEO, Raven Lab LLC, Santa Fe, New Mexico.
2021 - Jan 2024	Chief Technologist, Small Spacecraft Technology Program, NASA HQ.
2020 - 2021	Chief Technologist, Engineering Directorate, NASA Ames Research Center.
2018 - 2019	Director of Engineering (acting), NASA Ames Research Center.
2015 - 2018, 2019 - 2020	Deputy Director of Engineering, NASA Ames Research Center.
2012 - 2015	Chief, Mission Design Division. NASA Ames Research Center.
2007 - 2012	Autonomous Systems and Robotics Technical Area Lead, Intelligent Systems Division. NASA Ames Research Center.
2007 - 2011	Co-PI, Spacecraft Handling Qualities Center of Excellence. NASA.
2007	Collaborative and Assistant Systems Technical Area Lead, Intelligent Systems Division. NASA Ames Research Center.
2006 - 2007	Associate Principal Investigator, responsible for Flight Dynamics and Control element of the Sub- sonic - Rotary-Wing project within NASA's Fundamental Aeronautics program.
2005 - 2007	Collaborative and Assistant Systems Technical Area Deputy Lead, Intelligent Systems Division. NASA Ames Research Center.
2005 - 2006	Intelligent Mission Management L3 project manager, Autonomous Robust Avionics Project. NASA.

2004 - 2005	Deputy Chief (Acting), Flight Control and Cockpit Integration Branch, Army/NASA Rotorcraft Di- vision. NASA Ames Research Center.
2003 - 2005	Intelligent Autonomous Architectures lead, Autonomous Robust Avionics Project. NASA.
2002 - 2004	Assistant Chief, Flight Control and Cockpit Integration Branch, Army/NASA Rotorcraft Division. NASA Ames Research Center.
2000 - 2004	Control Systems Engineer, Flight Control and Cockpit Integration Branch, Army/NASA Rotorcraft Division. NASA Ames Research Center.
1999 - 2000	Senior Research Engineer, Cal Poly Foundation and San Jose State University Foundation. US Army Aeroflightdynamics Directorate.
1995 - 1996	Program manager, Spacecraft Structures, Applied Aerospace Structures Corp.
1991 - 1995	Project engineer, Preece Inc.
1986 - 1988	Firefighter, United States Forest Service.

### Education

- MSc in Aerospace Engineering, California Polytechnic State University, San Luis Obispo
  ADVISORS: Dr. Daniel Biezad (Cal Poly), Dr. Mark Tischler (U.S. Army Aeroflightdynamics Directorate)
- 1990 BSc in Aerospace Engineering, California Polytechnic State University, San Luis Obispo

TRAINING/CONTINUING EDUCATION

- <sup>2017</sup> FAC-COR Contracting Officer's Representative 40-hour training.
- <sup>2016 2017</sup> Leveraging Agency Supervisory Excellence and Resilience (LASER). 14-month cohort program developing line supervisors, NASA HQ Office of Human Capital.
- <sup>2015</sup> Congressional Operations Seminar (Government Affairs Institute, Washington D.C.)
- <sup>2012</sup> NASA Leading Through Influence.
- 2006 NASA Business Education Program.
- <sup>2004</sup> Strategic Leadership Boot Camp. Year-long cohort program to develop high-potential future leaders at NASA Ames Research Center.
- <sup>2003</sup> Art of Leadership Mastery.

- <sup>2003</sup> Presenting Data and Information. Edward Tufte.
- <sup>2001</sup> Interactive Development of Engineers, Administrators and Scientists (IDEAS). Year-long cohort program at NASA Ames Research Center.

## Service to the profession

	Engineering Industry Advisory Council, San Jose State University
2016 - 2022	NASA Representative
	American Institute of Aeronautics and Astronautics
2007	Associate Fellow
2002 - 2009 2006 - 2009 2004 - 2006	Atmospheric Flight Mechanics Technical Committee: Member Handling Qualities Subcommittee Chair Publications Subcommittee Chair
	Reviewer for Journal of Aircraft, Journal of Guidance, Control and Dynamics, Journal of Aerospace Computing, Information, ぐ Communication and Journal of Spacecraft and Rockets.
	American Helicopter Society
1986 - 2012 2003 - 2009	Member Handling Qualities Technical Committee member
2000 - 2001 1999 - 2004	San Francisco Bay Area chapter: President Board of directors

## Honors ${\ensuremath{\mathscr{C}}}$ awards

2016	Ames Honor Award - Capabilities Leadership Team.
2015	NASA Group Achievement Award - Quantum Applications of Integrated Learning Team.
2014	Space Flight Awareness Team Award - for contributions to human spaceflight programs.
2010	Aeronautics Directorate Technical Excellence in Publications Award - for paper "Dynamic Cou- pling and Control Response Effects on Spacecraft Handling Qualities During Docking".
2009	Ames Honor Award - Wildfire Research and Applications Partnership team.

- <sup>2008</sup> NASA Group Achievement Award Wildfire Research Applications Partnership.
- <sup>2008</sup> NASA Certificate of Recognition in appreciation for Federal Laboratory Consortium for Technology Transfer Far West Region Outstanding Partnership Award to the Wildfire Research and Applications Partnership (WRAP) project.
- 2008 NASA Group Achievement Award Western States UAS Fire Mission Team.
- AIAA Distinguished Service award Atmospheric Flight Mechanics Technical Committee.
- AIAA Associate Fellow.
- Ames Honor Award Lunar Landing Handling Quality Simulation Team.
- Ames Honor Award Western States UAS Fire Mission Team.
- <sup>2007</sup> AIAA Aerospace Software Engineering Award for (team) development and industry adoption of CONDUIT.
- <sup>2005</sup> Schroers Award for Outstanding Rotorcraft Research, San Francisco Bay Area Chapter of the American Helicopter Society - for the Autonomous Rotorcraft Project (team).
- Best Paper Award, AHS International Forum Avionics and Systems session with co-authors, for "In-flight Assessment of a Pursuit Guidance Display Format for Manually Flown Precision Instrument Approaches".
- <sup>2003</sup> NASA Group Achievement Award Rotorcraft Aircrew Systems Concepts Airborne Laboratory (RASCAL) Team, for successfully developing and qualifying America's only full-authority variable stability helicopter.
- 2002 Outstanding Contribution to the Local Chapter, San Francisco Bay Area Chapter of the American Helicopter Society.
- <sup>2001</sup> Schroers Award for Outstanding Rotorcraft Research, (with team) San Francisco Bay Area Chapter of the American Helicopter Society - for development of the RASCAL fly-by-wire Black Hawk helicopter.
- <sup>2001</sup> NASA Turning Goals Into Reality award, (with team) for successfully deploying CONDUIT on numerous government and industry flight control projects.
- Schroers Award for Outstanding Rotorcraft Research, (with team) San Francisco Bay Area Chapter of the American Helicopter Society - for development of the Control Designer's Unified Interface (CONDUIT) software.
- <sup>1987</sup> Co-recordholder, World's first flight of a human-powered helicopter, National Aeronautic Association.

### Patents

<sup>2018</sup> Nakamura, Faber, Frost and Alena: US 9,906,291 B1 Heterogenous Spacecraft Networks.

#### Publications & Presentations

BOOK CHAPTERS

Frost, C. "Challenges and Opportunities for Autonomous Systems in Space". In: *Frontiers of Engineering: Reports on Leading-Edge Engineering from the 2010 Symposium.* National Academy Press.

Invited Talks & Interviews

- 2021 Chad Frost on KMOX St. Louis, MO, "the Dave Glover Show" https://www.audacy.com/kmox/ podcasts/the-dave-glover-show-20667/11-4-21-hour-2-nasa-910845899
- 2021 Chad Frost quoted in Monterey Bay Aquarium article on Sea Otter tracking: https://www.montereybayaquarium. org/stories/nasa-otter-tags
- 2018 Chad Frost, Mary Beth Wilhelm, Scott Manley and Matthew Buffington: "NASA in Silicon Velley Live - Let's Play Space Video Games!" https://www.nasa.gov/ames/nisv-podcast-livelets-play-space-video-games
- Chad Frost and Susan De La Cruz, "Building the next generation of the Nation's wildlife tracking system". USGS Innovation Center 5th Anniversary Colloquium 2018, Reston, VA. February 28, 2018.
- 2018 Chad Frost, Mary Beth Wilhelm, Thomas Lambot, Matthew Buffington and Abby Tabor: "NASA in Silicon Valey Live - Ep. o5 - Let's Play Space Video Games!" https://www.nasa.gov/ames/ nisv-podcast-live-Ep3-Lets-Play-Space-Video-Games
- <sup>2018</sup> "Chad Frost and Susan De La Cruz talk about the 'Social Networks' of wildlife" NASA in Silicon Valley podcast, Feb 23, 2018. https://www.nasa.gov/ames/nisv-podcast-Chad-Frost-Susan-de-La-Cruz
- <sup>2016</sup> Chad Frost "Environmental awareness of ecosystems using next generation technology" USGS Innovation Center workshop on Ecosystems in a Changing World, Dec 2016.
- <sup>2015</sup> Chad Frost "Horizons in Smallsat applications" USGS Innovation Center workshop on A World of Changing Climate and Land Use, Dec 2015.
- 2013 Chad Frost interviewed in "NASA's 'PhoneSat' program points to satellites of the future" EDN.com, June 12, 2013. https://www.edn.com/electronics-blogs/now-hear-this/4416264/NASAs--PhoneSat--program-points-to-satellites-of-the-future-
- <sup>2010</sup> "Chad Frost shares stories from NASA's autonomous systems and robotics department and his thoughts on civilian usage of UAVs." DIYDrones podcast, Jan 11, 2010. https://diydrones.com/profiles/blogs/chad-frost-shares-stories-from

**Refereed Research Papers** 

- R. C. Hunter, E. F. Agasid, C. E. Baker, J. V. Treptow, C. R. Frost, D. J. Mayer, A. Guarneros Luna, R. 2022 De Rosee, A. N. Nguyen, and J. L. Fishman, "NASA small spacecraft technology (SST) program and recent technology demonstrations," in Proceedings of the 4S Symposium, (Vilamoura, Portugal), May 2022. I. G. Brosnan, C. R. Frost, J. Adams, M. Costa, S. DeLaCruz, E. Hyde, D. Kemp, J. Li, J. Tomoleoni, J. 2021 T. B. de Sousa, M. Casazza, J. D. Stock, O. Overton, Z. Randell, J. L. Yee, and J. Fujii."Next-generation wildlife tracking devices and integrated sensors for measuring species-environment interactions and advancing conservation." In Fall meeting, American Geophysical Union, New Orleans, LA, December 2021. Mazhari, Arash Alex, Diana M. Acosta, and Chad R. Frost. "Strengthening innovation at NASA 2017 Ames Research Center by encouraging prototyping and collaboration." IEEE Aerospace Conference, 2017. Descamps, Arthur and Frost, Chad "XCube Project: Use of U-class Standard for Embedded Ex-2016 periments, a Clean and Cost Effective Path, From Labs to Orbit" 13th Annual CubeSat Developers Workshop, Cal Poly State University, San Luis Obispo, CA April 20-22, 2016. Yang Yang, F., Nelson, B., Aziz, J., Carlino, R., Perez, A., Faber, N., Foster, C., Frost, C., Henze, 2016 C., Karacalıoğlu, A., Levit, C., Marshall, W., Mason, J., O'Toole, C., Swenson, J., Worden, S., and Stupl, J. LightForce photon-pressure collision avoidance: Efficiency analysis in the current debris environment and long-term simulation perspective. Acta Astronautica 126 (2016) 411-423. Nayak, M., Mauro, D., Stupl, J., Aziz, J., Colaprete, A., Dono-Perez, A., Frost, C., Jonsson, J., McKay, 2016 C., Sears, D. and Soulage, M., 2016. The Plume Chaser mission: Two-spacecraft search for organics on the dwarf planet Ceres. Advances in Space Research, 57(5), pp.1133-1146. M Busch, N Faber, S Eggl, D Morrison, A Clark, C Frost, BA Jaroux, V Khetawat. Mission Designs 2015 for Demonstrating Gravity Tractor Asteroid Deflection. AGU Fall Meeting, San Francisco. Jonsson, J., Mauro, D., Stupl, J., Nayak, M., Aziz, J., Cohen, A., Colaprete, A., Dono-Perez, A., Frost, 2015 C., Klamm, B. and McCafferty, J., 2015. Cost-Effective Icy Bodies Exploration using Small Satellite Missions. In: Proceedings of the 66th International Astronautical Congress (IAC 2015); 12-16 Oct. 2015; Jerusalem; Israel Faber, N., Y. Nakamura, R. Alena, D. Mauro, C. Frost, G. Bhat, and J. McNair. "Heterogeneous 2014 Spacecraft Networks: General Concept and Case Study of a Cost-effective, Multi-Institutional Earth Observation Platform" In: Proceedings of the 2014 IEEE Aerospace Conference. Nakamura, Y., N. Faber, D. Mauro, R. Alena, C. Frost, G. Bhat, and J. McNair. "Heterogeneous 2014 Spacecraft Networks: Performance Analysis for Low-cost Earth Observation Missions." In: Proceedings of the 2014 IEEE Aerospace Conference. Frost, C. Expanding the Global Sensor Web with Cubesats. 11th annual Cubesat Developers Work-2014
  - shop, April 23-25, 2014 San Luis Obispo, California.

- <sup>2011</sup> Mueller, E., K. Bilimoria, and C. **Frost**. Effects of control power and inceptor sensitivity on lunar lander handling qualities. *Journal of Spacecraft and Rockets* 48(3), 454.
- <sup>2010</sup> Mueller, E., K. Bilimoria, and C. Frost. Improved Lunar Lander Handling Qualities Through Control Response Type and Display Enhancements. In: *Proceedings of the American Institute of Aeronautics and Astronautics (AIAA) Guidance, Navigation, and Control (GNC) Conference*, Toronto, Canada.
- Bilimoria, K., E. Mueller, and C. Frost. Handling Qualities Evaluation of Pilot Tools for Spacecraft Docking in Earth Orbit. In: Proceedings of the American Institute of Aeronautics and Astronautics (AIAA) Guidance, Navigation, and Control (GNC) Conference, Chicago, Illinois.
- <sup>2009</sup> Mueller, E., K. Bilimoria, and C. Frost. Dynamic Coupling and Control Response Effects on Spacecraft Handling Qualities During Docking. *Journal of Spacecraft and Rockets* 46(6).
- 2009 Mueller, E., K. Bilimoria, and C. Frost. Effects of Control Power and Inceptor Sensitivity on Lunar Lander Handling Qualities. In: *Proceedings of the Space 2009 Conference and Exposition*. AIAA-2009-6407. American Institute of Aeronautics and Astronautics.
- Lutz, R., A. Patterson-Hine, S. Nelson, C. Frost, D. Tal, and R. Harris. Using obstacle analysis to identify contingency requirements on an unpiloted aerial vehicle. *Requirements Engineering* 12(1), 41–54.
- Jarvis, P., R. Harris, and C. Frost. Evaluating UAS Autonomy Operations Software In Simulation. In: AIAA Infotech@Aerospace 2007 Conference and Exhibit.
- Frost, C. and G. Tucker. If You've Got It, Use It (Simulation, That Is...) In: *Proceedings of the AIAA Atmospheric Flight Mechanics Conference*, Keystone, CO.
- Freed, M., P. Bonasso, K. Dalal, W. Fitzgerald, C. Frost, and R. Harris. An architecture for intelligent management of aerial observation missions. In: *Infotech@Aerospace*. AIAA-2005-6938. Arlington, VA.
- Lutz, R., S. Nelson, A. Patterson-Hine, C. Frost, and D. Tal. Identifying contingency requirements using obstacle analysis. In: *Proceedings of the 13th IEEE International Conference on Requirements Engineering*. IEEE, pp.263–272.
- Schoenung, S., S. Wegener, J. Frank, C. Frost, M. Freed, and J. Totah. Intelligent UAV airborne science missions. *Infotech@Aerospoace*, 1–12.
- Moralez, E., G. E. Tucker, W. S. Hindson, C. R. Frost, and G. H. Hardy. In-Flight Assessment of a Pursuit Guidance Display Format for Manually Flown Precision Instrument Approaches. In: *Proceedings of the American Helicopter Society 60th Annual Forum*. Baltimore, Maryland. Sullivan, D. et al. Intelligent mission management for uninhabited aerial vehicles. In: *Proc. SPIE*.
- Sullivan, D. et al. Intelligent mission management for uninhabited aerial vehicles. In: *Proc. SPIE.* Vol. 5661, pp.121–131.
- <sup>2004</sup> Wegener, S. et al. UAV autonomous operations for airborne science missions. In: *Proceedings of the American Institute for Aeronautics and Astronautics 3rd "Unmanned. . . Unlimited" Technical Conference.*

2002	<b>Frost</b> , C., J. Franklin, and G. Hardy. Evaluation of Flying Qualities and Guidance Displays for an Advanced Tilt-Wing STOL Transport Aircraft in Final Approach and Landing. In: <i>Proceedings of the Biennial International Powered Lift Conference and Exhibit</i> . Williamsburg, Virginia.
2002	<b>Frost</b> , C., W. Hindson, E. Moralez, G. Tucker, and J. Dryfoos. Design and testing of flight control laws on the RASCAL research helicopter. In: <i>Proceedings of the American Institute of Aeronautics and Astronautics Modeling and Simulation Technologies Conference</i> . Monterey, CA.
2002	Moralez, E. et al. Flight Research Qualification of the Army/NASA RASCAL Variable-Stability He- licopter. In: <i>Proceedings of the American Helicopter Society 58th Annual Forum</i> . Montreal, Canada.
2000	Colbourne, J. D., L. Cicolani, M. B. Tischler, C. Frost, C. Tomashofski, and T. LaMontagne. System Identification and Control System Design for the BURRO Autonomous UAV. In: <i>Proceedings of the</i> <i>American Helicopter Society 56th Annual Forum</i> . Virginia Beach, VA.
2000	<b>Frost</b> , C., M. B. Tischler, M. Bielefield, and T. LaMontagne. Design and Test of Flight Control Laws for the Kaman BURRO Unmanned Aerial Vehicle. In: <i>Proceedings of the AIAA Atmospheric Flight Mechanics Conference</i> . AIAA-2000-4205.
1999	Colbourne, J. D., C. <b>Frost</b> , M. B. Tischler, K. K. Cheung, D. K. Hiranaka, and D. J. Biezad. Control Law Design and Optimization for Rotorcraft Handling Qualities Criteria Using CONDUIT. In: <i>Proceedings of the American Helicopter Society 55th Annual Forum</i> . Montreal, Canada.
	Published technical reports
2014	<b>Frost</b> , C. et al. <i>Small Spacecraft Technology State of the Art</i> . Tech. rep. TP-2014-216648/REV1. NASA.
2009	Bailey, R., E. Jackson, K. Bilimoria, E. Mueller, C. Frost, and T. Alderete. <i>Cooper-Harper Experience Report for Spacecraft Handling Qualities Applications</i> . Technical Memorandum TM-2009-215767. NASA.
2009	<b>Frost</b> , C., W. A. Decker, B. T. Sweet, and C. R. Theodore. "Flight Dynamics and Control". In: <i>A Status of NASA Rotorcraft Research</i> . Ed. by G. K. Yamauchi and L. A. Young. TP-2009-215369. NASA. Chap. 6.
1998	Tischler, M., J. Colbourne, K. Cheung, C. Frost, W. Levine, and V. Moldoveanu. <i>CONDUIT "The Control Designer's Unified Interface" Course Notes</i> . Tech. rep. CP-1998-10157.
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