

3rd Space Imaging Workshop

October 10-12, 2022

Global Learning Center (GLC)
Georgia Institute of Technology
Atlanta, GA

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to the Sponsors*



Find more information online at <https://seal.ae.gatech.edu/workshop-2022>

Monday: 10 October 2022

- 7:30 Registration
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- 8:30 Welcome
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- 9:00 **Feasibility of a Planet's Horizon for Camera Calibration (Paper SIW22-01)**
K. R. Danas Rivera and M. A. Peck (Cornell University)
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- 9:20 **On-orbit Cross Calibration Between the OSIRIS-REx Orbiting Laser Altimeter and Navigation Camera (Paper SIW22-02)**
A. J. Liounis (NASA GSFC), J. M. Leonard (KinetX), K. Getzandanner (NASA GSFC), B. J. Bos (NASA GSFC), and M. G. Daly (York University)
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- 9:40 **Post-Launch Characterization and Calibration of the Optical Navigation Instruments for NASA's Lucy Mission (Paper SIW22-03)**
E. Sahr, E. Lessac-Chenen, J. Pelgrift, D. Nelson, C. Adam and D. Stanbridge (KinetX)
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- 10:00 **BREAK**
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- 10:20 **Multi-Agent Stereovision Sensitivity Analysis for Rendezvous with Non-cooperative Targets (Paper SIW22-04)**
K. Dennison and S. D'Amico (Stanford University)
-
- 10:40 **Thermal Image Simulation to Support GNC Testing with PANGU (Paper SIW22-05)**
I. M. Martin (University of Dundee), M. B. Dunstan (University of Dundee), D. Vural (University of Dundee), and M. Sanchez Gestido (ESA)
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- 11:00 **Realistic Small-Body Imagery Data Generation in a Controlled Lab Environment (Paper SIW22-06)**
M. Dor and P. Tsiotras (Georgia Tech)
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- 11:20 **Keynote: Coralie Adam, Optical Navigation Lead, KinetX Aerospace**
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- 12:20 **LUNCH (GLC Atrium)**
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- 2:00 **Optical Navigation for the DART Mission (Paper SIW22-07)**
B. P. Rush, D. M., Mages, A. T. Vaughan, J. Bellerose, and S. Bhaskaran (JPL)
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- 2:20 **Correcting for Rolling Shutter Distortion in DART Optical Navigation Imagery (Paper SIW22-08)**
D. M. Mages, B. P. Rush, and A. T. Vaughan (JPL)
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- 2:40 **Boulders Identification on Small Bodies Under Varying Illumination Conditions (Paper SIW22-09)**
M. Pugliatti and F. Toppoto (Politecnico di Milano)
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- 3:00 **Initial Pole Estimation using Infrared Imagery (Paper SIW22-10)**
K. Kuppa (CU-Boulder), J. McMahon (CU-Boulder), and A. Dietrich (Draper)
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- 3:20 **BREAK**
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- 3:40 **Simultaneous Localization, Mapping and Characterization Around a Small Body Using a Monocular Camera (Paper SIW22-11)**
F. Piccolo, P. Panicucci, and F. Toppoto (Politecnico di Milano)
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- 4:00 **Using Images to Estimate the Motion of Particles Disturbed during OSIRIS-REx Sample Collection at Bennu (Paper SIW22-12)**
C. E. Mario (Draper), E. B. Bierhaus (Lockheed Martin Space), C. D. Norman (Lockheed Martin Space), C. Miller (Lockheed Martin Space), B. Rizk (University of Arizona), B. J. Bos (NASA GSFC), and D. S. Lauretta (University of Arizona)
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- 4:20 **Deep Feature Detection and Description for Small Body Relative Navigation (Paper SIW22-13)**
T. Driver, K. Skinner, M. Dor, and P. Tsiotras (Georgia Tech)
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- 4:40 **Point Cloud Visual SLAM for Autonomous Navigation and Mapping around Small Celestial Bodies (Paper SIW22-14)**
J. Villa (CU-Boulder), J. McMahon (CU-Boulder), and I. A. Nesnas (JPL)

Keynote Speaker

Monday, October 10, 2022

11:20–12:20



Coralie Adam

Optical Navigation Lead, KinetX Aerospace

Coralie Adam is the Lead Optical Navigation Engineer at KinetX Aerospace, the first privately held company to provide deep space navigation and flight dynamics expertise to NASA. She holds a B.S. in Aerospace Engineering from the University of Illinois, and an M.S. in Aerospace Engineering Sciences from the University of Colorado. Coralie first started imaging and measuring asteroids at age 16 using ground-based telescopes and has since been involved in many robotic exploration missions to small bodies throughout the solar system. Since joining KinetX in 2011, she has worked as an optical navigator on historic NASA missions such as New Horizons' first reconnaissance of the Pluto System and OSIRIS-REx sample return mission to asteroid Bennu. In addition to navigation and systems engineering mission support, she has also contributed to planetary science as co-convener of the scientific investigation of Bennu's active particle ejection phenomena.

For her contributions to NASA's planetary exploration initiatives, she has received many honors, including a NASA Early Career Achievement Medal and main belt asteroid 128314 dedicated in her name. Coralie's enthusiasm for public outreach inspired the building of Muddy Run Observatory in Lancaster, PA, where one of the telescopes is dedicated in her name. Coralie is currently the Deputy Navigation Chief on NASA's recently launched Lucy mission, through which she is looking forward to exploring a new population of asteroids, the Jupiter Trojans, which will further expand our scientific understanding of our solar system and planet's origins. Ms. Adam is also excited to take on a new role as a science co-Investigator on OSIRIS-APEX, which will rendezvous with and characterize asteroid Apophis after its close encounter with Earth in 2029.



Tuesday: 11 October 2022

- 9:00 **Instrumentation Development at the University of Hawaii Institute for Astronomy (Paper SIW22-15)**
K. Hodapp, C. Baranec, M. Bottom, M. Chun, L. Denneau, J. Kuhn, H. Lin, E. Magnier, P. Onaka, B. Shappee, and J. Tonry (University of Hawaii)
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- 9:20 **Change Detection from Persistent Photometry (Paper SIW22-16)**
C. Ingram, J. Bishop, and B. Flewelling (ExoAnalytic Solutions)
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- 9:40 **Using Autoencoders to Assess Spin Stability and Spin-Rate on Unevenly Sampled Light Curves (Paper SIW22-17)**
G. Badura, C. R. Valenta, L. Churchill, and D. Hope (GTRI)
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- 10:00 **BREAK**
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- 10:20 **Improved Detection of a Near-Earth Asteroid from an Interplanetary CubeSat Mission (Paper SIW22-18)**
A. M. Mitchell (MIT), P. Panucci (Politecnico di Milano), V. Franzese (Politecnico di Milano), F. Topputo (Politecnico di Milano), and R. Linares (MIT)
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- 10:40 **3D Spacecraft Reconstruction from On-Orbit Imagery (Paper SIW22-19)**
D. Crispell and S. Richardson (Vision Systems, Inc.)
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- 11:00 **On-board Limb-based Shape Modeling For Small Body Navigation (Paper SIW22-20)**
J. Lyzhoft, J. Swenson, D. Baker, A. Liounis, and M. Fickett (NASA GSFC)
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- 11:20 **Keynote: Col. Marc Brock, Commander Space Delta 2, U.S. Space Force**
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- 12:20 **LUNCH (GLC Atrium)**
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- 2:00 **Automated Mapping for Comparison of Satellite Imagery (Paper SIW22-21)**
C. Abidi, S. Roffe, E. Gretok, and A. George (NSF-SHREC)
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- 2:20 **DEMkit & LunaRay: Tools for Mission Data Generation and Validation (Paper SIW22-22)**
K. Hough, M. E. Mohammadi, C. Owens, M. Bloom, L. Moon, and A. D. Horchler (Astrobotic)
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- 2:40 **Topographic Models from the Lunar Orbiter Laser Altimeter (LOLA) in Support of Terrain Relative Navigation at the Moon (Paper SIW22-23)**
M. K. Barker, E. M. Mazarico, and C. I. Restrepo (NASA GSFC)
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- 3:00 **Application of Earth-Analog Sites for Lunar Simulated Digital Elevation Models (Paper SIW22-24)**
S. P. Scheidt (Howard University), S. X. Hudziak (University of Iowa), J. A. Richardson (NASA GSFC), M. K. Barker (NASA GSFC), N. E. Petro (NASA GSFC), C. I. Restrepo (NASA GSFC), E. Mazarico (NASA GSFC)
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- 3:20 **BREAK**
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- 3:40 **Digital Elevation Map Parametric Error Analysis using Corresponding NAC Images (Paper SIW22-25)**
C. R. Gnam, C. I. Restrepo, and A. J. Liounis (NASA GSFC)
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- 4:00 **Shading without Shape for TRN Map Generation (Paper SIW22-26)**
Y. Cheng, A. Anzar, and Z. Morgan (JPL)
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- 4:20 **BREAK**
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- 4:30 **Discussion Session: Lunar Mapping and Navigation Challenges**
Moderated by the NASA LuNaMaps Team
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- 6:00 **WORKSHOP DINNER (Georgia Tech Hotel)**

Keynote Speaker

Tuesday, October 11, 2022

11:20–12:20



Col. Marc A. Brock

Commander, Space Delta 2, United States Space Force

Col Brock is the Commander, Space Delta 2, headquartered at Peterson Space Force Base, Colorado. He commands the Space Domain Awareness Delta spanning the globe with personnel at 10 locations supporting missions in four countries. DEL 2 is responsible for preparing and presenting assigned and attached forces for the purpose of executing combat-ready Space Domain Awareness operations to deter aggression, and, if necessary, fight to protect and defend the U.S. and our allies from attack in, through and from space.

Col Brock entered the Air Force in May 1998 from Syracuse University with a Reserve Officer Training Corps commission. He has been assigned to numerous operational and staff positions. Prior to his current position, he was the Chief, Programs Division, Headquarters Space Operations Command, Directorate of Plans, Programs and Financial Management, Peterson Air Force Base, Colorado.

Discussion Session: Lunar Mapping and Navigation Challenges

Moderated by the NASA LuNaMaps Team

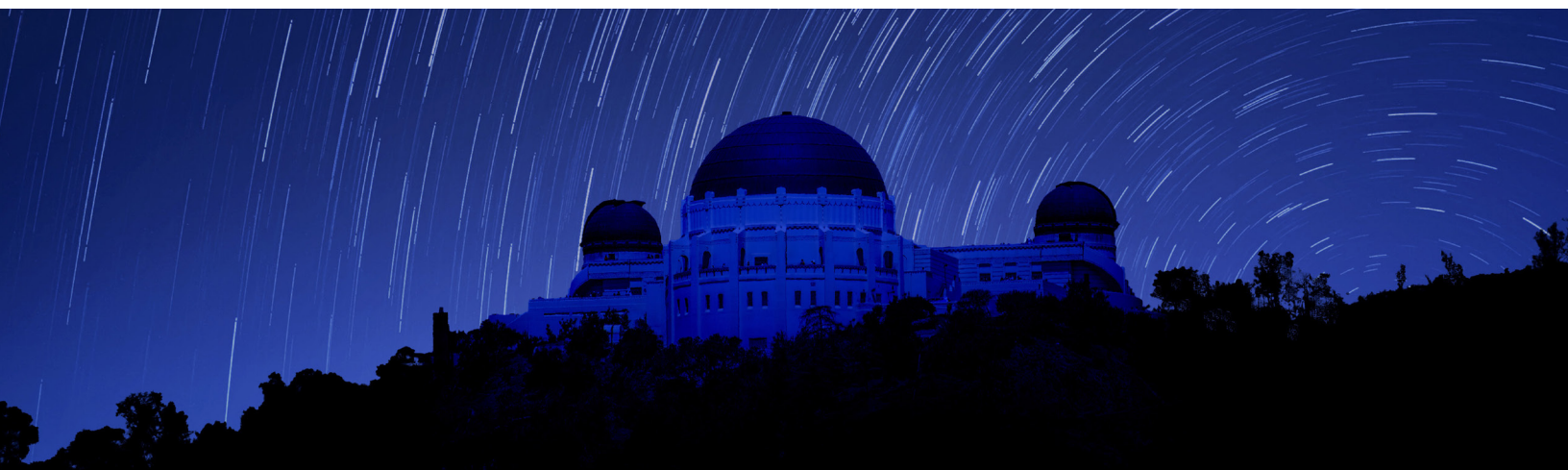
Today there are vast amounts of lunar imagery and topographic data to construct Digital Elevation Models (DEMs) of the lunar surface to be used for navigation. However, there are many challenges that remain given the uneven coverage of surface imagery, the existence of permanently shadowed regions, and the need for mission specific maps of certain sizes and resolutions. Terrain Relative Navigation (TRN) algorithms have yet to be flight-proven at the Moon, and understanding the requirements and relationships that exist between obtaining the right sets of maps that work for a particular TRN algorithm is a current challenge. In addition to TRN, some missions will require hazard detection and/or hazard relative navigation, for which orbital imagery is not available at the cm-scale resolution.

Participants of this session are encouraged to share their challenges and questions on obtaining lunar navigation maps for either south pole or non-polar regions, as well as challenges in generating realistic terrain models that can be used for hazard detection and avoidance algorithm development.



Wednesday: 12 October 2022

- 9:00 **Leveraging Terrestrial Testing to Design and Test Lunar Terrain Relative Navigation (Paper SIW22-27)**
A. B. Dietrich, C. E. Mario, and T. Steiner (Draper)
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- 9:20 **Optimization of LIDAR Based Landing Hazard Detection (Paper SIW22-28)**
A. E. Johnson, G. Vaughan, P.-T. Chen, and R. Bocchino (JPL)
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- 9:40 **Square Root Extended Information Filter Visual Odometry Applied to Blue Origin Deorbit, Descent, and Landing Dataset (Paper SIW22-29)**
M. W. Givens and J. W. McMahon (CU-Boulder)
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- 10:00 **BREAK**
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- 10:20 **Extending Capabilities of Crater Navigation and Timing for Autonomous Lunar Orbital Operations (Paper SIW22-30)**
R. E. Gold, S. G. Catalan, B. A. Jones, and R. Zanetti (University of Texas at Austin)
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- 10:40 **An H-Matrix Pose Estimation with TRN Applications (Paper SIW22-31)**
Y. Cheng and E. S. Bailey (JPL)
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- 11:00 **Preliminary Flight Testing of Dragonfly's Electro-optical Terrain Sensing Function (Paper SIW22-32)**
S. Jenkins, S. Bibelhauser, N. L. Mehta, J. Thomas, and I. R. Witte (JHU/APL)
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- 11:20 **Crater Projection in Linear Pushbroom Camera Images (Paper SIW22-33)**
M. Mancini, C. De Vries, A. Thrasher, and J. Christian (Georgia Tech)
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- 11:40 **LUNCH (GLC Atrium)**
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- 2:00 **Performance of Limb-Based Navigation Using Flight Data from OSIRIS-REx at Bennu (Paper SIW22-34)**
A. J. Liounis and K. Getzandanner (NASA GSFC)
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- 2:20 **New Optical Navigation Results Using Historical MESSENGER Data (Paper SIW22-35)**
V. V. Ramanan (Georgia Tech), M. A. Shoemaker (NASA GSFC), A. J. Liounis (NASA GSFC)
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- 2:40 **LOST in Space: Optimal Triangulation for Celestial Localization (Paper SIW22-36)**
S. Henry and J. Christian (Georgia Tech)
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- 3:00 **An Overview of the EXTREMA Deep-Space Optical Navigation Experiment (Paper SIW22-37)**
P. Panicucci, E. Andreis, V. Franzese, and F. Topputo (Politecnico di Milano)
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- 3:20 **BREAK**
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- 3:40 **A Vision-Based Navigation Algorithm for Autonomous Deep-Space Cruise (Paper SIW22-38)**
E. Andreis, P. Panicucci, V. Franzese, and F. Topputo (Politecnico di Milano)
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- 4:00 **Overview of Orion Docking Camera Bearing Algorithms (Paper SIW22-39)**
M. K. Whiteaker (Lockheed Martin), H. E. Reszka (Lockheed Martin), M. Samaan (Odyssey Space Research), and J. S. McCabe (NASA/JSC)



About Georgia Tech

The Georgia Institute of Technology is one of the nation's top public research universities with nearly 40,000 students who study in person at the main campus in Atlanta, at Georgia Tech-Lorraine in France, at Georgia Tech-Shenzhen in China, as well as through distance and online learning. With more than \$1 billion annually in research awards across all six Colleges and the Georgia Tech Research Institute (GTRI), Georgia Tech is among the nation's most research-intensive universities. It is an engine of economic development for the state of Georgia, the Southeast, and the nation.

Top-Ranked Aerospace Programs

The Daniel Guggenheim School of Aerospace Engineering boasts one of the oldest and largest aerospace programs in the country. Whether students want to build and fly aircraft or dream of going into space, the School's focus on problem-solving propels them into a rewarding career with many top aerospace firms and government-research labs. The U.S. News & World Report has ranked the School #1 for Best Undergraduate Aerospace Programs in the Nation (September 2022) and #4 for Best Graduate Aerospace Programs in the Nation, #1 amongst publicly-funded institutions (March 2022).

Connecting with Industry Partners

To better service our student population as well as connect with industry partners, the Guggenheim School of Aerospace Engineering recently established a Corporate Affiliates Program (CAP), which connects the aerospace community with students enrolled in our bachelor, master's and doctoral programs. The program has structured a diverse set of activities that make it easy for organizations to engage with our students and explore opportunities, such as involvement with the AE School Career Fair, specific one-on-one meetings with students, and an invitation to the School's Mentor-in Residence program to name a few.

In addition, many of our students embark on summer internships at top aerospace engineering companies and start-ups where they demonstrate their technical knowledge, as well as showcase their hands-on skill in various aerospace domains.

Research

All graduate students - and a growing number of undergraduate students - are involved in aerospace research at the School. Our research efforts are organized around eight multidisciplinary research areas:

- Space Exploration & Earth Monitoring
- Robotics, Autonomy and Human Interaction
- Sustainable Transportation & Energy Systems
- Large-Scale Computations, Data, & Analytics
- System of Systems and Complex Systems Integration
- Cyberphysical Systems, Safety, Security, & Reliability
- Mechanics of Multifunctional Structures and Materials
- Systems Integration Vertical Lift and Urban Air Mobility



3rd Space Imaging Workshop

Hosted and Organized by:
Space Exploration Analysis Laboratory (SEAL)
Space Systems Design Lab (SSDL)
Daniel Guggenheim School of Aerospace Engineering
Georgia Institute of Technology

Workshop General Chair:
Dr. John A. Christian
john.a.christian@gatech.edu

Find more information online at
<https://seal.ae.gatech.edu/workshop-2022>

