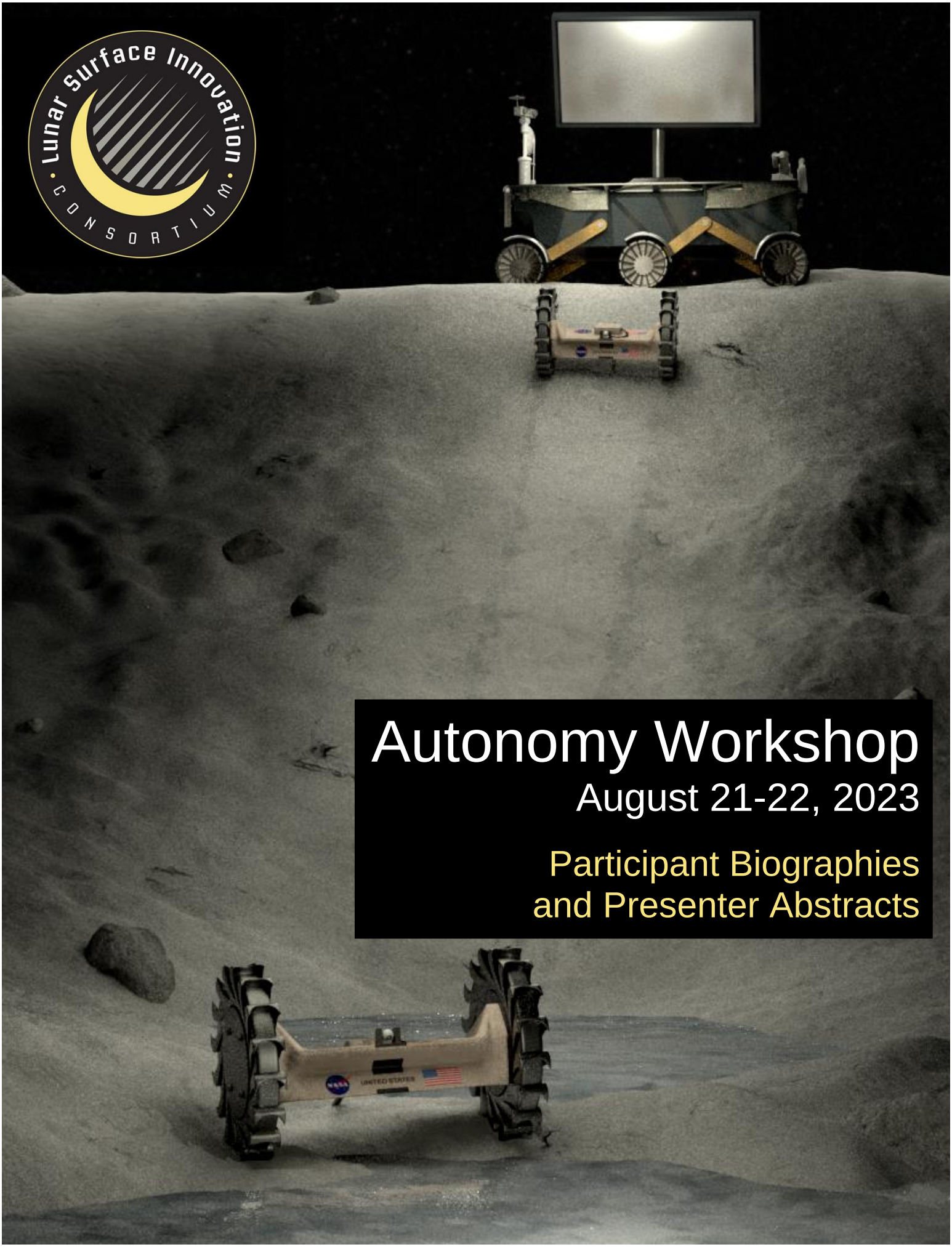


# Autonomy Workshop

August 21-22, 2023

## Participant Biographies and Presenter Abstracts

# Participants

## Presentations

Talks on autonomy-related work



## Panels

Open discussion of autonomy and the Moon

**Networking Sessions**

Intimate breakout discussions with subject matter experts

# Jim Bellingham (JHU)

**Bio:**
Dr. Bellingham is a Bloomberg Distinguished Professor of Exploration Robotics and Executive Director for the Institute for Assured Autonomy at the Johns Hopkins University. Jim founded the MIT AUV lab, co-founded Bluefin Robotics, and was founding Director of the Center for Marine Robotics at Woods Hole. He has extensive field experience including both the Arctic and Antarctic. He developed and number of Autonomous Underwater Vehicles, as well as the layered control approach to AUV autonomy, derivatives of which are common in vehicles today. He led the ONR funded Autonomous Ocean Sampling Network program, a system of systems approach to ocean prediction, that coupled fleets of robotic systems to shore-side prediction systems. His current interests revolve around assuring autonomous systems, particularly robotic systems operating in poorly understood environments.

**Title: Autonomous Systems, Humans, and Reliability**

**Abstract:**
Autonomy will assume an increasingly critical role in the realm of space exploration, spanning diverse domains. Its application will range from robots operating independently in remote and hostile environments to systems in close and continuously interaction with human counterparts. V&V of autonomous systems remains an outstanding challenge, with failure modes often coming to light only through extensive and costly experimentation. Consequently, the test, break, fix cycle can dominate cost and schedule risk in large AI systems. Further, AI systems interacting with humans have advanced rapidly recently but fall far short in many respects. In this case, the challenge is for AI to understand human objectives as well at the human cognitive and emotional state so that it can carefully structure interactions to mitigate human errors and optimize performance. Thus, while AI already offers powerful new capabilities, there are significant challenges to overcome when high reliability is critical.

# Fernando Figueroa (NASA Stennis)

**Bio:**
Dr. Fernando Figueroa received his BS Degree at the University of Hartford, CT, and MS and Ph.D. Degrees at The Pennsylvania State University, PA; all in Mechanical Engineering. He was faculty of Mechanical Engineering at Tulane University (New Orleans) for 10 years, and Associate Chair of Advanced Instrumentation and Control at The University of New Brunswick (Canada) for 2 years. He has been at NASA Stennis Space Center since 2000. He has led multiple R&D projects in collaboration with academia, industry, government agencies, and other NASA centers. He was acting Center Chief Technologist. He is a NASA Subject Matter Expert for Autonomous Systems and Operations, and lead and technical manager for projects funded by NASA Advanced Exploration Systems (now Mars Campaign Development Division), Space Technology Mission Directorate, and NASA Stennis Space Center. He is the architect and technical lead/manager for the project NASA Platform for Autonomous Systems (NPAS). His areas of interest include Autonomous Operations and Systems, Integrated System Health Management (ISHM), Intelligent Systems, Intelligent Sensors, Robotics, and Automatic Controls. In 2018, Dr. Figueroa received the NASA Exceptional Technology Achievement Medal, for exceptional accomplishments in the advancement of autonomous systems in support of ground operations and space flight missions.

**Presentation Title: Autonomy Technologies for Systems of a Moon Base**

**Abstract:**
The aim of the workshop is to “explore emerging autonomy technologies that could enable or enhance mission capabilities, reduce mission risk, and reduce mission cost.” Enhancing mission capabilities will depend on how capable and trustworthy the autonomy implemented is. As systems increase in complexity, and also with multiple interdependent/interacting systems, current autonomy capability and trustworthiness is very low. A paradigm and technology from NASA that addresses this shortcoming will be discussed, the NASA Platform for Autonomous Systems (NPAS). NPAS also happens to address reduction of mission risk and cost. NPAS will be discussed as a capability that is reaching readiness for space use, but also serves as a reference to develop technologies suitable for integrated autonomous operations of lunar systems; encompassing autonomous systems, situational awareness, and reasoning and acting.

# Alexander Pletta (Astrobotic)

**Bio:**
Alexander Pletta is a Flight Software Engineer in the Lunar Surface Systems department at Astrobotic. Prior to Astrobotic, he completed a M.S. Robotic Systems Development at Carnegie Mellon University following a double B.S. Mechanical Engineering, Computer Science at UW-Madison. His work focuses primarily on planning & navigation, localization, controls, and systems engineering, with additional breadth extending to computer vision and machine learning. He specializes in space robotics for lunar sitework autonomy with numerous previous experiences in off-road and on-road autonomous vehicles.

**Presentation Title (with Younes): The Future of Precision Lunar Localization**

**Abstract:**
Traditional planetary surface mobility platforms have historically relied on imprecise localization that excels in wide open, long distance traversal applications. The surface systems of the next century, especially within the context of Moon to Mars, however, will require high precision to enable continuous operation in dusty, high dynamic range, high speed, spectrally reflective, and texture-limited environments. Making the problem more challenging are long-term reliability requirements, especially when navigating around surface assets for construction, ISRU and increasingly complex science objectives.

This presentation will focus on discussing the localization difficulties posed by these challenges, tradeoffs in sensing modalities, and recommendations for future technology development to assess and de-risk potential approaches. Discussion will revolve around overcoming the unique environmental constraints inherent to robotic sitework in a lunar environment. Additional presentation emphasis will be on robotic total stations and their applicability to lunar sitework robotics as a particularly promising sensing modality. Lessons learned exploring this modality within a lunar construction context will be shared.

# Benjamin Younes (Astrobotic)

**Bio:**
Mr. Younes is a Flight Software Engineer in the Lunar Surface Systems department of Astrobotic, drawing on a broad background of previous flight experience. Benjamin has had contributions to the Mars 2020 Rover, Mars Sample Return Mission, Dragonfly Mission to Titan, and the VIPER Rover, just to name a few. A holistic "big picture view" of end-to-end robotic aerospace systems gives Ben insight to solving the most challenging multidisciplinary problems. Ben received a B.S. in Aerospace Engineering at California State Polytechnic University, Pomona, and an M.S. in Robotic Systems Development from the Robotics Institute at Carnegie Mellon University.

**Presentation Title (with Pletta): The Future of Precision Lunar Localization**

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# David Handelman (JHUAPL)

**Bio:**
David Handelman is a Senior Roboticist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He is a member of the Robotics Group in the Intelligent Systems Branch of the Research and Exploratory Development Department. He received a B.S. in Aerospace Engineering from the University of Virginia, and a Ph.D. in Mechanical and Aerospace Engineering from Princeton University. His research interests include robotics, artificial intelligence, machine learning, dexterous manipulation, and human-robot teaming.

**Title: Intuitive Delay-Tolerant Control of Dexterous Dual-Arm Robots**

**Abstract:**
The Johns Hopkins University Applied Physics Laboratory has developed a system that enables a human operator to easily control a dexterous dual-arm robot, even if large distances between the operator and robot cause significant communication time delays. Using an immersive mixed-reality interface, the operator first performs part of the task in real time using a simulated model of the robot. When the operator is satisfied with the motion, commands are sent to the robot, and returned 3D data is used to confirm robot performance. This iterative model-mediated control approach will enable remote operators to help robots complete tasks that are beyond the ability of autonomy.

# Lynn Reggia (JHUAPL)

**Bio:**
Lynn Reggia is the Supervisor of the Human-Machine Engineering Group within the Air and Missile Defense Sector at The Johns Hopkins University Applied Physics Laboratory (JHU/APL). She graduated in 2008 from University of Maryland with dual Bachelor's degrees in Computer Science and Piano Performance, then went on to earn her Master's in Human Systems Engineering from Johns Hopkins University in 2013. Professionally, her early contributions included modeling, simulation, and analysis for the U.S. Navy. After acquiring her M.S. and discovering her true passion for warfighter advocacy and creating systems and capabilities through human-centered design, she drove the strategic establishment of the team that she now leads.

**Presentation Title: Human-Machine Teaming Challenges for Future Operations**

**Abstract:**
As we consider how to advance and innovate across domains ranging from commercial delivery, to military, to space – advancing the state of the art of technology and machines to perform as teammates to our humans, rather than just tools, will be vital. Human-Machine Teaming is not new, but advances in Artificial Intelligence and robotics are opening a new frontier of both opportunities and challenges for developers, users, and policy makers. A high-level overview of how one team at JHU/APL thinks about this area will be offered in this session.

# Eddie Tunstel (Motiv)

**Bio:**
Edward Tunstel received B.S. and M.E. degrees in mechanical engineering from Howard University and the Ph.D. in electrical engineering from University of New Mexico. He is the CTO at Motiv Space Systems, Inc. since 2021, following several years as Robotics Associate Director and Group Leader at Raytheon Technologies Research Center, a decade at Johns Hopkins APL as a Senior Roboticist in its Intelligent Systems Center and Space Robotics & Autonomous Control Lead in its space department, and 18 years at NASA JPL as a Senior Robotics Engineer and Advanced Robotic Controls Group Lead. He worked on the NASA MER mission as flight systems engineer for autonomous navigation and as surface mission operations lead for mobility & robotic arm subsystems. He is the Sr. Past President of the IEEE SMC Society and an IEEE Fellow with over 180 publications in his areas of research interest including autonomous, cooperative and human-collaborative robotics.

**Presentation Title: Human-Collaborative Robotic Autonomy: Earth-Moon Maturation**

**Abstract:**
The promise of autonomous systems as applied to collaborative operations is clear, and approaches to human-autonomy interaction continue to evolve and improve. On Earth, there are many examples of collaborative robotic system applications and a growing number of human-robot systems that exhibit sufficient technological maturity and performance. The same should apply to surface operations involving autonomy and collaboration on the Moon. Development gaps hindering direct transfer of such capabilities to the lunar surface environment are associated with effectiveness, robustness, and survivability in that domain, more so than with the autonomy technology itself. Most technology gaps may in fact be associated with hardware that can host and execute the autonomy. This brief talk aims to share and support this perspective by highlighting related R&D that has been quite active within fundamental and applied robotics research in past decades, including as driven directly by envisioned lunar and planetary surface mission applications. In lieu of mission opportunities involving more than one surface asset, Earth-proven technology has not undergone the necessary tailoring and forging to achieve readiness for infusion into collaborative lunar or planetary surface systems. With deliberation now resurfacing with the prospect of real missions in mind, some thoughts are shared on what is needed.

# Julia Badger (NASA JSC)

**Bio:**
Dr. Julia Badger is the Autonomy and Vehicle Systems Manager (VSM) system manager for the Gateway program at NASA-Johnson Space Center. She also serves as the Autonomous Systems Technical Discipline Lead for JSC. She is responsible for the autonomous control system specification and design for the Gateway, as well as playing a leading role in driving autonomous systems technology research and development for human spaceflight. Julia has a BS from Purdue, and an MS and PhD from Caltech, all in Mechanical Engineering.

**Presentation Title: Gateway – Autonomous Control of Human Spacecraft**

**Abstract:**
NASA's Lunar Gateway is meant to provide a stepping stone to sustained human presence beyond low Earth orbit, and represents a cornerstone of technology maturation for the entire Artemis campaign. One significant Moon to Mars outlook espoused by Gateway is the concept of autonomous vehicle control, independent of ground control, in crewed and uncrewed configurations. This independence is achieved by many architectural design decisions, one of them being the addition of the Vehicle Systems Manager (VSM) as the highest level onboard software control system and its associated hierarchical and distributed Autonomous Systems Management Architecture over the modules and systems that make up Gateway. This talk will discuss the novel VSM system and its application to human spaceflight in lunar orbit.

# Neil Dantam (CSM)

**Bio:**
Neil T. Dantam is an Associate Professor of Computer Science at the Colorado School of Mines. His work focuses on robot planning and manipulation, covering task and motion planning, kinematics, robot communication, and real-time software. This research program is supported by the NSF, NASA, Army Research Lab, and Office of Naval Research.

Previously, Neil was a Postdoctoral Research Associate in Computer Science at Rice University working with Prof. Lydia Kavraki and Prof. Swarat Chaudhuri. Neil received a Ph.D. in Robotics from Georgia Tech, advised by Prof. Mike Stilman, and B.S. degrees in Computer Science and Mechanical Engineering from Purdue University. He has worked at iRobot Research, MIT Lincoln Laboratory, and Raytheon. Neil received the Georgia Tech President's Fellowship, the Georgia Tech/SAIC paper award, an American Control Conference '12 presentation award, was a Best Paper and Mike Stilman Award finalist at HUMANOIDS '14, and was a Best Paper in Cognitive Robotics finalist at IROS '21.

**Title: Autonomous Site Preparation: Excavation, Compaction, and Testing (ASPECT)**

**Abstract:**
The Autonomous Site Preparation: Excavation, Compaction, and Testing (ASPECT) project is a NASA LuSTR funded project to demonstrate autonomous site preparation of the lunar surface for the construction of lunar landing pads. Landing pads are needed on the Moon to ensure safe and reliable human access to the surface. The first step in building a lunar landing pad is clearing a site of rocks, filling craters with regolith, and leveling, smoothing, and compacting the surface. The ASPECT project is building a ground demonstration unit for surface preparation capable of autonomous task planning with no human intervention.

# Doug Morrison (CEMI)

**Bio:**
Douglas Morrison has over 40 years of mining experience, beginning in engineering of deep underground metal mines in Canada, and consulting internationally on mine safety and productivity. His focus has always been on safety and innovation, and he recognizes that the current technology platforms for mine production and mine tailings management must be transformed if mining is to meet the metal demand for the Energy Transition to a low-carbon economy and help arrest Climate Change.

At CEMI, Doug is directing the development of the continuous, autonomous technologies that are essential for mines to dramatically improve their productive capacity at lower cost. CEMI has also supported the development of solutions to improve mine waste management practices by processing mine waste and eliminating long-term storage of mine tailings. These technologies will transform the mining industry and help it integrate with the other natural resource sectors of agriculture and forestry, operate in harmony with indigenous and agricultural communities to create more sustainable and self-sustaining outcomes. CEMI's MICA Network is seeking solution providers in every sector of the economy to help the mining become more productive, profitable, and socially and environmentally progressive.

**Presentation Title: Mining Technologies for Lunar Surface Infrastructure**

**Abstract:**
It is 35 years since the metal mining industry made any significant change in its production technology platform and for the last 20 years costs have increased, and productivity has declined. The need to electrify the global economy requires current mine production systems to be transformed if mining is to meet the huge demand increase for metals by 2035. Increasing economies of scale further is not feasible, so the only option is smaller, more effective machines working autonomously, in concert, so mines can produce more metals at prices that out-compete fossil fuels. The mining industry cannot make a transformation of this magnitude without help. Similar autonomous production systems are necessary to build lunar surface infrastructure at scale in the next 10 years, and this convergence of technological imperatives allows the Mining and Space Sectors to operate synergistically, and helps the Space Sector to contribute to reversing Climate Change on Earth.

# Kostas Alexis (NTNU)

**Bio:**
Kostas Alexis is Full Professor at the Department of Engineering Cybernetics of the Norwegian University of Science and Technology (NTNU). Highlights of his research include leading Team CERBERUS winning the DAPRA Subterranean Challenge and a host of contributions in the domain of resilient robotic autonomy – in perception, planning and control including learned navigation policies. Earlier research has included contributions in setting the endurance world-record for UAVs in the below 50kg class with AtlantikSolar flying continuously for 81.5 hours. Since becoming professor, initially in the US and then in Norway, he has been the PI for a host of grants from NSF, DARPA, NASA, DOE, USDA, Horizon Europe, the Research Council of Norway and other public and private sources.

**Presentation Title: Resilient Robotic Autonomy: Methods and Systems**

**Abstract:**
Robotic systems are tasked to operate in an ever-expanding set of environments and conditions. Major breakthroughs in the state-of-the-art have allowed autonomous robots to "conquer" a wide variety of indoor and outdoor settings, yet a multitude of environments remains challenging if not beyond reach. Examples include perceptually degraded GNSS-denied settings with involved confined geometries, clutter, and possibly other dynamic agents. Progress in all individual subdomains of autonomy, from localization and mapping to control and planning, supports the goal of resilience but individually may not be sufficient. In this talk we present a perspective on how to instill resilience in autonomous robots and how a holistic treatment of embodiment, perception and autonomy allows to facilitate robust performance, redundancy against degradation of sensors (or other faults) and overall resourcefulness in the ability of the robot to maintain its autonomous operational capacity despite challenges and adversities. We support this discussion with a selected set of diverse results including those of Team CERBERUS winning the DARPA Subterranean Challenge, as well as earlier and later work from various settings and mission profiles including multiple robot configurations.

# Ed Brouwers (JHUAPL)

**Bio:**
Ed Brouwers is an autonomy framework developer and autonomy test engineer within the Intelligent Combat Platforms Group at JHU/APL. He has overseen the development/validation of autonomy frameworks for multiple autonomous approaches to complex problems on complex systems. Testing has included classic SIL/HIL, but also hybridized testing specific to unique systems prior to multiple rounds of flight testing.

**Presentation Title: Test and Evaluation of Autonomous Systems**

**Abstract:**
Test and evaluation of autonomous systems is as complex as designing and building the autonomy/system itself. Features need to be instantiated in the autonomy framework from the start of development to enable the safe and efficient stimulation of the system in ways that emphasize explain-ability. Many RL/ML approaches result in non-deterministic agents that require significant stimulation repetition to generate a full understanding of behavior. Interactions between multiple autonomous systems, especially ones that operate at different control levels and time scales need special attention.

# Craig Knuth (JHUAPL)

**Bio:**
Craig Knuth is a Robotics Research Scientist with the Johns Hopkins University Applied Physics Laboratory. He specializes in applications of machine learning techniques to autonomous navigation that utilize statistical analysis techniques to consequently guarantee safety and robustness. He also researches topics in test and evaluation of autonomous systems, heterogeneous robotic teams, and advanced robotic control. He has applied these approaches to a wide variety of robotic systems and environments, including satellites, robotic arms, fixed wing flying robots, and ground vehicles on Earth and on the moon. He holds a B.S. in Computer Science and a B.S. in Mathematics from the University of Wisconsin-Madison. He holds a M.S. in Robotics from the University of Michigan.

**Presentation Title: Challenges in Developing Advanced Autonomous Navigation for the Moon**

**Abstract:**
Advanced autonomous navigation will provide a critical backbone to autonomous operations on the moon. Navigating from point A to point B safely, efficiently, and quickly enables essential logistic productivity in support of a lunar base and science missions. Recent advances in autonomous navigation on Earth progress towards solving critical navigation challenges, e.g. quadruped navigation over challenging terrain and fast navigation in unstructured environments. However, a number of barriers exist in translating these methods to the moon including extreme environments, reduced human guidance and intervention, lack of relevant and high-quality data, and trust and assurance. I will discuss each of these challenges, how many of these challenges are relevant beyond navigation, and propose potential solutions to enable sustained deployment of autonomous resources on the moon.

# Rama Chellappa (JHU)

**Bio:**
Prof. Rama Chellappa is a Bloomberg Distinguished Professor in the Departments of Electrical and Computer Engineering and Biomedical Engineering at Johns Hopkins University (JHU). At JHU, he is also affiliated with CIS, CLSP, IAA, and MINDS. He holds a non-tenured position as a College Park Professor in the ECE department at UMD. His researcher interests are in computer vision, pattern recognition, machine learning and artificial intelligence. He received the 2012 K. S. Fu Prize from the International Association of Pattern Recognition (IAPR). He is a recipient of the Society, Technical Achievement, and Meritorious Service Awards from the IEEE Signal Processing Society, the Technical Achievement and Meritorious Service Awards from the IEEE Computer Society and the Inaugural Leadership Award from the IEEE Biometrics Council. He received the 2020 IEEE Jack S. Kilby Medal for Signal Processing. He is an elected member of the National Academy of Engineering. He is a Fellow of AAAI, AAAS, ACM, AIMBE, IAPR, IEEE, NAI, OSA, and the Washington Academy of Sciences and holds nine patents.

# Emma Holmes (JHUAPL)

**Bio:**
Emma Holmes is an associate staff robotics engineer focused on robotic control and intelligence. Her research interests span many branches of robotics, including robotic navigation, control of quadrupedal robots, multi-domain robots, heterogeneous robotic teaming, and human-robot teaming. Her current projects include the development of quadruped behaviors for medic-robot teaming, the development of a robotic mission planner that includes semantic information for navigational decision-making, and the integration of an underwater crawling vehicle on a heterogeneous robotic team.

# Andrew Petruska (CSM)

**Bio:**
Dr. Andrew J Petruska joined Colorado School of Mines, Golden, in 2016, where he is currently a tenured Professor of Mechanical Engineering and the Director of the Robotics Interdisciplinary Graduate Program. He holds a Doctorate in Mechanical Engineering (Robotics) from the University of Utah, Salt Lake City, and dual B.S. degrees in Mechanical Engineering and Physics as well as an M.S. degree in Mechanical Engineering from Carnegie Mellon University, Pittsburgh. Prior to returning for his Ph.D. in 2010, Dr. Petruska worked as a design engineer responsible for designing, testing, and qualifying solid rocket motor components. During his PhD, he was awarded an NSF IGERT Traineeship to study noncontact magnetic manipulation and developed the first real-time reconfigurable magnetic manipulation system. During his PostDoc at the Multiscale Robotics Laboratory at ETH Zurich he was awarded a Max Planck ETH Center for Learning Systems fellowship and investigated the magnetic manipulation of needles, endoscopes, and catheters. He developed the first real-time magnetic control of magnetic catheters with multiple magnetic segments. After joining the faculty at Mines he was named a Boettcher Investigator for his work on magnetic guidance for Neurosurgical procedures and has developed numerous systems for controlling and modeling flexible magnetic devices. His current research focus has pivoted to perception, state estimation, and control in GPS denied environments for applications ranging from underground mining, search for rescue, tactical maneuvering, on-orbit manufacturing, to lunar construction navigation and mining.

# Edward Chow (NASA JPL)

**Bio:**

Dr. Edward Chow is the Manager of the Civil Program Office at the NASA Jet Propulsion Laboratory (JPL). He also served as the project manager/principal investigator/investigator for a number Artificial Intelligent (AI), advanced networking, and cybersecurity projects such as the Real-time Automated Insight Engine for Data to Decision (RAID) Project funded by OSD T&E S&T C4T to develop the next generation AI technologies to enable human-like automated data analytics for testing of complex system; the cloud-based AI agent called AUDREY for the Department of Homeland Security (DHS) Next Generation First Responder Program; the Trusted and exPlainable Artificial Intelligence for Saving Lives (TruePAL) project for the National Highway Traffic Safety Administration to reduce the traffic accidents for first responder vehicles; a high performance 5G edge computing project for DHS; a zero-day exploit detection project. Dr. Chow also served as a Research Associate Professor at the University of Southern California where he taught graduate level classes for five years. Dr. Chow received his Ph.D. in Electrical Engineering from the University of Southern California in 1988. Dr. Chow is the recipient of the prestigious NASA Exceptional Engineering Achievement Medal and the JPL Lew Allen Award.

# Grace Gao (Stanford)

**Bio:**
Grace Gao is an assistant professor in the Department of Aeronautics and Astronautics at Stanford University. She leads the Navigation and Autonomous Vehicles Laboratory (NAV Lab). Before joining Stanford University, she was faculty at University of Illinois at Urbana-Champaign. She obtained her Ph.D. degree at Stanford University. Her research is on robust and secure perception, localization and navigation with applications to manned and unmanned aerial vehicles, autonomous driving cars, as well as space robotics.

# Julie Obenauer-Motley (JHUAPL)

**Bio:**
Dr. Julie Obenauer-Motley is a Senior National Security Analyst and Section Supervisor in the National Security Analysis Department and has lead a variety of efforts focused on artificial intelligence (AI), human enhancement technology (HET), and responsible technology development. They have shaped and led analyses on a wide variety of topics, with a primary focus on AI and HET. Their analytical efforts include developing implementation frameworks for AI development, analyzing the potential ethical, legal, and social implications of HET, and working with stakeholders to identify and deploy AI best practices throughout the development lifecycle.

Julie earned a BA in the History of Science, Technology, and Medicine from the University of Florida and subsequently received an MHS in Epidemiology from the Johns Hopkins Bloomberg School of Public Health and DrPH from East Tennessee State University. Julie's dissertation focused on machine learning in predictive geospatial modeling to identify areas of potential Aedes aegypti vector expansion due to climate change and human population movement.

# Kris Zacny

**Bio:**
Dr. Kris Zacny is VP and Senior Research Scientist at Honeybee Robotics. His interests include space mining, sample handling, soil and rock mechanics, extraterrestrial drilling, and In Situ Resource Utilization (ISRU). He co-founded Exploration Systems Division (EX), based in Altadena, CA. EX, with over 200 employees, focuses on developing space robots.

In his previous capacity as an engineer in South African underground mines, Dr. Zacny managed numerous mining projects and production divisions. This hands-on experience related to drilling and mining became invaluable in developing such technologies for space. Dr. Zacny received his PhD (UC Berkeley, 2005) in Extraterrestrial Drilling and Mining, ME (UC Berkeley, 2001) in Petroleum Engineering, and BSc cum laude (U. Cape Town, 1997) in Mechanical Engineering. He participated in several Antarctic, Arctic, Atacama, and Greenland expeditions. Dr Zacny has over 200 publications, and several NASA Group Achievement Awards. Dr. Zacny is a Principal Investigator on PlanetVac pneumatic sample delivery system, as well as two TRIDENT lunar drills scheduled to fly on VIPER rover and PRIME-1 lander missions.

# Terry Fong (NASA Ames)

**Bio:**
Terry Fong is the Deputy Rover Manager and the Co-Lead Rover Driver for NASA's VIPER lunar rover mission. He is also Chief Roboticist and former Director of the Intelligent Robotics Group at the Ames Research Center.

Terry previously was NASA's Senior Scientist for Autonomous Systems in support of the Space Technology Mission Directorate. Terry led development of the Astrobee free-flying robot, which was installed on the Space Station in 2019. Terry has published more than 150 papers in space and field robotics, human-robot interaction, virtual reality, and planetary mapping. Terry received his B.S. and M.S. in Aeronautics and Astronautics from MIT and his Ph.D. in Robotics from Carnegie Mellon University.

# Alhassan Yasin (JHUAPL)

**Bio:**
Dr. Yasin is a multidisciplinary scientist working and researching at the intersections of four topics: (1) theoretical and applied physics, (2) machine learning and artificial intelligence, (3) bioinformatics, and (4) mechanical and aerospace engineering. He is a Senior Research Scientist with the Johns Hopkins University Applied Physics Laboratory, Lecturer at Johns Hopkins University, and Leads NASA's LSIC autonomy groups for Extreme Access and Excavation and Construction. Overall, in his academic and professional career he has had the privilege and honor to work with amazing students, faculty, researchers, educators, mentors, and scholars from academia and industry. He is actively working and developing various frameworks with the aim of providing a sustainable footprint in our evolving society. Most of the research aims at developing better approaches to solving multi-process challenges. Some of the areas that are critical to our future and currently his group pursues are biomedical/healthcare, human factor, security of control systems and formal methods, Cyber Physical Systems (CPS), Digital Twins, risk and assurance of autonomous agents, robotics, understanding how to assess risk in complex systems and design optimal security controls measurably based on that and possibly automating some of the processes through formal models and intelligent algorithms. Much of his work is motivated by and related to the diversity in thinking and perspective as applied to technology, ecosystem, ethics, and governance. The work is and will be at the heart of public policy questions and debates in many future conversations. His research aims at contributing to the improvement of society and all that interact with and govern it. The debate over the most effective health, technology, and human policy interventions and social welfare are to be expected and must be addressed to better target improvement to the health and well-being of our society. Ultimately, his group research aims to inform scholarly, policy, and the general public about the social consequences of technology on our society and policies by capturing its short- and long-term effects on the well-being of all lives.

# Julia Antoniou (MathWorks)

**Bio:**
Julia Antoniou is a Senior Application Engineer for the aerospace and defense industry at MathWorks. She specializes in modeling and simulation of physical systems, with a focus on robotic and autonomous systems. She has significant experience working with robotics engineers across industries, including manufacturers of large construction vehicles where she helped them implement autonomous navigation algorithms for various types of heavy equipment. Julia has also assisted design engineers at space-focused government entities develop dynamic simulations of vehicles and environments.

Julia is a recognized expert in autonomy and has presented on autonomous navigation and environment simulation at AGV-focused summits and large engineering-focused virtual events, such as MATLAB Expo. She has also developed MATLAB reference applications for developing autonomous navigation algorithms. She holds BS and MS degrees in mechanical engineering from Northeastern University. Prior to joining MathWorks in 2017, Julia has worked at companies such as iRobot and Johnson & Johnson in their mechanical engineering, systems engineering, and manufacturing engineering departments.

# Cam Dickinson (MDA)

**Bio:**
Cam's work at MDA includes designing and developing scientific instruments for Planetary exploration. He is technical lead for the OSIRIS Laser Altimeter, which reached the asteroid Bennu in fall of 2018, and will return a sample in 2023. He was also the technical lead for Replacement CAMeras on the International Space Station (RCAM), which is currently being manufactured for the Canadian Space Agency. More recently, he has been working on different methodologies of introducing Artificial Intelligence (AI) into the Canadarm3 architecture, and was the Vision System Architect for Canadarm3 for the initial phase of development. He is currently working a number of different R&D initiatives relating to manipulators and autonomy on the Lunar surface.

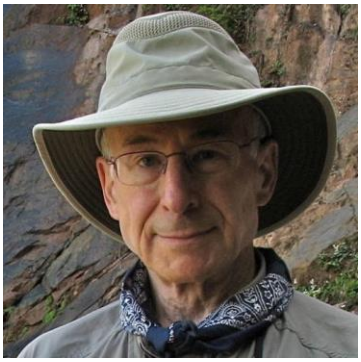
# Becca Bonham-Carter (MCSS)

**Bio:**
Becca Bonham-Carter is an embedded software engineer in the autonomy team at Mission Control where they work on autonomous systems for spacecraft. Their work focuses on deploying machine learning algorithms on spacecraft hardware for increased autonomy of rovers, landers and satellites. Their projects have included technology for Earth orbit, and on the Moon and Mars. Recent projects include the MoonNet neural network lunar demonstration which flew aboard the ispace M1 lunar lander, and a neural network deployment studyfor earth observation on ESA's OPS-SAT satellite. In previous work at Mission Control, Becca developed novel light-weight neural networks for the ASAS-CRATERS project with the Canadian Space Agency, and deployed real-time terrain classifiers and novelty detectors during the NASA-funded SAND-E Mars analogue mission in Iceland. Becca holds a B.A.Sc in Mathematics and Engineering from Queen’s University, and a M.Sc in Applied Mathematics from the University of British Columbia.

Thomas Cheng (JHUAPL)

Bob Chalmers (JHUAPL)

# John Gersh (JHUAPL)



**Bio:**

John Gersh is a Principal Cognitive Engineer in the AI Group of the Johns Hopkins University Applied Physics Laboratory's Research and Exploratory Development Department. He has worked on human interaction with complex, automated, and autonomous systems since 1980. He has been the Principal Investigator for several research projects investigating human interaction with automation and with systems acting autonomously. Applications of this work have involved naval combat systems, ground control systems for autonomous spacecraft, and mixed-initiative intelligence analysis and reporting. Much of this work focused on the contextual depiction of automated and autonomous systems' state, actions, and expected behavior.

Mr. Gersh was involved in the design and engineering of human interaction with Navy weapon system automation and chaired several Navy working groups on automation design and coordination. Mr. Gersh did similar design work for other DoD shipboard and intelligence analysis systems. Recent work has focused on human interaction with systems which include artificial intelligence and machine learning components, in particular investigating how people form mental models of system function and capability. He is also involved in studies addressing trust in the context of human-machine teaming,

Mr. Gersh has taught courses in user interaction design and human-systems engineering in the Johns Hopkins Whiting School of Engineering's Engineering for Professionals program and taught human-machine teaming in an internal JHU/APL course.

Mr. Gersh has been a Hertz Foundation Fellow and a Sigma Xi Distinguished Lecturer. He received degrees in Electrical Engineering from M.I.T (S.B. 1973, S.M. 1973, E.E. 1979) and also studied philosophy at Harvard. He holds an FAA Commercial Pilot certificate.

Matthew Fifer (JHUAPL)

# Bobby Wilson (JHUAPL)

**Bio:**
Bobby Wilson is a Senior Research Engineer in the Health & Human-Machine Systems Group inside AOS. His background is rooted in Biomedical Engineering with a throughline revolving around improving human performance in austere environments through HMT. Previously, he served as Co-PI of a HSR study using VR and HMT for lunar exploration in a field robotics context and currently focuses on architecture design for patient monitoring in remote low resource environments and non-contact biometric measurements. His long-term efforts are aimed at informing the machine on the state of the human through online models of psychophysiology.

Bob Bamberger (JHUAPL)

# Amir Rahmani (NASA JPL)

**Bio:**
Dr. Amir Rahmani is the technical group supervisor of the multi-agent autonomy group at NASA's Jet Propulsion Laboratory. Amir has a Ph.D. from University of Washington in Aeronautics and Astronautics and was an assistant professor of Aerospace Engineering at the University of Miami prior to joining JPL. He has over 15 years of research experience in distributed space systems, formation flying, networked dynamical systems, as well as swarm robotics. Amir is overseeing a number of projects on autonomy technologies for spacecraft and planetary robot teams. He is the NASA STTR subtopic manager on coordination and control of swarms of space vehicles.

Issa Nesnas (NASA JPL)

Danette Allen (NASA Langley)

# Kristen John (NASA)


**Bio:**
Dr. Kristen John is the Technical Integration Manager for Lunar Dust Mitigation for the Space Technology Mission Directorate at NASA. Her focus is on finding technology solutions for dust mitigation, and working across multiple programs and projects on their dust mitigation strategies. Prior to Artemis, Dr. John spent several years studying asteroid regolith and sent several payloads to the International Space Station. Kristen received her Bachelors from The University of Texas at Austin in Aerospace Engineering, and her Masters and Ph.D. in Aerospace Engineering from Caltech.

# Saptarshi Bandyopadhyay (NASA JPL)

**Bio:**
Dr. Saptarshi Bandyopadhyay is a robotics technologist at the NASA Jet Propulsion Laboratory, California Institute of Technology, where he develops novel algorithms for future multi-agent and swarm missions. In 2020, he was named a NASA NIAC fellow for his work on the Lunar Crater Radio Telescope on the far side of the Moon. He received his Ph.D. in Aerospace Engineering in 2016 from the University of Illinois at Urbana-Champaign, USA, where he specialized in probabilistic swarm guidance and distributed estimation. He earned his bachelor's and master's degrees in Aerospace Engineering in 2010 from the Indian Institute of Technology Bombay, India, where as an undergraduate, he co-founded and led the institute's student satellite project, Pratham, which was launched into low Earth orbit in September 2016. His engineering expertise stems from a long-standing interest in the science underlying space missions, since winning the gold medal for India at the 9th International Astronomy Olympiad held in Ukraine in 2004.

Currently, Saptarshi is focused on conceptualizing space missions that can leverage the unique capabilities of multiple spacecraft. His research interests include understanding the evolution of the Solar System by probing the interiors of small bodies, using interferometry to image exoplanets and gain insights into the origin of life and our place in the Universe, as well as developing autonomous spacecraft. He has published more than 70 papers in journals and refereed conferences.

James Curbo (JHUAPL)