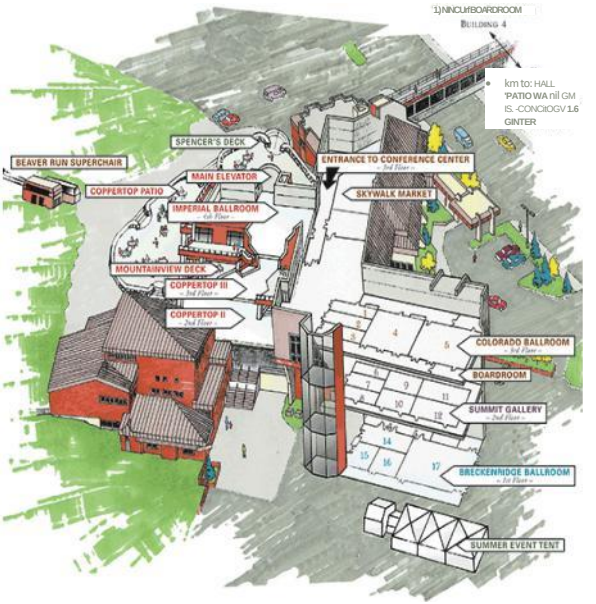
PROGRAM

43rd ANNUAL AAS GUIDANCE, NAVIGATION & CONTROL CONFERENCE

January 30th to February 5th, 2020

American Astronautical Society
Rocky Mountain Section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COPPERTOP III
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COLORADO BALLROOM
BOARDROOM
SUMMIT GALLERY
BRECKENRIDGE BALLROOM
SUMMER EVENT TENT

CLASSIFIED SESSION
Classified Advances in GN&C and Classified Recent Experiences

THURSDAY JANUARY 30TH
Registration and Breakfast
8:00-9:00 AM

FRIDAY JANUARY 31ST
Registration and Breakfast
8:00-8:30 AM

Pre-registration by Jan 18, 2020 is required and will be controlled (walk-ins will NOT be admitted). Attendees must register for the entire AAS conference to be eligible to attend classified sessions. Contact a local chairperson for more information.

Location of Classified Session:

Aerospace Corporation
Colorado Springs Conference Facility
Colorado Springs, CO

Traditional Conference Location

BEAVER RUN
CONFERENCE CENTER
Breckenridge, Colorado

Room check-in at the Beaver Run Resort
front desk 4:00 PM daily

Conference Registration

Friday 5:00 to 8:00 PM
Daily 6:30 to 10:00 AM and 4:00 to 6:00 PM

Registration Questions

Michelle Barath	303-887-7724
Amy Delay	303-731-9876

43rd Annual AAS Guidance, Navigation & Control Conference Chairperson

Jastesh Sud
Lockheed Martin Space
303-919-8453
jastesh.sud@lmco.com

Wi-Fi Access

Select "Beaver Run Meeting" wireless network.
Open a browser window
Enter voucher code: **AAS2020**

Conference Website

https://aas-rocky-mountain-section.org/

Pre-print Paper Access (read-only)

https://tinyurl.com/aasgnc2020

Conference Schedule Overview

Thursday January 30th

Badging and Breakfast	8 – 9 AM
Classified Session	9 AM – 4:30 PM

Friday January 31st

Badging and Breakfast	8 – 8:30 AM
Classified Session	9 AM – 4:30 PM
Conference Registration	5 – 8 PM
Welcome Reception	6 – 9 PM

Saturday February 1st

Breakfast	6:15 AM – 7:00 AM
Morning Sessions	7 – 10 AM
AAS STEM SCAPE	10:30 AM – 4:00 PM
NASA Astronaut for Children	4 – 5 PM
Technical Exhibits	5 – 7 PM

Sunday February 2nd

Breakfast	6:15 AM – 7:00 AM
Morning Sessions	7 – 10:30 AM
Poster Session Break	8:30 – 9:00 AM
Afternoon Session	1:30 – 4 PM
Super Bowl in Imperial Ballroom	4:15 PM

Monday February 3rd

Breakfast	6:15 AM – 7:00 AM
Morning Sessions	7 – 10 AM
Afternoon Sessions	4 – 6 PM
Networking & Career Event	6:30 – 7:30 PM

Tuesday February 4th

Breakfast	6:15 AM – 7:00 AM
Morning Sessions	7 – 10 AM
Workshop/Tutorial	12:30 – 3:30 PM
Afternoon Sessions	4 – 7 PM

Wednesday February 5th

Breakfast	6:15 AM – 7:00 AM
Morning Session	7 – 10:00 AM

SATURDAY, FEBRUARY 1ST
7AM CONFERENCE OPENING

Session I Saturday 7:00-10:00 AM

STUDENT INNOVATIONS IN GN&C

This session embraces the wealth of research and innovative projects related to spacecraft GN&C being accomplished in the university setting. Papers in this session address hardware/software research as well as component, system or simulation advances. Papers submitted must have a student as the primary author and presenter. Papers will be adjudicated based on level of innovation, complexity of problem solved, perceived technical readiness level, applicability and field-ability to near-term systems, clarity of written and verbal delivery, number of completed years of schooling and adherence to delivery schedule. The session will be limited to 8 papers with the top 3 papers receiving monetary awards.

National Chairpersons
Luke Sauter, USAF
luke.sauter@usafa.edu
David Geller, Utah State University
david.geller@usu.edu

Local Chairpersons
Ian Gravseth, Ball Aerospace
igravset@ball.com
Heidi Hallowell, Ball Aerospace
hhallowe@ball.com

20-011 **Autonomous Guidance for Robust Achievement of Science Observations around Small Bodies**
Kenshiro Oguri, Jay McMahon
(University of Colorado at Boulder)

20-012 **Root Locus Analysis of the Ground-to-Space Geolocation Problem**
Christopher Ertl, Steven Beseler, and John Christian (Rensselaer Polytechnic Institute)

20-013 **Withdrawn**

20-014 **L1-Moon Transfers to Polar Quasi-Frozen Orbits Using Invariant Manifolds**
Sandeep Singh (Texas A&M University), Robyn Woollands (JPL-CalTech), Ehsan Taheri (University of Auburn)

20-015 **Hybrid Strategy for Fuel-Optimal Trajectory Optimization using Solar Electric Propulsion and Hyperbolic Tangent Smoothing**
Vishala Arya (Texas A&M University), Ehsan Taheri (University of Auburn), Robyn Woollands (JPL-CalTech), John L Junkins (Texas A&M University)

20-016 **The Design of a Space-based Observation and Tracking System for Interstellar Objects**
Ravi Nallapu, Jekan Thangavelautham (University of Arizona – SpaceTREx Laboratory)

20-017 **Investigation of Prandtl-Ishlinskii Hysteresis Compensation for Deep Space Optical Communications Pointing Control**
Lindsey Marinello (Johns Hopkins University – APL), John Y. Liu (JPL-CalTech)

20-018 **Multifunctional Structures for Spacecraft Attitude Control**
Vedant, Albert Patterson, and James T Allison (University of Illinois – Urbana Champaign)

AAS STEM-SCAPE Event

Saturday 10:30 AM-4:00 PM

In 2020, we will be hosting an annual STEM event for 100 high school students of diverse background from across the Denver metropolitan area. The event, called AAS STEM-SCAPE for "Student Career Arcs to Professional Engineers," will trace the elements of a successful career journey in aerospace including High School and University education, initial employment and ultimately a rewarding profession. The keynote speaker will be followed by a STEM career panel. The event concludes with a short design project that will be co-led with student volunteers from the University of Colorado.

Michael Drews, Lockheed Martin Space
michael.e.drews@lmco.com
Meredith Stephens, Ball Aerospace
mlstephe@ball.com

Special Event for Children of Conference Attendees at 4 PM

Imperial Ballroom

NASA Astronaut, Janet Kavandi

This presentation will inspire our next generation of engineers by offering kids the opportunity to interact with an astronaut who flew three STS missions!

TECHNICAL EXHIBITS
Saturday 5:00 PM – 7:00 PM

The Technical Exhibits Session is a unique opportunity to observe displays and demonstrations of state-of-the-art hardware, design and analysis tools, and services applicable to advancement of guidance, navigation, and control technology. The latest commercial tools for GN&C simulations, analysis, and graphical displays are demonstrated in a hands-on, interactive environment, including lessons learned and undocumented features. Come enjoy excellent complimentary hors d'oeuvres and interact with the technical representatives and authors. This session takes place in a social setting and family members are welcome!

Local Chairpersons
Graeme Ramsey, Lockheed Martin Space
graeme.d.ramsey@lmco.com
Andrew Riskus, Ball Aerospace
ariskus@ball.com

Exhibitors:

Advanced Space	**Jena Optronik**
Airbus	**Lockheed Martin**
Amazon Project Kuiper	**MathWorks**
AGI	**Moog**
Astrofein	**Northrop Grumman**
Ball Aerospace	**Sierra Nevada Corp**
Blue Canyon	**Sodern**
Cayuga	**STEM**
Innalabs ltd	**Utah State – SDL**

SUNDAY, FEBRUARY 2ND
TRIPLE MORNING SESSIONS

Session II Sunday 7:00-10:00 AM
SMALL SAT GN&C

In recent years, small satellites including NanoSats and CubeSats have seen greater use for a range of applications in government, commercial, and educational sectors. At the high end of this mass range, ESPA-class spacecraft are now trusted platforms for scientific and defense missions. These missions require advanced technology insertion (GN&C, on-board processing) while advancing manufacturing practices to achieve higher production rates. Some key challenges related to increasing production volume include: supply-chain management, automated production and testing, and design for manufacturing approaches. This session is open to papers covering advanced technology insertion on small sats (e.g. propulsion, optical communications, proximity operations, drag sails, etc) and advanced manufacturing practices (e.g. best practices for satellite production, automation and design for manufacturing). Papers on practical mission experience in these areas are welcomed.

National Chairpersons
Scott Palo, University of Colorado at Boulder
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Ivan Bertaska, NASA Marshall Space Center
ivan.r.bertaska@nasa.gov

Local Chairpersons
Ellis King, Lockheed Martin Space
ellis.king@lmco.com
Jeffrey Parker, Advanced Space
parker@advanced-space.com

20-021 **Passive Roll Stabilization of the Near-Earth Asteroid Scout Solar Sail Mission**

Ivan Bertaska, Andrew Heaton, Juan Orphee (NASA/MSFC), Benjamin Diedrich (Dynamics Concepts, Inc)

20-022 **Wi**thdrawn

20-023 **Advancing Asteroid Spacecraft GNC Technology Using Student Built CubeSat Centrifuge Laboratories**
Jekan Thangavelautham, Erik Asphaug (University of Arizona – SpaceTREx Laboratory)

20-024 **Decentralized Spacecraft Swarms for Inspection of Large Space Structures**
Byong Kwon, Jekan Thangavelautham (University of Arizona – SpaceTREx Laboratory)

20-025 **Mobility, Power and Thermal Control of SphereX for Planetary Exploration**
Himangshu Kalita, Jekan Thangavelautham (University of Arizona – SpaceTREx Laboratory)

20-026 **GNC of Shape Morphing Microbots for Planetary Exploration**
Rachel Moses, Himangshu Kalita, Jekan Thangavelautham (University of Arizona – SpaceTREx Laboratory)

20-027 **A Multiplicative Extended Kalman Filter for Low Earth Attitude Estimation Using a Radically Inexpensive MEMs IMU in a 0.5U Cubesat**

Omar Awad, Robert Bishop
(University of South Florida)

20-028 **Design and Performance of Open Source Star Tracker on Commercial Off-the-Shelf Cameras and Computers**
Sam Pedrotty, Ronney Lovelace (NASA/JSC), John Christian, Devin Renshaw, Grace Quintero (Rensselaer Polytechnic Institute)

Session III Sunday 7:00-10:30 AM
ADVANCES IN HARDWARE

Many programs depend on heritage, but the future is advanced by those willing to design and implement new and novel architectures, technologies, and algorithms to solve GN&C problems. This session is open to papers with topics ranging from theoretical formulations to innovative systems and intelligent sensors that will advance the state of the art, reduce the cost of applications, and speed the convergence to hardware, numerical, or design trade solutions.

National Chairpersons
Steeve Kowaltschek, European Space Agency - Agence Spatiale Européenne
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Scott Cryan, NASA Johnson Space Center
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Local Chairpersons
Vasili Kamtsioras, Ball Aerospace
vkmatsio@ball.com
Jim Russell, Lockheed Martin Space
james.f.russell@lmco.com
Mathew Sandnas, Ball Aerospace
msandnas@ball.com

20-031 **RVS®3000-3D LIDAR – Gateway Rendezvous and Lunar Landing**
Christoph Schmitt, Sebastian Dochow, Michael Windmüller, Johannes Both, (Jena-Optronik GmbH), Olivier Mongrard (European Space Agency)

20-032 **The Magnetically Clean Reaction Wheel: Is Active Magnetic Field Compensation a Feasible Solution?**
Anja Nicolai, Stephan Stoltz, Dr. Sebastian Scheiding (Astro-und Feinwerktechnik Adlershof GmbH), O. Hillenmaier, J. Ludwig, C. Strauch (Magson GmbH)

20-033 **GPS Navigation from Geo-Transfer to Geosynchronous Orbit: A New Receiver for Efficient Electric Orbit Raising**
Yu Nakajima, Toru Yamamoto (JAXA), Ryo Harada, Satoko Kawakami, Susumu Kumagai (NEC Space Technologies Ltd.)

20-034 **ASTRO XP - First Test Results**
Uwe Schmidt, Jörg Reichert, Paul Petruck, Richard Wuerl (Jena-Optronik GmbH)

20-035 **Preliminary Test Results from Arietis, a High to Medium Performance, Hi-Rel, Radiation Hardened Gyro**
Alberto Torasso, Jose Beitia (InnaLabs Ltd), Steeve Kowaltschek (European Space Agency - ESTEC)

20-036 **A Low-Cost Radiation-Hardened ASIC for CV Gyroscope Control**
Peter Bond, Jeremy D. Popp and Anthony D. Challoner (IntertialWave)

20-037 **Auriga Star Tracker - Flight Heritage on Inaugural Airbus OneWeb Satellites Constellation**
Damien Piot, Benoit Gelin, Marc Maksimous (Sodern), Audrey Lieutaud (Airbus OneWeb Satellites), Bruno Vignon (Airbus OneWeb Satellites)

20-038 **On-Orbit Self-Calibration of Inertial Instruments**
A.D. Meyer, J. Campanile, A.A. Trusov, G.H. Mccammon (Northrop Grumman Systems Corporation)

Session IV Sunday 7:00-10:30 AM

HUMAN SPACEFLIGHT/DEEP SPACE GATEWAY

NASA and its commercial and international partners strive to bring astronauts to new Lunar, asteroid and Martian destinations, increasingly new and innovative GN&C technologies will be required to transport and deliver crews and return them safely to the Earth. There is an increased urgency with Vice President Pence's call to "return American astronauts to the moon within the next five years". As Orion and Space Launch System (SLS) programs approach their final stages of development, new systems such as the Deep Space Gateway and Lunar Landers are being developed as the next steps to reach Mars in the coming decades. This session explores key advancements in automation, guidance, navigation and Fault Detection/Isolation (FDI)

technologies which will ultimately enable human exploration onto lunar bases and beyond.

National Chairpersons
Tim Straube, NASA Johnson Space Center
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Howard Hu, NASA Johnson Space Center
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Diane Davis, NASA Johnson Space Center
diane.c.davis@nasa.gov

Local Chairperson
Harvey Mamich, Lockheed Martin Space
harvey.r.mamich@lmco.com

20-041 **Analysis of Cislunar autonomous Navigation with StarNAV and OpNAV**
John A. Christian (RPI) and Christopher N. D'Souza (NASA/JSC)

20-042 **Evaluating Relative Navigation Filter Designs and Architectures for Human Spaceflight**
David Woffinden (NASA/JSC)

20-043 **Path-Adaptive Guidance Algorithm Trades for a Two-Stage Lunar Descent Vehicle**
Jason Everett, Anand Iyer (NASA/MSFC)

20-044 **Powered Descent Guidance for a Crewed Lunar Landing Mission**
Sergio A. Sandoval, Ping Lu (SDSU)

20-045 **GN&C Sequencing for Orion Rendezvous, Proximity Operations and Docking**
Peter Z. Schulte (Draper)

20-046 **Attitude Control and Perturbation Analysis of a Crewed Spacecraft with a Lunar Lander in Near Rectilinear Halo Orbits**
Clark Newman, Diane Davis (A.I. Solutions)

20-047 **Phase Control and Eclipse Avoidance in Near Rectilinear Halo Orbits**
Diane Davis (A.I. Solutions)

20-048 **A Practical Method for Truncating Spherical Harmonic Gravity Fields**
Sean McArdle, Ryan P. Russell (University of Texas at Austin), Srinivas Bettadpur (Center for Space Research)

POSTER SESSION BREAK
Sunday 8:30-9:00 AM

Tom Knight, Sierra Nevada Corp
tom.knight@sncorp.com

A focused poster session break will take place Sunday morning to allow the poster presenters to interact with the attendees one-on-one or in small groups. Posters will remain on display for the duration of the conference.

SINGLE AFTERNOON SESSION

Session V Sunday 1:30-4:00 PM

PIONEERS/TECHNOLOGY EVOLUTION

This session will offer reflections on the careers and contributions of scientists and engineers who pioneered notable technical solutions for our aerospace community and highlight significant technological advances that led to historical achievements in the space industry.

National Chairpersons

Neil Dennehy, NASA Eng. & Safety Center
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Tooraj Kia, NASA Jet Propulsion Laboratory
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Local Chairperson

Lee Barker, Lockheed Martin Space
lee.a.barker@lmco.com
Larry Germann, Left Hand Design Corp
germannl@lefthand.com

20-051 **Dr. Richard Battin: Inventing and Applying Modern Space Guidance While Being a Moral Compass**
Philip Hattis (Draper)

20-052 **Corona: America's First Reconnaissance Satellite**
Cornelius (Neil) Dennehy (NASA)

20-053 **A Cautionary Tale of a Secret, a Small Team, an Accelerated Schedule, and the Gemini IV Station-Keeping Failure**
John Goodman (Odyssey Space Research, LLC)

20-054 **William Lear's Pioneering Contributions to Spacecraft Navigation Filtering**

J. Russell Carpenter (NASA/GSFC), T. James Blucker (NASA-Retired), John Goodman (Odyssey Space Research, LLC), James S. McCabe (NASA/JSC), Thomas D. Bruchmiller (NASA/JSC)

20-055 **Voyager and its Team – A Journey to the Outer Planets and Beyond**
Aron Wolf (JPL-Caltech)

4:15 PM SUPER BOWL '20

Imperial Ballroom

Family Members of conference attendees are welcome!
Sandwiches and appetizers will be served

MONDAY, FEBRUARY 3RD
TRIPLE MORNING SESSIONS

Session VI Monday 7:00-10:00 AM

ADVANCES IN PROPULSION

The development of advanced propulsion technologies is critical for enabling spacecraft platforms ranging from CubeSats to ambitious human and robotic space exploration missions. Innovative developments in chemical, electric, nuclear, and propellant-less propulsion will provide higher performance and greater operability, enabling new approaches ranging from launch to interstellar travel. This session will highlight advanced propulsion technologies matured by NASA, DOD, industry, and academia.

National Chairpersons
Jeff Sheehy, NASA Space Technology Mission Directorate
jeffrey.sheehy@nasa.gov
Marc Young, Air Force Research Laboratory
marcus.young@us.af.mil

Local Chairperson
John Abrams, Analytical Mechanics Assoc. Inc.
j.abrams@ama-inc.com
Nick Patzer, Laboratory for Atmospheric and Space Physics
Nicholas.Patzer@lasp.colorado.edu

20-061 **Magnetic Control of Propellant Sloshing in Microgravity**
A. Romero-Calvo, H. Schaub (University of Colorado at Boulder)

20-062 **Flight Performance of the Propulsion Subsystem on the Green Propellant Infusion Mission**

C. McLean, B. Marott, B. Porter (Ball Aerospace)

20-063 **Performance of the HYDROS Water-Electrolysis Thruster**
R. Hoyt, A. Porter, M. Freedman (Tethers Unlimited, Inc.)

20-064 **Withdrawn**

20-065 **Mission Analysis for Mars Opposition Missions 2033 to 2048**
B. Muzek, C. R. Joyner, J. Horton (Aerojet Rocketdyne)

20-066 **Gateway Logistics Services Using High TRL Propulsion and Flight Proven Elements**
J. Horton, C. Reynolds, R. Noble, W. Sack, T. Kokan, D. Morris (Aerojet Rocketdyne)

20-067 **Withdrawn**

20-068 **Prospects for Interstellar Propulsion**
R. Litchford, J. Sheehy (NASA)

Session VII Monday 7:00-10:00 AM

HYPERSONICS, RE-ENTRY VEHICLES AND EDL

This session will focus on the status and evolutionary development of hypersonic flight, entry vehicles, and Entry Decent and Landing (EDL). Of specific interest will be mission enabling advancements including but not limited to the areas of hypersonics, deployable decelerators, GN&C sensors, novel EDL algorithms and methodologies that will be required to support hypersonic flight, large-scale Earth EDL, and aero capture capabilities for human and autonomous missions to Mars and beyond.

National Chairpersons
Sam Thurman, Jet Propulsion Laboratory
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Henry Cordova, NASA Johnson Space Center
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Local Chairpersons
Jim Chapel, Lockheed Martin Space
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DeAnn Redlin Sanders, Ball Aerospace
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Ernie Lagimoniere, Sierra Nevada Corp
ernie.lagimoniere@sncorp.com

20-071 **Sample-Based Robust Trajectory Optimization for Entry Vehicles**
R. Derollez, Z. Manchester (Stanford University)

20-072 **Entry, Descent and Landing Trajectory Design Methods for the Dream Chaser® Spacecraft**
E. Lagimoniere Jr., J. Tardy, M. Muktoyuk, R. Avram (Sierra Nevada Corp)

20-073 **Robustifying Mars Descent Guidance Through Neural Networks**
D. Amato, S. Hume, B. Grace, J. McMahon (University of Colorado at Boulder)

20-074 **Comparative Study of Lift and Drag Modulation Control Strategies for Aerocapture**
C. Heidrich, E. Roelke, S. Albert, and R. Braun (University of Colorado at Boulder)

20-075 **Trajectory Reconstruction for the HTV Small Reentry Capsule**
R. Nakamura, M. Haruki (JAXA)

20-076 **Preliminary Design, Testing, and Performance of the LOFTID Navigation System**

J. Amert (NASA/MSFC)

20-077 **Dream Chaser® Spacecraft Entry, Descent and Landing (EDL) Guidance, Navigation and Control Design (GN&C) Overview**
E. Lagimoniere Jr., M. Lyons, T. Carl, A. Rainier, K. Speckman, (Sierra Nevada Corp), S. Thrasher (Draper)

20-078 **International Space Station Deorbit Controllability Analysis**
E. Gambone (NASA/JSC)

Session VIII Monday 7:00-10:00 AM

ASTEROID EXPLORATION/SMALL BODY SAMPLE RETURN

The past few years have seen a marked increase in small body exploration for the purposes of science investigations and future in-situ resource utilization. The success of these efforts depends on the ability to guide, navigate and control the robotic systems needed to accomplish the demanding mission objectives, such as characterizing the small body after arrival, collecting samples from the surface and returning them to Earth. This session will highlight the GN&C challenges, experiences, successes and lessons learned in the exploration of asteroids, comets and other small bodies.

National Chairperson
Michael Moreau, NASA Goddard Space Center
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Jay McMahon, University of Colorado at Boulder
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Local Chairpersons
Dan Kubitschek, Laboratory for Atmospheric and Space Physics
daniel.kubitschek@lasp.colorado.edu

Alex May, Lockheed Martin Space
alexander.j.may@lmco.com

20-081 **Evolving Design and Mobility of a Spacecraft on Stilts to Explore Asteroids**
F. Aldava, H. Kalita, J. Thangavelautham (University of Arizona—SpaceTREx Laboratory), E. Asphaug (Lunar and Planetary Laboratory)

20-082 **Polyhedral Shape from Silhouettes for Small Body Characterization**
P. Panicucci, M. Delpech, (CNES) J. McMahon (University of Colorado at Boulder), E. Zenou (ISAE-SUPAREO), J. Lebreton, K. Kanani (Airbus Defense and Space)

20-083 **A Covariance Study for Gravity Estimation of Binary Asteroids**
A. Davis, D. Scheeres (University of Colorado at Boulder)

20-084 **Strategies and Flight Results of GNC System in Hayabusa2 Touchdown Operations: Artificial Landmark Target Marker Separation and Acquisition**
G. Ono, H. Ikeda, N. Ogawa, S. Kikuchi, F. Terui, T. Saiki, Y. Tsuda (JAXA)

20-085 **Strategies and Flight Results of GNC System in Hayabusa2 Touchdown Operations: Autonomous Six Degree of Freedom Control after Target Marker Acquisition**

F. Terui, N. Ogawa, S. Kikuchi, G. Ono, T. Saiki, Y. Tsuda (JAXA)

20-086 **Withdrawn**

20-087 **Image Correlation Performance Prediction for Autonomous Navigation of OSIRIS-REx Asteroid Sample Collection**
C. Mario (Draper), C. Norman, C. Miller, R. Olds (Lockheed Martin Space), E. Palmer, J. Weirich (Planetary Science Institute), D. Lorenz (GSFC KBR Wyle), D. Lauretta (University of Arizona – Lunar and Planetary Laboratory)

20-088 **Revisiting OSIRIS-REx Touch-And-Go (TAG) Performance Given the Realities of Asteroid Bennu**
K. Berry, M. Moreau (NASA/GSFC) C. Miller, R. Olds (Lockheed Martin Space), P. Antreasian (KinetX) D. Lauretta (University of Arizona – Lunar and Planetary Laboratory)

DUAL EVENING SESSION

Session IX Monday 4:00-6:00 PM

SYSTEMS ENGINEERING IMPACTS ON GN&C DESIGN

For spacecraft missions, Systems Engineering and GN&C have an important relationship. Critical decisions are made throughout the spacecraft design by both teams and have a reciprocal impact on the other team. If done properly, the Systems Engineering and GN&C collaboration can lead to very successful designs; in contrast, poor decisions can lead to difficult and non-optimal designs leading to hardship on both teams. This session will examine the impact of Systems Engineering decisions on GN&C design and also how payload integration affects GN&C design and CONOPS. This session is open to discussing optimal Systems Engineering approaches that lead to a seamless GN&C design and process; additionally, this session is open to instances where Systems Engineering decisions have led to difficult GN&C experiences and have required ingenuity and clever solutions to meet requirements and result in successful missions.

National Chairpersons
Bill Frazier, Jet Propulsion Laboratory
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Paul Graven, Cateni
paul@graven.com

Local Chairpersons
Michael Osborne, Lockheed Martin Space
michael.l.osborne@lmco.com
Cody Allard, Ball Aerospace
callard@ball.com

20-091 **Simulation-Based Analysis and Prediction of Thrust Vector Servoelastic Coupling**
J. Orr, J. Wall (NASA/MSFC), and T. Barrows (Draper-Retired)

20-092 **Hardware Verification and Validation for a Navigation Sensor Software Model in Support of Flight Vehicle Performance Analysis**
E. Anzalone, N. Hoen, and T. Park (NASA/MSFC)

20-093 **System Design for Near-Global Imaging of Triton**
W. Frazier (JPL-CalTech), D. Putnam, R. Schindhelm, and M. Veto (Ball Aerospace)

20-094 **Dream Chaser Spacecraft Thruster Fault Detection, Isolation, and Recovery Algorithm Design during Breakout Maneuvers**
R. Avram (Sierra Nevada Corp)

20-095 **Linear Covariance Tool Development for Navigation System Design and Analysis of Lunar Lander Missions**
R. Christensen, D. Geller, and M. Hansen (Utah State University)

20-096 **Launcher Structural Dynamics and Control Integrated Design**
M. Ganet-Schoeller, V. Pothier, and V. Le-Gallo (Ariane Group)

Session X Monday 4:00-6:00 PM

EXPLORING MARS

In recent years, the exploration and habitation of Mars has become popularized in the commercial and private aerospace communities. As the closest and most hospitable planet near Earth, it is the most obvious next step in human space exploration. Exploring Mars poses a unique set of challenges in navigation, entry into a highly variable atmosphere, radiation resistance, and autonomous exploration. This session will explore the difficulties present in reaching Mars

and the innovative GN&C technologies and spacecraft operations that will aid in the manned and unmanned exploration of the planet.

National Chairpersons
Hanspeter Schaub, University of Colorado at Boulder
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Local Chairpersons
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Jorgen Baertsch, Left Hand Design Corp
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Zach Yearout, Left Hand Design Corp
zyearout@lefthand.com

20-101 **Mars 2020 Autonomous Rover Navigation**
N. Abcouwer, J. Biesiadecki, T. Del Sesto, A. Johnson, T. Litwin, M. Maimone, M. McHenry, R. Rieber, O. Toupet, P. Twu (JPL-CalTech)

20-102 **Escape and Plasma Acceleration and Dynamics (ESCAPADE)**
J. S. Parker, N. Parrish (Advanced Space), R. Lillis, S. Curry, and D. Curtis (University of California at Berkeley)

20-103 **Avionics Hardware Modeling and Embedded Flight Software Testing in an Emulated Flat-Sat**
M. C. Margenet, H. Schaub, and S. Piggott (University of Colorado at Boulder)

20-104 **Attitude Control of an Inflatable Aircraft for Mars Exploration**
T. Schuler (University of Arizona – SpaceTREx Laboratory), A. Bouskela, S. Shkarayev (Micro Air Vehicle laboratory), J. Thangavelautham (University of Arizona – SpaceTREx Laboratory)

20-105 **The Mars 2020 Lander Vision System Field Test**
A. Johnson, N. Villaume, C. Umsted, A. Kourchians, D. Sternberg, N. Trawny, Y. Cheng, E. Giepel, J. Montgomery (JPL-CalTech)

20-106 **Challenges of Mars Sample Return Lander Entry, Descent, and Landing**
M. C. Ivanov and S. W. Sell (JPL-CalTech)

NETWORKING AND CAREER EVENT: INSPIRATIONAL WOMEN IN SPACE

6:30-7:30 PM at Imperial Ballroom

Light Appetizers and Cocktails

This event is open to anyone who has ever been inspired by what is possible in our field and how our most accomplished professional women found their way to a rewarding career.

Keynote Speaker: Dr Janet Kavandi

Dr Kavandi is a veteran of three spaceflights. She previously served as director of NASA's Glenn Research Center. After a 25-year career with NASA, Dr Kavandi joined Sierra Nevada Corporation as Senior VP for Space Systems.

TUESDAY, FEBRUARY 4TH
DUAL MORNING SESSIONS

Session XI Tuesday 7:00-10:00 AM

GENERAL ADVANCES IN GUIDANCE & CONTROL

The depth and breadth of control and guidance theory often enables several solutions for a given problem. Of particular interest is the novel application of established and recently advanced techniques. This session brings together solutions to aerospace problems that were solved using a wide variety, and various combinations, of traditional and recent advances in control and guidance theory.

National Chairperson
Tim Crain, Intuitive Machines,
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Robyn Woollands, Jet Propulsion Laboratory
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Local Chairpersons
Hank Steadman, Lockheed Martin Space
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Drew Engelmann, Laboratory for Atmospheric Space and Physics
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20-111 **Design and Development of a Fixed-Pitch Electric Coaxial Helicopter with Variable Center of Gravity Control**
I. Khawaja, G. Gensler, N. Gupta, M. Pandya, N. Pillai (University of Maryland)

20-112 **Modeling Effective Control of Satellite Oscillations Using a Finite Element Method**
R. Sakamoto, D. Scheeres (University of Colorado at Boulder)

20-113 **Characterization of Planetary Resources with Deep Learning Enabled Model Predictive Control: Applied to Lunar Ice Mapping**
M. Lieber, R. Rohrschneider, R. Schindhelm, Z. Britt, J. Weinberg, S. Roark (Ball Aerospace)

20-114 **Optical Wavefront Error Estimation Algorithm Using Temperature Measurements for Segmented Space Telescopes**
J. Runnels, C. Allard, J. Scott Knight (Ball Aerospace)

20-115 **Lyapunov Optimal Control for Many-Revolution Low-Thrust Orbit Transfers and Guidance**
J. Peterson, J. Junkins (Texas A&M University), E. Taheri (University of Auburn)

20-116 **Dream Chaser® Spacecraft Deorbit Burn Guidance Algorithm and Fuel Efficiency Analysis**
B. Cannataro, D. Benson, S. Thrasher (Draper)

20-117 **Deep On-Board Scheduling for Autonomous Attitude Guidance Operations**
A. Harris, H. Schaub (University of Colorado at Boulder)

20-118 **A Generalized Guidance Approach to In-Space Solid-Propellant Vehicles Maneuvers**
J. Everett (NASA MSFC)

Session XII Tuesday 7:00-10:00 AM

ADVANCES IN NAVIGATION

Recent advances in navigation seek to push the boundaries of spacecraft navigation technology and address the shortcomings of current navigation systems. With the prospect of deploying large-scale constellations in the Earth orbit and the need for maintaining a safe orbital environment for all operators, new navigation techniques and robust architectures are required to complement the existing ground-based and GNSS systems. Other future lunar, interplanetary, and interstellar mission concepts require novel ways for collecting and processing observations from non-traditional sources. In this session, we will explore novel and advanced ground-based, space-based, and autonomous spacecraft navigation approaches. Of particular interest are methods for inter-satellite navigation and lost-in-space scenarios as well as new filtering techniques for processing optical observations, pulsar observations, and other deep space signals of opportunity.

National Chairpersons
John Christian, Rensselaer Polytechnic Institute
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Local Chairpersons
Siamak Hesar, Blue Canyon Technology
shesar@bluecanyontech.com
Morgan Yost, Lockheed Martin Space
morgan.yost@lmco.com

20-121 **Simultaneous and Distinct Visible and Thermal Radiation Pressure Dynamics**
S. Carnahan, H. Schaub (University of Colorado at Boulder)

20-122 **Europa-Clipper Stellar Reference Unit Filtering Techniques for Processing Optical Observations**
B. Gelin, Y. Henriquel, L. Nicollet (Sodern), G. Massone, J. Alexander, Herrick Chang (JPL-CalTech)

20-123 **Guide Star Selection for Spacecraft Navigation with StarNAV**
W. Parker, R. Thibeault, J. A. Christian (Rensselaer Polytechnic Institute)

20-124 **Satellite Navigation Using X-ray Pulsars and Horizon Crossings of X-ray Stars**
K. S. Wood (Praxis Inc.)

20-125 **Optical Navigation for Autonomous Approach of Small Unknown Bodies**
J. Villa (KTH, Royal Institute of Technology), S. Bandyopadhyay, B. Morrell, B. Hockman (JPL-CalTech), A. Harvard, S.J. Chung (California Institute of Technology), S. Bhaskaran, I. Nesnas (JPL-CalTech)

20-126 **Autonomous on-orbit Optical Navigation Techniques for Robust Pose-Estimation**
T. Teil, H. Schaub (University of Colorado at Boulder)

20-127 **Smart Nav Targeting Algorithm for the Dart Mission**
P. Ericksen, M. Chen, S. Jenkins, M. Jensenius (Johns Hopkins University – APL)

20-128 **THIN VPU: Open Source Vision Processing for Space Navigation**
S. Stewart, T. Crain, G. Molina (Intuitive Machines)

TUTORIAL SESSION 12:30 PM-3:30 PM

Machine Learning, Deep Learning and Stochastic Control Algorithms for Safe Autonomy

Leader: Dr. Evangelos Theodorou, Georgia Institute of Technology
evangelos.theodorou@gatech.edu

DUAL EVENING SESSIONS

Session XIII Tuesday 4:00-7:00 PM

ADVANCES IN SOFTWARE

Successful GN&C system performance is often dependent on innovative software. This session is open to all development processes and systems ranging from vehicle code used to operate the spacecraft system, ground software used for operations/analysis, or simulations/frameworks used to test, validate or develop GN&C systems. The intent is to include current best practices as well as challenges in future software development such as the inclusion of complex systems like artificial intelligence, machine learning, vision processing, and iterative numerical solvers.

National Chairpersons
Miguel San Martin, Jet Propulsion Laboratory
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Local Chairpersons
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Tomas Ryan, Ball Aerospace
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20-131 **Compact Frame Independent Spacecraft Dynamics Development Using Sympy Python Library**
Cody Allard (Ball Aerospace), Drew Engelmann (Laboratory for Atmospheric Space Physics)

20-132 **Effect of Spacecraft Parameters on Identification of Debris Strikes in GN&C Telemetry**
Anne Aryadne Bennett and Hanspeter Schaub (University of Colorado at Boulder)

20-133 **Alpha-Beta Filter: Design, Implementation, And Performance for Spacecraft GN&C Applications**
Tom L. Riggs (USAF and Lockheed Martin – Retired)

20-134 **A New Messaging System for Basilisk**
Scott J.K. Carnahan, Scott Piggott, Hanspeter Schaub (University of Colorado at Boulder)

20-135 **Semi-Analytic Method for Repeat Ground Track Orbit Design**
Blair Thompson, Aaron Brogley (Odyssey Space Research)

20-136 **Python Scientific Programming Tool Suite for Analysis and Verification of Artemis-1 Navigation System**
Brandon Wood (NASA/JSC)

20-137 **Validation of The Laguerre Method for Solving the 8th Order Polynomial of Angles-Only Initial Orbit Determination**
Blair Thompson, Ryan Cobb (Aleut Aerospace Engineering)

20-138 **Optimal Relative Trajectory Design with Mission Constraints and Performance Requirements**
Nathan B. Stastny (Space Dynamics Laboratory), David K. Geller (Utah State University)

Session XIV Tuesday 4:00-7:00 PM

AUTONOMOUS RPOD, SERVICING, COLLISION AVOIDANCE AND DEBRIS REMOVAL

With each passing year, the utilization of space and complexity of systems continues to grow at an ever-increasing rate. Autonomous rendezvous, proximity operations, and docking are key enablers to supporting our key objectives such as maintaining the International Space Station or placing boots on the lunar surface again. Additionally, there is continued interest in the commercial servicing of existing spacecraft and removing orbital debris. This session explores all aspects of enabling technologies for Navigation, Guidance and Control, Computer Vision, Robotics, and Safety of Flight to support this class of missions.

National Chairpersons
Tim Payne, USSF S3/6Z
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Apoorua Bhopale, Air Force Research Laboratory, apoorua.bhopale.1@us.af.mil

Local Chairpersons
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David Chart, Sierra Nevada Corp
david.chart@sncorp.com

20-141 **Rendezvous and Proximity Operations for Active Debris Removal Satellites Considering Trajectory Safety**

Takahiro Sasaki, Yu Nakajima, and Toru Yamamoto (JAXA)

20-142 **An Analytic Guidance Law for Safety Ellipse Reconfigurations**
Simon Shuster and David Geller (Utah State University)

20-143 **Sub-Minimum Impulse Attitude/Rate Control of Spacecraft**
John P. McCullough, III (NASA/MSFC), Steven L. Hough (Dynamic Concepts, Inc), Keith R. Clements (ERC, Inc), Robert A. Hall (Mclaurin Aerospace)

20-144 **Design, Development and Ground Testing of an Autonomous Astronautical Debris Mitigation (AADM) System**
Caleb Peck, Joe Hiemerl, James McElreath, Andrew Verras, Davis Adams, Manoranjan Majji, Moble Benedict, J. Junkins (Texas A&M University)

20-145 **Design of Safe Abort Corridors for the Dream Chaser® Spacecraft**
Christopher Jewison, David Benson, Louis Breger (Draper)

20-146 **Optimal Low Thrust Orbit Transfers for Space Telescope Refueling at SEL2**
Robyn Woollands (JPL-CalTech), Siegfried Eggl (University of Washington)

20-147 **Modeling, Control and Laboratory Testing of an Electromagnetic Docking System for Small Satellites**

Aaditya Ravindran, Leonard Vance, Jekan Thangavelautham (University of Arizona – SpaceTREx Laboratory)

20-148 **Flash LIDAR On-Orbit Performance at Asteroid Bennu**
Estelle Church (Lockheed Martin Space), Tyler Bourbeau, James Curriden (Advanced Scientific Concepts, Inc), Angelica Deguzman, Frank Jaen (Lockheed Martin Space), Brad Short (Advanced Scientific Concepts, Inc), Huikang Ma, Keith Mahoney, Kristian Waldorff, Oliver Walthall (Lockheed Martin Space), Dante Lauretta (University of Arizona – Lunar and Planetary Laboratory)

WEDNESDAY, FEBRUARY 5TH
MORNING SESSION

Session XV Wednesday 7:00-10:00 AM

RECENT EXPERIENCES

This session focuses on recent experiences in spaceflight GN&C, providing a forum to share insights gained through successes and failures. Discussions typically include GN&C experiences ranging from Earth orbiters to interplanetary spacecraft. This session is a traditional part of the conference and has shown to be most interesting and informative.

National Chairpersons
David Dannemiller, NASA Johnson Space Center
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Local Chairpersons
Kip Gwin, Ball Aerospace
kgwin@ball.com
Cody Griffin, Sierra Nevada Corp
cody.griffin@sncorp.com

20-151 **Trajectory Design and Maneuver Performance of the OSIRIS-REx Detailed Survey of Bennu**
D. Wibben, A. Levine, S. Rieger, J. McAdams, P. Antreasian, J. Leonard (KinetX, Inc.), K. Getzandanner, M. Moreau (NASA/GSFC), and D. Lauretta (University of Arizona - Lunar and Planetary Laboratory)

20-152 **Orion Ascent Abort-2 Navigation System Implementation and Post-Flight Assessment**
E. Kollin (NASA/JSC)

20-153 **OSIRIS-Rex Shape Model Performance During the Navigation Campaign**

J. Leonard, J. Geeraert, B. Page, A. French, P. Antreasian, C. Adam, E. Lessac-Chenen, L. McCarthy, D. Nelson, J. Pelgrift, E. Sahr (KinetX, Inc.), B. Ashman, A. Liounis, M. Moreau (NASA/GSFC), E. Palmer, J. Weirich (Planetary Science Institute), B. Kennedy, J. Bellerose, D. Lubey, B. Rush, D. Velez, N. Mastrodemos (JPL-CalTech), O. Barnouin (Johns Hopkins University - APL), and D. Lauretta (University of Arizona - Lunar and Planetary Laboratory)

20-154 **On Orbit Evaluation of Natural Feature Tracking for OSIRIS-Rex Sample Collection**
C. Miller, R. Olds, C. Norman, S. Gonzales (Lockheed Martin Space), C. Mario (The Charles Stark Draper Laboratory), J. Leonard (KinetX, Inc.), D. Lauretta (University of Arizona - Lunar and Planetary Laboratory)

20-155 **Withdrawn**

20-156 **On-Orbit Performance of the BCP-100 Green Propellant Infusion Mission**
B. Marotta, C. McLean, B. Porter (Ball Aerospace)

20-157 **The Voyagers: Risky Business Beyond the Heliopause**
B. Waggoner, W. Frazier (JPL - Caltech)

20-158 **Seeker Free-Flying Inspector GNC Flight Performance**
S. Pedrotty, J. Sullivan, E. Gambone (NASA/JSC), and T. Kirven (Jacobs Engineering)

NOTES:

2020 Planning Committee:

Amy Delay	Lockheed Martin Space
Michelle Barath	Lockheed Martin Space
John Abrams	Analytical Mechanics
Cody Allard	Ball Aerospace
Jorgen Baertsch	Left Hand Design Corp
Lee Barker	Lockheed Martin Space
John Bendle	Lockheed Martin Space
Jim Chapel	Lockheed Martin Space
David Chart	Sierra Nevada Corp
Michael Drews	Lockheed Martin Space
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Shawn McQuerry	Lockheed Martin Space
Kyle Miller	Ball Aerospace
Michael Osborne	Lockheed Martin Space
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Graeme Ramsey	Lockheed Martin Space
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Jim Russell	Lockheed Martin Space
Tomas Ryan	Ball Aerospace
DeAnn Redlin Sanders	Ball Aerospace
Mathew Sandnas	Ball Aerospace
Hank Steadman	Lockheed Martin Space
Meredith Stephens	Ball Aerospace
Jastesh Sud	Lockheed Martin Space
Cheryl Walker	Parsons
Zach Yearout	Left Hand Design Corp
Morgan Yost	Lockheed Martin Space

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AAS GN&C Conference