

## PROGRAM

### 42<sup>nd</sup> ANNUAL AAS GUIDANCE & CONTROL CONFERENCE

January 31<sup>st</sup> to  
February 6<sup>th</sup>, 2019





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

**THURSDAY JANUARY 31<sup>ST</sup>**

Registration and Breakfast

**8:00-9:00 AM**

**FRIDAY FEBRUARY 1<sup>ST</sup>**

Registration and Breakfast

**8:00-8:30 AM**

Pre-registration by Jan 18, 2019 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**

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### **BEAVER RUN CONFERENCE CENTER Breckenridge, Colorado**

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

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## **Conference Registration**

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

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## **Registration Questions**

Lis Garratt	303-931-7622
Amy Delay	303-731-9876

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## **42<sup>nd</sup> Annual AAS Guidance, Navigation & Control Conference Chairperson**

Heidi Hallowell  
Ball Aerospace  
303-939-6131

[hhallowe@ball.com](mailto:hhallowe@ball.com)

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## **Wi-Fi Access**

Select "**Beaver Run Meeting**" wireless network.  
Open a browser window  
Enter voucher code: **AAS2019**

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## **Pre-print Paper Access (read-only)**

Go to webpage: [www.tinyurl.com/aas2019](http://www.tinyurl.com/aas2019)

Note: Download the .zip file for all available  
pre-print papers

## **Conference Schedule Overview**

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### **Thursday January 31<sup>ST</sup>**

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

### **Friday February 1<sup>ST</sup>**

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 2<sup>ND</sup>**

Morning Sessions	7 – 10 AM
AAS STEM SCAPE	10:30 AM – 4:00 PM
NASA Astronaut for Children	4 – 5 PM
Technical Exhibits	5 – 8 PM

### **Sunday February 3<sup>RD</sup>**

Morning Sessions	7 – 10 AM
Tutorial Session	11:30 AM – 1:30 PM
Afternoon Sessions	2 – 4 PM
Super Bowl in Imperial Ballroom	4:15 PM

### **Monday February 4<sup>TH</sup>**

Morning Sessions	7 – 10 AM
Tutorial Session	1:30 – 3:30 PM
Afternoon Sessions	4 – 7 PM

### **Tuesday February 5<sup>TH</sup>**

Morning Sessions	7 – 10 AM
Tutorial Session	1:30 – 3:30 PM
Afternoon Sessions	4 – 7 PM

### **Wednesday February 6<sup>TH</sup>**

Technical Session	7 – 10:00 AM
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**SATURDAY, FEBRUARY 2<sup>ND</sup>  
7AM CONFERENCE OPENING**

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**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 fieldability 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](mailto:luke.sauter@usafa.edu)

David Geller, Utah State University

[david.geller@usu.edu](mailto:david.geller@usu.edu)

**Local Chairpersons**

Ian Gravseth, Ball Aerospace

[igravset@ball.com](mailto:igravset@ball.com)

Morgan Yost, Lockheed Martin Space

[morgan.yost@lmco.com](mailto:morgan.yost@lmco.com)

**19-011 Guidance, Navigation and  
Control of Asteroid Mobile  
Imager and Geologic Observer  
(AMIGO)**

G. Wilburn, H. Kalita, A. Chandra,

S. Schwartz, E. Asphaug, J.

Thangavelautham (University of

- Arizona – SpaceTReX)
- 19-012 Withdrawn
- 19-013 **Application of Predictive Control for Desired Attitude stabilization with Magnetic Actuators**  
D. Newberry, B. Mayhall, D. Western, D. Jennings, H. Pernicka (Missouri Univ. of Science and Technology)
- 19-014 **Development and Analysis of NRHO Rendezvous Reference Trajectories Using Convex Optimization**  
S. Shuster (Utah State University)
- 19-015 **Design and Verification of a Stereoscopic Imager for Use in Spacecraft Close Proximity Operations**  
A. Reynolds, H. Pernicka (Missouri University of Science and Technology)
- 19-016 **Extracting CubeSat Relative Motion Using In Situ Deployment Imagery**  
A. Boylston, J. Gaebler, P. Axelrad (University of Colorado Boulder)
- 19-017 **Motion Planning on an Asteroid with Irregular Gravity Fields**  
H. Kalita, J. Thangavelautham (University of Arizona – SpaceTReX)
- 19-018 Withdrawn
- 19-019 **Visual and Thermodynamic Analysis of PolyMethyl MethAcrylate Combustion in Hybrid Rockets**  
M. Langas, C. Brazinski, A. Danchi, R. Golding, N. Juhasz, A. Shune, D. Cunningham (United

States Air Force Academy)

## **AAS STEM-SCAPE Event**

**Saturday 10:30 AM-4:00 PM**

In 2019, 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](mailto:michael.e.drews@lmco.com))

Meredith Stephens, Ball Aerospace  
([mlstephe@ball.com](mailto:mlstephe@ball.com))

### **Special Event for Children of Conference Attendees at 4 PM**

#### **NASA Astronaut, Richard Hieb**

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

**Session II**

**Saturday 5:00-8:00 PM**

### **Technical Exhibits**

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. Associated papers not presented in other sessions are also provided and can be discussed with the author. Come enjoy an excellent complimentary buffet and interact with the technical representatives and authors. This session takes place in a social setting and family members are welcome!

### **Local Chairpersons**

Meredith Stephens, Ball Aerospace  
[mstephe@ball.com](mailto:mstephe@ball.com)

Andrew Riskus, Ball Aerospace  
[ariskus@ball.com](mailto:ariskus@ball.com)

### **Exhibitors:**

**AAC Microtec**

**Adcole Maryland Space**

**Advanced Space**

**AGI**

**Airbus**

**Astro- und Feinwerktechnik Adlershof GmbH**

**Ball Aerospace**

**BEI**

**Blue Canyon Technologies**

**Jena-Optronik GmbH**

**Lockheed Martin**

**The Mathworks, Inc.**

**Oakman Aerospace**

**Sierra Nevada Corp.**

**Sodern**

**ZARM Technik**

**SUNDAY, FEBRUARY 3<sup>RD</sup>  
DUAL MORNING SESSIONS**

**Session III      Sunday 7:00-10:00 AM  
GN&C Challenges with Robotic Deep  
Space Exploration**

This session examines the GN&C challenges of present and future deep space exploration. The first satellites formed the technological basis for advanced space exploration, enabling robotic missions beyond low Earth orbit. Future space exploration goals call for much more challenging missions throughout the solar system. Achieving these ambitious exploration goals will require further advancements in the areas of remote sensing, propulsion and power, autonomous navigation, precision pointing, landing and sampling, advanced onboard fault management and autonomous operations amongst other capabilities.

**National Chairpersons**

Bill Frazier, NASA Jet Propulsion Laboratory  
[William.e.frazier@jpl.nasa.gov](mailto:William.e.frazier@jpl.nasa.gov)

Paul Graven, Cateni  
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**Local Chairpersons**

Jastesh Sud, Lockheed Martin Space  
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Larry Germann, Left Hand Design Corporation  
[germannl@lefthand.com](mailto:germannl@lefthand.com)

**19-031      An Autonomous Passive  
Navigation Method for  
Nanosatellite Exploration of the  
Asteroid Belt**

L. Vance, E. Asphaug, J.  
Thangavelautham (University of  
Arizona- SpaceTREx)

- 19-032 **LIDAR-Generated Digital Elevation Models for Hazard Detection**  
P. Chen, S. Kaki, A. San Martin, D. Skulsky, A. Katake, and N. Trawny (NASA - JPL)
- 19-033 **Guidance, Navigation, and Control for NASA Lunar Pallet Lander**  
J. Orphee, M. Hannan, E. Anzalone, N. Ahmad, S. Craig, N. Olson, B. Bae, V. Tapia (NASA-MSFC), E. Braden (NASA-JSC)
- 19-034 **Guidance and Navigation Design for a Martian Sample Return Ascent Vehicle**  
E. Anzalone, N. Ahmad, D. Erikson (NASA – MSFC), C. Montalvo (University of South Alabama)
- 19-035 **Early Navigation Performance From the OSIRIS-REx Approach to Bennu**  
P. Antreasian, C. Adam, J. Leonard, D. Wibben (KinetX, Inc.), M. Moreau, K. Getzandanner (NASA-GSFC), D. Highsmith (Aerospace Corp.), and the OSIRIS-REx Navigation Team
- 19-036 **Demonstration of Stereo Vision for Deorbit Descent and Landing**  
D. Sternberg, T. Setterfield, A. Johnson (JPL-Caltech)
- 19-037 **Architecture of a Fault-Tolerant and Verifiable Outer Planet Flyby**  
W. Frazier, K. Mitchell, E. Rice (JPL-Caltech)

**Small Satellite 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.

**National Chairpersons**

Bruce Yost, NASA Ames Research Center

[Bruce.D.Yost@nasa.gov](mailto:Bruce.D.Yost@nasa.gov)

Scott Palo, University of Colorado at Boulder

[Palo@colorado.edu](mailto:Palo@colorado.edu)

**Local Chairpersons**

Jim Russell, Lockheed Martin Space,

[james.f.russell@lmco.com](mailto:james.f.russell@lmco.com)

Tom Segal, Metropolitan State University,  
Denver

[tsegal1@msudenver.edu](mailto:tsegal1@msudenver.edu)

**19-041     Improving Orbit Determination  
of Clustered CubeSat  
Deployments Using Camera-  
Derived Observations**

J. Gaebler, P. Axelrad (University  
of Colorado Boulder)

**19-042     Control Design and Simulated  
Performance of a Drift-mode  
Accelerometer**

A. Nguyen (NASA Ames  
Research Center), J. Conklin  
(University of Florida)

- 19-043 **Advanced Algorithm and Design Implementations for Small Spacecraft GN&C**  
M. Baumgart, M. Ferenc, D. Hegel, B. Rogler, D. Sanders (Blue Canyon Technologies)
- 19-044 **Small Spacecraft State of the Art in Guidance, Navigation, and Control**  
B. Yost (NASA Ames Research Center, C. Baker, C. Norton (NASA HQ)
- 19-045 **Attitude Control of an Inflatable Aircraft for Mars Exploration**  
A. Chandra, J. Thangavelautham (University of Arizona – SpaceTREx)
- 19-046 **GNC Challenges and Opportunities of CubeSat Science Missions Deployed from the Lunar Gateway**  
H. Kalita ((University of Arizona – SpaceTREx), R. Furfaro (University of Arizona – Systems and Industrial Engineering), C. Hamilton, E. Asphaug (University of Arizona – Lunar and Planetary Laboratory), J. Thangavelautham (University of Arizona – SpaceTREx)
- 19-047 **Imaging X-Ray Polarimetry Explorer (IXPE) Small Satellite and Payload Attitude Determination and Control**  
J. Bladt (Ball Aerospace)
- 19-048 **Honeywell 3-Axis Space Rate Sensor for Small Satellites**  
D. Horkheimer (Honeywell)

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## TUTORIAL SESSION 11:30 AM - 1:30 PM

**Beyond the Textbook Tutorial:** This session focuses on going beyond software-only simulation, to quickly and efficiently test your control designs for Aerospace systems in real-time while connecting to hardware.

**Speaker:** Abhi Shankar Abhinav,  
MathWorks

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## DUAL AFTERNOON SESSIONS

**Session V**

**Sunday 2:00-4:00 PM**

### **Extended Mission Spacecraft**

Some spacecraft outlive their design lives and remain useful for many extra years. Typically, they continue their planned missions, while in others they are re-born with new unplanned applications. This session will explore the issues faced by these spacecraft and the unique and often clever efforts devised by their operators to eke out every bit of operational life and new opportunities for them.

#### **National Chairpersons**

Bill Frazier, NASA Jet Propulsion Laboratory  
[William.e.frazier@jpl.nasa.gov](mailto:William.e.frazier@jpl.nasa.gov)

Tooraj Kia, NASA Jet Propulsion Laboratory  
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#### **Local Chairperson**

Scott Mitchell, Ball Aerospace  
[smitchel@ball.com](mailto:smitchel@ball.com)

19-051     **CloudSat Development of Thruster Only Maneuvering and Delta-V Capability**

- I. Gravseth, H. Hallowell (Ball Aerospace)
- 19-052 **All Stellar Navigation Implementation on Mars Reconnaissance Orbiter**  
B. Mihevc, E. Schmitz, P. Travis (Lockheed Martin Space)
- 19-053 **Fast Attitude Maneuvers for the Lunar Reconnaissance Orbiter**  
M. Karpenko, T. Lippman, I. M. Ross (Naval Post Graduate School), J. Halverson, T. McClanahan, M. Barker, E. Mazarico (NASA-GSFC), R. Besser (KBRwyle), N. Dennehy, T. VanZwieten (Langley Research Center), A. Wolf (JPL-Caltech)
- 19-054 **The K2 Mission's Final Campaigns: Extending Science Collection through Operations and Controls Approaches**  
K. McCalmont-Everton, K. Larson, C. Peterson (Ball Aerospace)
- 19-055 **SMAP Science Recovery Efforts**  
C. Ballard (JPL-Caltech)
- 19-056 **Suomi NPP (S-NPP) On Orbit Performance Summary**  
R. Brewster, B. Hood, E. Hamilton, R. Burns, D. States, S. Silva (Ball Aerospace)

**Session VI**

**Sunday 2:00-4:00 PM**

### **GN&C Innovations**

As space flight evolves rapidly the industry sees many innovations that push forward GN&C. These innovations seek to answer a variety of GN&C challenges from lessons learned on

recent flights to creative ways to approach new challenges. This session seeks to showcase some of these innovations

### **National Chairpersons**

Bill Frazier, NASA Jet Propulsion Laboratory  
[William.e.frazier@jpl.nasa.gov](mailto:William.e.frazier@jpl.nasa.gov)

Paul Graven, Cateni  
[paul@graven.com](mailto:paul@graven.com)

### **Local Chairperson**

Cheryl Walker, Parsons  
[cheryl.walker@polarisalpha.com](mailto:cheryl.walker@polarisalpha.com)

- 19-061 **Trajectory Characteristics of Spacecraft Propelled by a Ground-based PLP System about a Non-spherical Central Body**  
Y. Wen, F. Hsiao (Department of Aerospace Engineering, Tamkang University)
- 19-062 **Recent Flight Experiences of Blue Canyon Technologies Spacecraft, ADCS, and Components**  
B. Rogler, M. Baumgart, M. Ferenc, D. Sanders (Blue Canyon Technologies)
- 19-063 Withdrawn
- 19-064 **Sextant Navigation on the International Space Station: A Human Space Exploration Demo**  
G. Holt, B. Wood (NASA-JSC)
- 19-065 **Rapid Development of the Seeker Free-Flying Inspector Guidance, Navigation, and Control System**  
J. Sullivan, S. Pedrotty, E. Gambone, B. Wood (NASA -



JSC), T, Kirven (Jacobs  
Engineering)

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**Super Bowl '19**

**Sponsored by AAC Microtec  
North America**

**4:15 in the Imperial Ballroom**

Family Members of conference  
attendees are welcome!

Sandwiches and appetizers will be served

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**MONDAY, FEBRUARY 4<sup>TH</sup>  
DUAL MORNING SESSIONS**

**Session VII**

**Monday 7:00-10:00 AM**

**Advanced Navigation Applications and  
Technologies**

New space navigation technologies and methods are being continuously driven by upcoming interplanetary deep space lunar, asteroid, and Martian missions, as well as by existing limitations and vulnerabilities of both ground-based ranging and current GNSS (GPS) space architectures. As new space missions are challenged to reliably navigate in LEO and venture further out of MEO, GEO and beyond, innovative navigation approaches will be required to compliment or replace existing systems to achieve higher levels of autonomy in the maintenance of spacecraft states. In this session we will explore advances and novel approaches to ground-based, GNSS-based, and onboard spacecraft sensor navigation algorithms and technologies including x-ray and optical navigation, deep space signal tracking, relative navigation and new filtering applications.

**National Chairpersons**

Renato Zanetti, University of Texas Austin  
[renato@utexas.edu](mailto:renato@utexas.edu)

Jay McMahon, University of Colorado Boulder  
[jay.mcmahon@colorado.edu](mailto:jay.mcmahon@colorado.edu)

### **Local Chairpersons**

Ellis King, Lockheed Martin Space  
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Lee Barker, Lockheed Martin Space  
[lee.a.barker@lmco.com](mailto:lee.a.barker@lmco.com)

Jeffrey Parker, Advanced Space  
[parker@advanced-space.com](mailto:parker@advanced-space.com)

- 19-071     **Spacecraft Proximity  
Navigation Using the iVisNav  
Sensor System**  
K. Sung, D. Adams, J. Peterson,  
M. Majji, J. Junkins (Texas A&M  
University)
- 19-072     Withdrawn
- 19-073     **Six Degree of Freedom  
Navigation using Astrophysical  
Signals of Opportunity**  
J. Runnels, D. Gebre-Egziabher  
(University of Minnesota)
- 19-074     **GOES-R Series GEO Side-Lobe  
Capable GPSR Post-Launch  
Refinements and Operational  
Capabilities**  
G. Ramsey, L. Barker (Lockheed  
Martin Space)
- 19-075     Withdrawn
- 19-076     **Lidar-Based Autonomous  
Shape Reconstruction and  
Navigation about Small Bodies  
Under Uncertainty**  
B. Bercovici, J. McMahon  
(University of Colorado Boulder)
- 19-077     **Progression of Recovering  
Time & State for Autonomous**

## **Navigation Systems in Deep Space**

A. Dahir, D. Kubitschek, S. Palo  
(University of Colorado Boulder)

**Session VIII                      Monday 7:00-10:00 AM**

### **Advanced 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 Chairperson**

Jeff Sheehy, NASA STMD  
[jeffrey.sheehy@nasa.gov](mailto:jeffrey.sheehy@nasa.gov)

#### **Local Chairpersons**

John Abrams, Analytical Mechanics Associates, Inc.  
[j.abrams@ama-inc.com](mailto:j.abrams@ama-inc.com)

Nick Patzer, Laboratory for Atmospheric and Space Physics (LASP)  
[Nicholas.Patzer@lasp.colorado.edu](mailto:Nicholas.Patzer@lasp.colorado.edu)

**19-081      Propulsion-Enabled, ESPA-Class Spacecraft for Near-Earth Applications**

W. Deininger, K. McConnell, S. Green, P. Woznick, M. Santi, and S. Mitchell (Ball Aerospace)

**19-082      Analyzing Mission Opportunities for Earth to Mars Roundtrip Missions**

- B. Muzek, J. Horton, C. Russell  
Joyner (Aerojet Rocketdyne)
- 19-083 **Lunar Landing and Sample  
Return from Near Rectilinear  
Halo Orbit Using High-Powered  
SEP**
- J. Horton, T. Kokan, C. Russell  
Joyner, D. Morris, R. Noble  
(Aerojet Rocketdyne)
- 19-084 **GNC of Interplanetary  
Spacecraft Utilizing Water-  
Steam Propulsion**
- J. Martinez, A. Chandra and J.  
Thangavelautham (University of  
Arizona – SpaceTReX)
- 19-085 **Development Plan for a Fission  
and Fusion Powered  
Propulsion System to Reach  
Mars in 45 Days**
- J. Cassibry, D. Thomas, R.  
Frederick, S. Kumar (University of  
Alabama Huntsville), R. Wood  
(University of Tennessee  
Knoxville)
- 19-086 **Capability Development  
Strategy for Deep Space Rapid  
Transit Propulsion**
- R. Litchford (NASA)
- 19-087 **The Air Force Research  
Laboratory's In-Space  
Propulsion Program**
- J. Koo (AFRL)

# **Beyond the Textbook Tutorial: Rapid Spacecraft Design and Simulation with the New STK SOLIS 11.4**

**Speaker: Jason Ruggieri, AGI**

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## **DUAL EVENING SESSIONS**

**Session IX**

**Monday 4:00-7:00 PM**

### **Autonomous Navigation in the Earth- Moon System**

Recent and near-term planned missions in the Earth-Moon system and beyond have begun to rely heavily on autonomous navigation and related disciplines such as autonomous targeting, guidance, and control, all of which are currently undergoing rapid development. Crewed vehicles including Orion and the upcoming Lunar Orbital Platform-Gateway have stringent requirements for long-term navigation and operations in the absence of ground contact, while rendezvous and docking concepts rely on onboard navigation technologies to intelligently and autonomously approach their targets. This session will explore state-of-the-art and developmental concepts and technologies for autonomous onboard navigation and operations of spacecraft in the vicinity of the Earth-Moon system. Crewed applications, such as those relevant to NASA's Lunar Orbital Platform-Gateway and related programs, are especially encouraged.

#### **National Chairpersons**

Joel Parker, NASA Goddard Space Flight Center  
[joel.j.k.parker@nasa.gov](mailto:joel.j.k.parker@nasa.gov)

Ryan Whitley, NASA Johnson Space Center  
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#### **Local Chairpersons**

Ellis King, Lockheed Martin Space,  
[ellis.king@lmco.com](mailto:ellis.king@lmco.com)

Lee Barker, Lockheed Martin Space,  
[lee.a.barker@lmco.com](mailto:lee.a.barker@lmco.com)

- 19-091 **Guidance and Navigation Design Trades for the Lunar Pallet Lander**  
J. Orphee, M. Hannan, E. Anzalone, N. Ahmad, S. Craig, N. Olson, B. Bae, V. Tapia (NASA-MSFC), E. Braden (NASA-JSC)
- 19-092 **A Deep Space Autonomous Navigation System for the Lunar Orbital Platform-Gateway**  
S. Bhatt, S. Steffes, G. Barton (Draper Laboratory)
- 19-093 **The Deep Space Positioning System (DPS) Navigator Concept for the Lunar Gateway**  
S. Bhaskaran, M. Abrahamson, T. Ely, B. Kennedy, T. Martin- Mur, N. Mastrodemos, R. Park, J. Riedel, A. Vaughan, J. Guinn (JPL-Caltech)
- 19-094 **The Cislunar Autonomous Positioning System (CAPS)**  
J. Parker, J. Smith, A. Forsman, C. Rabotin, C. Cain, B. Cheetham (Advanced Space)
- 19-095 Withdrawn
- 19-096 **GPS Based Autonomous Navigation Study for the Lunar Gateway**  
L. Winternitz, M. Hassouneh (NASA), B. Bamford (Emergent Space Technologies), A. Long (a.i. solutions)
- 19-097 **Predicted Performance of a X-ray Pulsar Navigation System for Future Deep Space and Lunar Missions**  
J. Getchius (a.i. solutions), A. Long, M. Farahmand (NASA\_GSFC), L. Winternitz, J. Mitchell (NASA-JSC)
- 19-098 **Proba-3 Precise Orbit Determination based on GNSS Observations**  
W. Enderle, F. Gini (ESA)

**Session X**

**Monday 4:00-7:00 PM**

## **Lessons Learned in GN&C Simulation, Verification, and Validation**

Testing of GN&C systems for spaceflight presents a unique challenge, particularly for closed-loop control in the non-space environment. Industry tends to rely on a combination of algorithm-level high-fidelity simulation, software-only simulation, hardware-in-the-loop testbeds with flight software and open-loop and closed-loop flight system testing. The success of spaceflight programs, human and robotic alike, depends on adequate GN&C testing in the form of comprehensive performance, risk reduction, robustness, faulted-scenario, phasing and latency tests in a constrained environment that cannot fully recreate the space environment. This session will highlight the GN&C lessons learned and recent experiences associated with simulation, integration, test, verification and validation.

### **National Chairpersons**

Mike Hughes, NASA Jet Propulsion Laboratory  
[michael.p.hughes@jpl.nasa.gov](mailto:michael.p.hughes@jpl.nasa.gov)

Mike Moreau, NASA Goddard Space Flight Center  
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### **Local Chairpersons**

Dan Kubitschek, Laboratory for Atmospheric and Space Physics,  
[Daniel.Kubitschek@lasp.colorado.edu](mailto:Daniel.Kubitschek@lasp.colorado.edu)

Jim Chapel, Lockheed Martin Space,  
[jim.d.chapel@lmco.com](mailto:jim.d.chapel@lmco.com)

- 19-101    **GPS Receiver Testing at GSFCs Formation Flying Testbed**  
B. Bamford (Emergent Space Technologies), L. Winternitz, S. Price, T. Lulich (Libration Systems Management)

- 19-102 **Contact Dynamics at the Space Operations Simulation Center**  
A. Carrier, C. Norman, N. Eshleman, D. Huish (Lockheed Martin Space)
- 19-103 **Simulation-Based Analysis and Prediction of Thrust Vector Servoelastic Coupling**  
J. Orr, J. Wall (NASA-MSFC), T. Barrows (Draper Laboratory)
- 19-104 **Adaptations of Guidance, Navigation, and Control Verification and Validation Philosophies for Small Satellites**  
C. Pong, D. Sternberg, G. Chen (JPL-Caltech)
- 19-105 **A Formal Approach to Verification & Validation of Guidance, Navigation, and Control Algorithms**  
J. Crane, A. Vinod, J. Westphal, I. Hussein (L3 Applied Defense Solutions), J. Gleason, M. Oishi (University of New Mexico)
- 19-106 **Verification and Validation Testing for the Parker Solar Probe Guidance and Control System**  
R. Vaughan, D. O'Shaughnessy, J. Wirzburger (JHU Applied Physics Laboratory)
- 19-107 **GOES-R Spacecraft Verification and Validation Compared with Flight Results**  
J. Chapel, T. Bevacqua, D. Stancliffe, G. Ramsey (Lockheed Martin Space), T. Rood (Advanced Solutions, Inc.), D. Freesland (ACS Engineering), J. Fiorello (Aerospace



Corp.), A. Krimchansky (NASA-GSFC)

**19-108 Testing of the Lunar  
Reconnaissance Orbiter Attitude  
Control System Re-Design  
Without a Gyro**

J. Halverson, O. Hsu, P. Calhoun,  
S. Snell, R. Besser, R. DeHart  
(NASA-GSFC)

**TUESDAY, FEBRUARY 5<sup>TH</sup>  
DUAL MORNING SESSIONS**

**Session XI**

**Tuesday 7:00-10:00 AM**

**Advances in GN&C 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.

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Tomas Ryan, Ball Aerospace  
[tryan@ball.com](mailto:tryan@ball.com)

- 19-111      **Hypersonic Communications  
Blackout: How Lasercom Could be  
the Solution**  
R. Golding (United States Air Force  
Academy)
- 19-112      **RVS3000-3D LIDAR - Pose  
Estimation for Satellite Servicing**  
Schmitt, Dochow, Both, Linhart,  
Schwarz, Windmaller (Jena-Optronik  
GmbH)
- 19-113      **Autonomous Calibration of Horizon  
Sensors for Sun Nadir Steered  
Satellites**  
E.Maben, (NASA-MSFC), D. Gitomer,  
P. Mavroudakis (Lockheed Martin)
- 19-114      Withdrawn
- 19-115      **A Method to Estimate Co-states  
from a Given Near Optimal  
Trajectory for Low Thrust Orbit  
Transfer**  
S. Ratan (Lockheed Martin)
- 19-116      **Imaging X-Ray Polarimetry Explorer  
Deployment Dynamics Simulation  
Supporting Concept of Operations  
Development**  
C. Allard, J. Bladt, I. Gravseth (Ball  
Aerospace)

**Session XII**

**Tuesday 7:00-10:00 AM**

**Advances in GN&C 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**

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[kgwin@ball.com](mailto:kgwin@ball.com)

Todd Tygesen, Ball Aerospace  
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- 19-121      **Modeling and Optimizing Carbon Fiber Reinforced Plastic Reflectors Using Finite Element Analysis**  
S. Sutedjo (United States Air Force Academy), T. Hiroaki (National Defense Academy of Japan)
- 19-122      **AURIGA - a reliable and cost affordable Star Tracker series for Constellations and Small Satellite missions**  
B. Gelin, L. Nicollet (SODERN ArianeGroup)
- 19-123      **Active Magnetic Field Mitigation in a Reaction Wheel**  
A. Nicolai, S. Stoltz, S. Scheiding (Astro-und Feinwerktechnik Adlershof GmbH), O. Hillenmaier, J. Ludwig, C. Strauch (Magson GmbH, Germany)
- 19-124      **The Hadamard Variance for Rate Sensing Gyroscope Noise Characterization**  
M. Hilsenrath (Lockheed Martin Space)

- 19-125 **The KODIAK GNSS Receiver For Microlaunchers and Sounding Rockets**  
A. Grillenberger, B. Braun, M. Markgraf (German Aerospace Center DLR)
- 19-126 **Airbus DS, New CMG for Agile Satellites**  
P. Faucheux, A. Pepoz (AIRBUS Defence and Space)
- 19-127 **Exploiting Terrestrial MEMS Gyro Development**  
R. Durrant, M. Utton (Thales Alenia Space-UK), E. Whitley (Silicon Sensing Systems Ltd), S. Kowaltschek (ESA)

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**TUTORIAL SESSION 1:30 PM – 3:30PM**

**Beyond the Textbook Tutorial:  
Spacecraft Line-of-Sight Jitter  
Management**

**Speakers: Neil Dennehy, NASA-NESC  
and Gary Henderson (Aerospace Corp.)**

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**DUAL EVENING SESSIONS**

**Session XIII Tuesday 4:00-7:00 PM**

**Space Observatory Line-of-Sight  
Jitter/Micro-Vibration**

Predicting and managing space observatory Line-of-Sight jitter/micro-vibrations due to on-board internal disturbance sources is a formidable multi-disciplinary systems engineering challenge, especially for sensitive optical sensors. In this session, examples of high-performance missions with demanding jitter engineering challenges will be introduced and described. Areas of focus include modeling, simulation, and analysis; and architectural approaches such as disturbance isolation

systems to minimize the impacts. Other topics of interest are: test facilities and techniques for component-level disturbance characterization; observatory-level testing of dynamic interactions; comparisons of in-flight to pre-launch predictions; and lessons learned from addressing this difficult problem.

### **National Chairpersons**

Neil Dennehy, NASA-NESC

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Oscar Alvarez-Salazar, NASA Jet Propulsion Laboratory

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Pat Brown, Laboratory for Atmospheric and

Space Physics [Pat.Brown@lasp.colorado.edu](mailto:Pat.Brown@lasp.colorado.edu)

#### **19-131 A Survey of the Spacecraft Jitter Problem**

C. Dennehy (NASA-NESC) and O. Alvarez-Salazar (JPL-Caltech)

#### **19-132 GOES I-M Observatory Dynamic Interaction and Jitter: A Historical Case Study Featuring Critical Lessons Learned**

M. Hagopian (Sigma Space Corporation), J. Sudey (Retired), C. Dennehy (NASA-NESC)

#### **19-133 In-Flight Line-of-Sight Pointing Performance for the GOES-16 and GOES-17 Spacecraft**

T. Bevacqua, J. Chapel, D. Stancliffe (Lockheed Martin Space), T. Rood (Advanced Solutions, Inc.), D. Freesland (ACS Engineering), A. Krimchansky (NASA-GSFC)

- 19-134      **TSIS Experiences with ISS Jitter from Inception to On-Orbit Operation**  
P. Brown, D. Engelmann (Laboratory for Atmospheric and Space Physics)
- 19-135      **The Consequences of Your Microvibration Requirement on Mechanism Design and Verification: Some Dos and Don'ts**  
G. Smet and J. Vandersteen (ESA)
- 19-136      **Europa Clipper Pointing Stability: Challenges on a Multi-instrument Mission to Jupiter**  
B. Smith (JPL-Caltech)
- 19-137      **High Precision Pointing Control for WFIRST CGI Instrument**  
N. Fathpour, O. Alvarez-Salazar, M. Mandic, J. Shields (JPL-Caltech)

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**Introduction from Michelle Miller  
Ball Aerospace Director of Missions and  
Systems Engineering  
4:00-4:15 PM**

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**Session XIV                      Tuesday 4:15-7:00 PM**

### **Formation Flying and Autonomy**

Many missions could benefit from formation flying and autonomy in defense, civil, and commercial applications. Formation flying and autonomy can be used by mission planners to improve performance, reduce cost, and/or reduce mission data downlink requirements. Science applications include improved data capture efficiency for Earth science and sparse aperture telescopes for astronomy. Commercial applications include automated operations, target identification for efficient image acquisition, and automated resource allocation.

This session welcomes all forms of formation flying and autonomy papers.

### **National Chairperson**

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Tim Bevacqua, Lockheed Martin Space  
[timothy.bevacqua@lmco.com](mailto:timothy.bevacqua@lmco.com)

- 19-141      **Improved Data Collection Using Model Predictive Control for Constellation Pointing**  
R. Rohrschneider, M. Leiber, C. Weimer (Ball Aerospace)
- 19-142      **Use of Laser Beams to Configure and Command Spacecraft Swarms**  
H. Kalita, L. Vance, J. Thangavelautham (University of Arizona – SpaceTREx), V. Reddy (University of Arizona – Lunar and Planetary Laboratory)
- 19-143      **Effect of Navigation and Maneuver Execution Errors on Optimal RPO Trajectory Design**  
K. Jin, D. Geller, J. Luo (Utah State University)
- 19-144      **Spacecraft Swarm Attitude Control for Small Body Surface Observation**  
R. Nallapu, J. Thangavelautham (University of Arizona – SpaceTREx)
- 19-145      Withdrawn
- 19-146      **Precise and Efficient Formation Keeping at Earth-Sun L2 for Starshade Missions**  
T. Flinois, D. Scharf, C. Seubert, M. Bottom, S. Martin (JPL-Caltech)

**WEDNESDAY, FEBRUARY 6<sup>TH</sup>  
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.

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Sam Thurman, NASA Jet Propulsion Laboratory  
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Drew Engelmann, Laboratory for Atmospheric and Space Physics  
[Drew.Engelmann@lasp.colorado.edu](mailto:Drew.Engelmann@lasp.colorado.edu)

- 19-151      **In-Flight Validation of the OSIRIS-REx Sample Mass Measurement Technique**  
R. M. Skeen, H. Ma, E. Bierhaus (Lockheed Martin Space), D. Laurretta (University of Arizona – Lunar and Planetary Laboratory)
- 19-152      **EchoStar III Attitude Recovery**  
X. Li, S. Ratan, F. Tsen, K. Byun (Lockheed Martin Space)
- 19-153      **Vision Navigation using the ISS Selfie**



- F. Monterroza, S. Steffes (Draper Laboratory), S. Pedrotty, S. Robinson, P. Spehar (NASA-JSC)
- 19-154 **A Geosynchronous Satellite Anomaly Resolution: Attitude Determination for Deorbit Maneuvers**  
X. Li, S. Ratan, F. Tsen, K. Byun (Lockheed Martin Space)
- 19-155 **Developing the GNC System for NASA's Mars Helicopter**  
H. Grip (JPL-Caltech)
- 19-156 **Seeker Free-flying Inspector Overview**  
S. Pedrotty, J. Sullivan, E. Gambone (NASA - JSC), T. Kirven (Jacobs Engineering)
- 19-157 **Pointing Control of a High Performance Large Angle Scanner**  
M. Ostaszewski, Y. Lee (Ball Aerospace)
- 19-158 **Overview of the Advanced Supersonic Parachute Inflation Research Experiments (ASPIRE) Targeting System and Flight Results**  
E. Leylek, M. Ivanov (JPL-Caltech), V. Gsell (Northrop Grumman/NASA Wallops Flight Facility), S. Dutta, A. Bowes, E. Queen (NASA Langley Research Center)

NOTES

## **2019 Planning Committee**

Amy Delay

Michelle Barath

Lis Garrett

Lockheed Martin Space

Lockheed Martin Space

Ball Aerospace

John Abrams	Analytical Mechanics
Lee Barker	Lockheed Martin Space
Tim Bevacqua	Lockheed Martin Space
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Scott Piggott	LASP
Andrew Riskus	Ball Aerospace
Reuben Rohrschneider	Ball Aerospace
Jim Russell	Lockheed Martin Space
Tomas Ryan	Ball Aerospace
Tom Segal	Metropolitan State
Meredith Stephens	Ball Aerospace
Jastesh Sud	Lockheed Martin Space
Todd Tygesen	Ball Aerospace
Cheryl Walker	Parsons
Morgan Yost	Lockheed Martin Space

Please join us next year for the 2020  
AAS GN&C Conference

**Chair:**

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