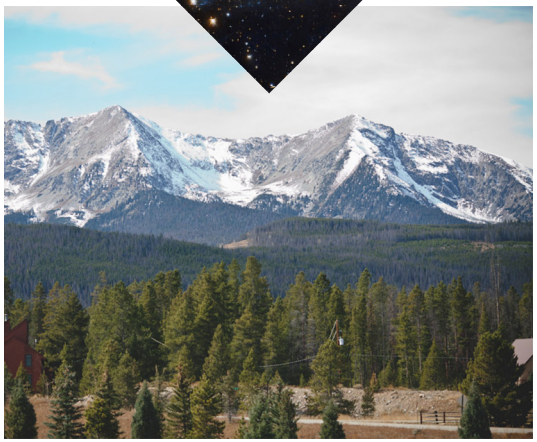
American Astronautical Society
Rocky Mountain Section

39th Annual Guidance, Navigation and Control Conference



Breckenridge, Colorado
Beaver Run Conference Center
Feb. 5 to Feb. 10, 2016

39th ANNUAL AAS GUIDANCE & CONTROL CONFERENCE

February 5th to February 10th, 2016

Friday, February 5th

7:30 AM Check in 8:00 AM Session

CLASSIFIED SESSION

Classified Advances in GN&C and

Classified Recent Experiences

Location of Classified Session:

Lockheed Martin SSC Waterton Campus
12257 S. Wadsworth Blvd
Littleton, CO 80125
Building No.120, 4th Fl. MAC Conf. Rm.

Beaver Run Resort
Breckenridge, CO
Room check-in at front desk
4 PM Daily

Conference Registration
Friday 5:00-8:00 PM
Daily 6:30-10:00 AM and 4:00-6:00 PM

Registration Questions

Carolyn O'Brien	**720-277-5851**
Lis Garratt	**303-931-7622**
Amy Delay	**303-884-5728**

39th Annual AAS Guidance, Navigation & Control (GN&C) Conference
Chairperson
David Chart
Lockheed Martin Space Systems Company
303-977-6875
david.a.chart@lmco.com

Wireless Access in Conference Area
Username: AAS2016
Password: beaver

PAPER LOCATION:
AAS RMS has invited you to **view** the following shared folder/AAS GN&C 2016 Papers:
https://goo.gl/6xfZ4Z

Conference Outline

Friday, February 5, 2016

Classified Session	7:30 AM - 3:00 PM
Conference Registration	5:00 – 8:00 PM
Wine & Cheese Reception	6:00 – 9:00 PM

Saturday, February 6, 2016
Conference Opening & Keynote Address by Mike Gazarik 7:00 AM
Morning Session: 7:15 – 10:15 AM
AAS STEM SCAPE Event 10:30 AM – 4:00 PM
Astronaut Talk for Children 4:00 – 5:00 PM
Technical Exhibits: 5:00 – 8:00 PM

Sunday, February 7, 2016
Posters in Breakfast Room
Morning Sessions: 7:00 – 10:30 AM
Beyond the Textbook Tutorial Session 11:00 AM-1:30 PM
Afternoon Sessions 2:00 – 4:00 PM

Monday, February 8, 2016
Morning Sessions: 7:00 – 1000 AM
Beyond the Textbook Tutorial Session 10:30 AM – 3:30 PM
Afternoon Session 4:00 – 6:00 PM
Networking Event
Presentation of Student Awards

Tuesday, February 9, 2016
Morning Sessions: 7:00 – 10:00 AM
Beyond the Textbook Tutorial Session 10:30 AM – 3:30 PM
Afternoon Sessions 4:00 – 7:00 PM

Wednesday, February 10, 2016
Morning Session: 7:00 – 10:00 AM

Traditional Conference Located at 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

Wine and Cheese 6:00-9:00 PM/Peak 17

SATURDAY, February 6th
7am Conference Opening & Keynote Address
By: Mike Gazarik,
VP Engineering, Ball Aerospace & Technologies Corp.

Session I **7:15-10:15 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 relevancy 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 awards.

National Chairpersons
Tim Crain, Intuitive Machines
tim@intuitivemachines.com
David Geller, Utah State University
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Lt. Col. David Richie, United States Air Force Academy
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Local Chairpersons
Ian Gravseth, Ball Aerospace & Tech.Corp.
igravseth@ball.com
Jastesh Sud, Lockheed Martin Space Systems Company
jastesh.sud@lmco.com

16-011 **Investigation of Combining X-ray Pulsar Phase Tracking Estimates to Form a 3D Trajectory**
K. Anderson, D. Pines, S. Sheikh (University of Maryland)

16-012 **Solar Radiation Pressure Applications on Geostationary Satellites**
P. Kelly, R. Erwin, R. Bevilacqua, L. Mazal (University of Florida)

16-013 **A Geometric Approach To Second -Order, Circular-Reference Spacecraft Relative Motion**
A. Harris, L. Benhacine, T. Lovell, A. Sinclair (State University of New York at Buffalo)

16-014 **Hardware-in-the-Loop Simulator for Rapid Prototyping of CMG-Based Attitude Control Systems**
B.C. Fields, S.M. Kocis, K. Williams, M. Karpenko (Naval Postgraduate School)

16-015 **Spacecraft Attitude Estimation for Low Cost CubeSat Missions**
V. Goecks, A. Probe, R. Woollands, J. Hurtado, J. Junkins (Texas A&M University)

16-016 **Relative Spacecraft Navigation via Inter-Satellite Range Measurements**
C.Rundberg, T. Lovell (University of Wyoming)

16-017 **Error Sensitivities for Flash LIDAR Based Relative Navigation around Small Bodies**
A. Dietrich, J. McMahon (University of Colorado)

16-018 **Improving Control of FalconSAT-3**
C. Arnold, B. Kester, D. Richie (US Air Force Academy)

10:30 AM-4:00 PM

AAS STEM-SCAPE Event

In 2016, we will be hosting our second STEM event for one hundred 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. Our keynote speaker is Lisa Hardaway, PH.D., Senior Program Manager in National Defense at Ball Aerospace & Technologies Corp., who 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. If you are interested in volunteering at the event, please contact our Education Committee planning POCs:

Local Chairperson
Michael Drews
michael.e.drews@lmco.com

Special Event for Children of Conference Attendees at 4 PM

NASA Astronaut, Jim Voss

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 **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 & Technologies Corp.
mlstephe@ball.com
Jim Russell, Lockheed Martin Space Systems Company
james.f.russell@lmco.com

Technical Exhibit Participants

Analytical Graphics, Inc. (AGI)
Airbus Defence & Space
Astro- und Feinwerktechnik Adlershof GmbH
Ball Aerospace & Technologies Corp.
BEI Precision Systems and & Space Company
Blue Canyon Technologies
Cayuga Astronautics
Jena-Optronik GmbH
Lockheed Martin Space Systems Company
NewSpace Systems
Northrop Grumman
Sierra Nevada Corporation
SODERN
Surrey Satellite Technology
University of Colorado Aerospace Eng. Sciences
Utah State University Space Dynamics Laboratory
UTC Aerospace Systems
Texas A&M

SUNDAY, FEBRUARY 7th

Poster Focus During Extended Morning Session Break

The Poster Session offers a unique forum for authors and interested parties to discuss relevant topics. Posters do not require an accompanying written paper. However, authors who wish to have their work published in the proceedings can submit a written paper along with the poster. The Poster Session will be available for viewing every day in the main conference room.

Local Chairpersons
Cheryl Walker, Lockheed Martin Space Systems Company
cheryl.a.walker@lmco.com

16-151 **Observations on the Geometry of Horizon-Based Optical Navigation**
J. Christian (West Virginia University) S. Robinson (NASA JSC)

16-152 **Methods for a Non-Iterative Solution to Angles-Only Inertial Relative Orbit Determination**
A. Ceniceros (University of Arizona)

16-153 **Simulating the Wheel World: Reaction Wheel Simulators for Small Satellite Avionics Testing**
W. Jantscher (United States Air Force Academy)

16-154 **Compact Magnetic Torque Bars**
J. Krebs (Cayuga Astronautics)

16-155 **Adaptive Control System for CubeSat Attitude**
A. Probe (Texas A&M University)

16-156 **General Hinged Solar Panel Dynamics Approximating First-Order Spacecraft Flexing**
H. Schaub, C. Allard, S. Piggott (University of Colorado)

16-157 **Freewheelin: Reaction Wheel Motor Sizing and Torque Analysis for EyasSAT3**
T. Townley (United States Air Force

16-158 **Validation of Inverse Mapping Algorithms for Analytically Propagating Nonlinear Probability Density**
A. B. Younes (Khalifa University, Abu Dhabi, UAE)

16-159 **Assessment of uSat Constellation for a Small Body Science Mission**

Dual Morning Sessions

SESSION III **7:00-10:30 AM**

GNC Future Concepts

Without innovative thinking, the state of the art cannot be advanced. This session explores innovative concepts that will enable the community to field more capable, less costly, and/or timelier systems. Topics are open to all aspects of flight including ascent, re-entry, simulation and modeling, in-flight operations, payload accommodation, and ground system elements.

National Chairpersons
Doug Freeland, NASA/GSFC
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Local Chairperson
Tim Bevacqua, Lockheed Martin Space Systems Company
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Denniks Nicks, Jr, Ball Aerospace & Technologies Corp.
dnicks@ball.com

16-031 **Paper Withdrawn**

16-032 **GN&C Design for Autonomous Payload Return from ISS**
S. Stewart, W. Johnson, C. Chomel, S. Tamblyn, J. Woods (Intuitive Ma-

16-033 **Split-Maneuver Targeting Based on Pseudo-Lambert Targeting and the Clohessy-Wiltshire Equations**
N. Ortolano, D. Geller, T. Lovell (Utah

16-034 **GEO-Hosted Imaging Spectrometer**
J. Speed, J. Carr, H. Gutierrez, D. Nicks (Ball Aerospace &

16-035 **Paper Withdrawn**

16-036 **Differential Geometry for Motion Along a Rotating Ellipse for Remote Sensing Applications**

16-037 **Paper Withdrawn**

16-038 **Attitude Control Performance Analysis Using Discretized Thruster With Residual Tracking**
J. Alcorn, H. Schaub, D. Kubitschek (University of Colorado), A. AlSayegh (Emirates Institution for Advanced Science and

SESSION IV **7:00-10:30 AM**

Future of Space Servicing

This session focuses on the advanced relative navigation and control technologies that enable future space servicing applications. Relative navigation all the way to contact has been used in cooperative applications many times, but this session discusses the unique challenges and solutions for navigating to objects not originally designed for servicing. For spacecraft control, contact and coupled dynamics introduce challenges that must be handled robustly to maintain safety and stability during the servicing operations.

National Chairpersons
Gordon Roesler, DARPA
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Brook Sullivan, Sullivan Analytics
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Glenn Creamer, NRL
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Local Chairpersons
Alex May, Lockheed Martin Space Systems Company
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Kickoff **Future of Space Servicing**
Presenters: G. Creamer (NRL), J. Van Eopel (NASA/GSFC), B. Miller (Lockheed Martin).
Presentation only.

16-041 **Setting the Standards for Satellite Servicing**
B.Miller (Lockheed Martin SSC)

16-042 **Vision Navigation Sensor (VNS) with Adaptive Electronically Steerable Flash LIDAR (ESFL)**
R. Rohrschneider, C. Weimer, J. Masciarelli, M. Lieber, C. Adkins, J. Domber (Ball Aerospace)

16-043 **Paper Withdrawn**

16-044 **Accurate Range Resolution of LADAR Images by Binary Shift Keying**
M. Majji (University of Buffalo), B. Sallee (Systems and Processes Engineering Corp), J. Junkins (Texas A&M University)

16-045 **Fast Kalman Filtering for Relative Spacecraft Position and Attitude Estimation for the Raven ISS Hosted Payload**
J. Galante, J. Van Eepoel NASA/GSFC), C. Souza (NASA/JSC), B. Patrick (Emergent Space Technolo-

16-046 **Reusable Bird's-Eye View for On-Orbit Satellite Servicing Using CubeSats**
C. Roscoe, J. Westphal, R. MacMillan (Applied Defense Solutions)

16-047 **Laboratory Experiments for Orbital Debris Removal**
C. Moody (Texas A&M University)

TUTORIAL SESSION 11:00 AM-1:30 PM

Beyond the Textbook: GNSS

Speaker: Frank Bauer, FBauer Aerospace Consulting Services

Dual Afternoon Sessions

Session V 2:00-4:00 PM

Advanced Access to Space

Developing advanced technologies and applying new operational approaches to launch systems is critical to increase the flexibility, affordability, and performance of advanced systems for space access. This may include air-breathing, hypersonic stages; air launched vehicles; methods for system reuse; and optimization of the trajectory and control of the mission. The session will highlight both the technologies and operations of advanced launch systems, including challenges and

solutions of such approaches with respect to guidance, navigation, and control.

National Chairpersons
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Mike Hannan, MSFC mike.r.hannan@nasa.gov

Local Chairpersons
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John Reed, United Launch Alliance
john.g.reed@ulalaunch.com
Tim Bevacqua, Lockheed Martin Space Systems Company
timothy.bevacqua@lmco.com

16-051 **Paper Withdrawn**

16-052 **Vulcan, ACES and Beyond: Providing Launch Services for Tomorrows Spacecraft**
R. Deroy, J. Reed (United Launch Alliance)

16-053 **Paper Withdrawn**

16-054 **Advanced Control Strategy for European Launchers**
M. Ganet-Schoell (Airbus Defense and Space)

16-055 **Generalized Predictor-Corrector Guidance Scheme used for a Multi-Stage All Solid Guidance Strategy**
C.Maunder (Orbital ATK)

Session VI 2:00-4:00 PM

Miniaturization of GN&C Components

The miniaturization of GN&C components represents an enabling technology for certain mission types, such as sample return missions, and promises to greatly improve capabilities of other mission types, such as cubesats. This session focuses on miniaturization technologies, including system on chip and mixed signal ASICs and hy-

brids, as well as integration of miniaturized sensor packages into GN&C designs. Topics include current development work and technology demonstrations, as well as future concepts.

National Chairpersons
Andrew Shapiro, JPL/CIT
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Glenn Lightsey, Georgia Institute of Technology
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Local Chairpersons
Suraj Rawal, Lockheed Martin Space Systems Company,
suraj.rawal@lmco.com
Jim D.Chapel, Lockheed Martin Space Systems Company
jim.d.chapel@lmco.com

16-061 **Conceive, Believe and Achieve; A Path to Miniaturization, COTS Infusion, and SWaP**
D. J. Hunter, D. Schatzel (JPL/CIT), S. Fadler, F. D. Egitto, A. Schwartz-Bowling (i3 Electronics)

16-062 **State of the Art in Guidance Navigation and Control: A Survey of Small Satellite GNC Components**
E. Agasid (NASA/Ames), R. Burton (Millenium Engineering & Integration), S. Weston (SGT Inc.),

16-063 **No Longer Tumbling: GNC Capabilities of Today's CubeSats**
A. Klesh, A. Wolf (JPL/CIT)

16-064 **Reducing Size Weight Power and Cost in Stellar Inertial Space Navigation**
B. Klein, D. Chamberlin (Honeywell), J. F. Bouvry, B. Gelin (Sodern)

16-065 **Recent Advances in Commercial Memories and Potential Contribution to GN&C Miniaturization**
J. Yang-Scharlotta, S. Guertin (JPL/CIT)

MONDAY, FEBRUARY 8th

Parallel Morning Sessions

Session VII **7:00-10:00 AM**

GNSS Precision PNT

Global Navigation Satellite Systems (GNSS) put the 'N' in GN&C. Precise Position, Navigation, and Timing (PNT) are essential in modern spacecraft mission design and execution. The GNSS Precise PNT session highlights advances, success stories, and lessons learned in all aspects of the use of GNSS for GN&C systems. Session topics include traditional Global Positioning System (GPS) applications, use of modernized signals and mixed systems (GPS, GLONASS, GALILEO, etc.), GNSS improvements; advances in receiver hardware and software designs; advances in PNT estimation and signal processing algorithms; innovative applications that may include advanced techniques, extended service volume, new users, and new or alternative service applications; Government policy highlighting GNSS deployment and usage; GNSS technology roadmaps; and operations, demonstrations, or experiment results.

National Chairpersons
Col. David Goldstein, U.S. Air Force
david.goldstein@us.af.mil
Cheryl Gramling, NASA/GSFC,
cheryl.j.gramling@nasa.gov

Local Chairpersons
Lee Barker, Lockheed Martin
lee.a.barker@lmco.com
Mark Crews, Ball Aerospace & Technologies Corp.
mcrews@ball.com

16-071 **Achieving GNSS Compatibility and Interoperability to Support Space Users**
Dr. A. J. Oria (Overlook Systems Technologies), J. Miller (NASA), J. Parker (NASA/GSFC), F. Bauer (F. Bauer Aerospace Consulting Services)

16-072 **Use and Protection of GPS Sidelobe Signals for Enhanced Navigation Performance in High Earth Orbit**
J. Parker (NASA/GSFC), J. Valdez (NASA/GSFC), F. Bauer (F. Bauer Aerospace Consulting Services), M. Moreau (NASA/GSFC), E. Carter, (University of Tennessee)

16-073 **Solar Flare Degradation of GPS Navigation at GEO**
C. Voboril (Lockheed Martin), S. Winkler (Lockheed Martin), Kristin Larson (Emergent Space Technologies), D. Freesland (ACS Engineering)

16-074 **LION NEO – A Versatile Space GNSS Receiver**
P. Krauss (Airbus DS), M. Hartrampf (Airbus DS), A. Barrios-Montalvo (Airbus DS), H. Filippi (Airbus DS), E. Gottzein (University Stuttgart)

16-075 **GPS Based Navigation Implementation for GOES R**
J. Gillette (Relative Dynamics), M. Concha (Relative Dynamics)

16-076 **GPS Navigation above 76,000km with NASA's Magnetospheric Multiscale Mission**
L. Winternitz (NASA), W. Bamford (Emergent Space Technologies), S. Price (NASA), R. Carpenter (NASA), A. Long (AI Solutions), M. Farahmand (AI Solutions)

16-077 **Post-Flight Analysis of GPSR Performance During Orion Exploration Flight Test 1**
L. Barker (Lockheed Martin), H. Mamich (Lockheed Martin), J. McGregor (Odyssey Space Research)

16-078 **Navigation Architecture for a Space Mobile Network**
J. Valdez, J. Carpenter, C. Gramling, G.Heckler, B. Ashman (NASA)

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

Image-Based Optical Navigation

Image-based optical navigation is becoming an increasingly important part of all space missions, in part due to the decrease in cost of cameras and the increasing capabilities of both flight processors and algorithms. Image-based navigation systems include sensors that can detect visible light, the thermal IR, or optically measure range; virtually any sensor that produces data in real-time that can be viewed as an image. Optical navigation algorithm capabilities range from star identification and tracking to object identification in point cloud data. Applications include attitude and position determination relative to the stars, the Earth, another spacecraft, and planetary surfaces. This session explores algorithms for optical navigation and performance of systems for current and future missions that use optical navigation.

National Chairpersons
John Christian, West Virginia University
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Anup Katake, JPL/CIT
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Local Chairpersons
Ellis King, Charles Stark Draper Laboratory
eking@drapercom
Reuben Rohrschneider, Ball Aerospace & Technologies Corp.
rrohrsch@ball.com

16-081 **Uncertainty Quantification of Image Feature Tracks Generated by the KLT Tracker**
X.I. Wong, M. Majji (SUNY Buffalo)

16-082 **Vision Navigation Performance for Autonomous Orbital Rendezvous and Docking**
E. Dahlin, D. Woffinden, P. Spanos (Rice University, Draper)

16-083 **New Horizons Optical Navigation on Approach to Pluto**
C.D. Jackman, D.S. Nelson, P.J. Dumont, W.M. Owen, M.W. Buie, S.A. Stern, H.A. Weaver, L.A. Young, K. Ennico, C.B. Olkin (KinetX, JPL, SwRI, JHU/APL, NASA Ames)

16-084 **Relative Terrain Imaging Navigation Tool (RETINA) for ARRM**
C. Wright, M. Shoemaker, J. Van Eepoel, K. DeWeese, K. Getzandanner (GSFC)

16-085 **Development and Flight of a Stereoscopic Imager for use in Spacecraft Close Proximity Operations**
J.E. Darling, K.A. LeGrand, P. Galchenko, H.J. Pernicka, K.J. DeMars, A.T. Shirley, J.S. McCabe, C.L. Schmid, S.J. Haberberger, A.J. Mundahl (Missouri University)

16-086 **OSIRIS-Rex Asteroid Sample Collection - Open Loop Testing of Optical Based Feature Tracking at the SOSC**
R. Hamilton, C. Norman (Lockheed Martin Corp.)

16-087 **Robustness and Performance Impacts of Optical-Based Feature Tracking to OSIRIS-Rex Asteroid Sample Collection Mission**
C. Mario, C. Debrunner (Draper)

16-088 **ASTRO APS Star Tracker Performance on Sentinel-2A**
U. Schmidt, B. Pradarutti, J. Mehlhorn, I. Steinbach, A. Kwiatkowski (Jena

TUTORIAL SESSION 10:30 AM-3:30 PM

Beyond the Textbook: Simulating Observations to Assess OD Performance

Speaker: David Vallado and the AGI Team

Session IX 4:00-6:00 PM

Pioneers in GN&C and Astronautics

This session will be reflections on the experiences of technologists who pioneered technology solutions in the Aerospace community from sounding rockets through human space flight to today's commercial applications.

National Chairpersons
Louis Herman, Aerospace Corp.
louherman@aol.com

Local Chairpersons
James McQuerry, Ball Aerospace & Technologies Corp. (Retired)
mcquerrydj@comcast.net
Larry Germann, Left Hand Design Corp.
germannl@lefthand.com

16-091 **Guidance Developments of Robert Goddard and the Germans at Peenemünde**
J. Goodman (Odyssey Space Research)

16-092 **Advances in Planetary Entry, Descent, and Landing Systems**
Z. Putnam (University of Illinois at Urbana-Champaign), R. Braun (Georgia Institute of Technology)

16-093 **Powered Guidance Development for Apollo and the Space Shuttle**
J. Goodman (Odyssey Space Research)

16-094 **Paper Withdrawn**

16-095 **A Short History of the Space Shuttle Orbit Flight Control System Development and Application Evolution**
P. Hattis (Draper Laboratory)

SOCIAL NETWORKING EVENT

6:00 to 7:30 PM

Opportunity for conference attendees and guests to network with others. The winners of student competition will be announced; and continued networking after the formal event is encouraged!

TUESDAY, FEBRUARY 9th

Parallel Morning Sessions

Session X **7:00-10:00 AM**

Small Body Encounters

Over the last few decades, a plethora of space science missions have been directed towards the study of small planetary bodies. Several missions had successful encounters during this timeframe, and several others were launched. Preliminary results from these missions have led to an exciting renaissance in solar system exploration over the past year. Each of these missions faced unique Guidance, Navigation, and Control systems challenges, and planned sample return missions present a whole new set of challenges associated with very close proximity operations leading to contact with the surface. This session will highlight the Guidance, Navigation and Control recent experiences and challenges associated with designing, testing and operating spacecraft for the purpose of small body encounters.

National Chairpersons
Mike Moreau, NASA/GSFC
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Dante Lauretta, University of Arizona
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Local Chairpersons
Dan Kubitschek, University of Colorado/Boulder

LASP
daniel.kutitschek@lasp.colorado.edu
Lisa Hardaway, Ball Aerospace & Technologies Corp.
lhardawa@ball.com

16-101 **OSIRIS-REx Orbit Determination Covariance Studies at Bennu**
P. Antreasian, C. Jackman, K. Williams, B. Page, J.M. Leonard (KinetX), and M. Moreau (NASA GSFC)

16-102 **Guidance and Optical Navigation for Small Body Descent Trajectories**
B. Duffy, T. McGee, A. Diaz-Calderon (JHU-APL)

16-103 **An Independent Orbit Determination Simulation for the OSIRIS-REx Asteroid Sample Return Mission**
K. Getzandanner, D. Rowlands, E. Mazarico, M. Moreau (NASA-GSFC), P. Antreasian,
C. Jackman (KinetX)

16-104 **Surface Proximity Gravitational Field Analysis of the Asteroid 433 Eros**
S. G. Hesar (CU-Boulder)

16-105 **Asteroid Redirect Mission Proximity Operations for Reference Target Asteroid 2008 EV5**
D. M. Reeves, D. D. Mazanek (NASA-LaRC), B. D. Cichy (AS and D, Inc.), S. B. Broschart (NASA JPL), and K. D. DeWeese (NASA GSFC)

16-106 **GN&C of Hayabusa2 in "Cruising Phase" and "Asteroid Proximity Phase"**
F. Terui (JAXA)

16-107 **Determination of Ceres Parameters Using Radiometric and Optical Data**
B. Kennedy (NASA-JPL)

Session XI **7:00-10:00 AM**

ORION Special Session

Orion completed a nearly flawless flight test of its Crew Module in 2014. The next milestone is a complete systems flight test beyond the moon in 2018 on the first launch of the Space Launch System booster, leading to certification of Orion for exploration. This session will review results from the Exploration Flight Test 1 mission and explore new design features of the first human-rated spacecraft to visit the moon in 46 years.

National Chairpersons
Tim Straube, Johnson Space Center
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Jack Brazzel, Johnson Space Center
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Local Chairpersons
Mike Begley, Lockheed-Martin Space Systems Company
michael.e.begley@lmco.com
John Bendle, Lockheed-Martin Space Systems Company
john.r.bendle@lmco.com

16-111 **Evolution of Orion Mission Design for Exploration Mission 1 and 2**
J. Gutkowski, T. Dawn, R. Jedrey (NASA)

16-112 **Encke-Beta Predictor for Orion Burn Targeting and Guidance**
S. Robinson, S. Scarritt (NASA), J. Goodman (Odyssey)

16-113 **Orion Burn Management Nominal and Response to Failures**
C. Barrett, K. Pohlkamp, S. Robinson, (NASA), R. Odegard (Draper), J. Goodman (Odyssey)

16-114 **Orion GN&C Detection and Mitigation of Parachute Pendulosity**
M.Kane (NASA), R. Wacker (Lockheed Martin)

16-115 **Orion GN&C Fault Management System Verification Scope and Methodology**
D. Brown, R. Flanary (Odyssey), D. Weiler (NASA)

16-116 **Geometric Calibration of the Orion Optical Navigation Camera using Star Field Images**
J. Christian, L. Benhacine, J. Hikes (West Virginia University)

16-117 **Orion EFT-1 Best Estimated Trajectory Development**
G. Holt, A. Brown (NASA)

TUTORIAL SESSION **10:30 AM-3:30 PM**

Beyond the Textbook: Spacecraft Precision Pointing, Tracking, and Stabilization: A Holistic View of Instrumentation, Algorithms, and Applications

Speaker: Tim Henderson, Charles Stark Draper Laboratory

Parallel Afternoon Sessions

Session XII **4:00-7:00 PM**

In Space Propulsion Innovations

Technology innovations in the area of space propulsion have become prominent recently with notable DOD, NASA, and industry investment in green propellant thrusters, cryogenic propellant storage, high-power electric propulsion systems, and propellantless propulsion. Additionally, trends toward employing small spacecraft for an increasing range of applications are driving demand for efficient propulsion technologies for high-mobility micro/nano/picosatellites. This session will highlight emerging propulsion hardware and systems and their GN&C and mission planning implications that address diverse implementations such as fine pointing for science spacecraft, low-thrust cargo transfer, high-thrust Earth and Mars departure, and descent to / ascent from planetary bodies.

National Chairpersons
Jeff Sheehy, NASA
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Local Chairpersons
Bryce Unruh, Ball Aerospace & Technologies Corp.
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Christopher McLean, Ball Aerospace & Technologies Corp.
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Jeff Parker, University of Colorado/Boulder
parkerjs@colorado.edu

16-121 **Green Propellant Infusion Mission (GPIM) Program Overview and Status**
C. McLean (Ball Aerospace)

16-122 **A Green Propulsion Case Study for Spacecraft Controls**
P. Mason (NASA/GSFC)

16-123 **Suitability of Propulsion Technologies for Nano-Spacecraft**
B. Hargus (AFRL)

16-124 **Current Capabilities of Scalable Ionic Liquid Electrospray Thrusters for Nano-Satellites**
D. Krejci (MIT Space Propulsion Lab)

16-125 **Considerations for Operation of a Deep Space Nanosatellite Propulsion System**
M. Sorgenfrei (NASA/ARC)

16-126 **Assessing and Taking Up the Challenges to an EP-based Space Tug System for On-orbit Commercial Servicing**
G. Pionnier (Airbus Defence & Space)

16-127 **GN&C Applications Using Nest Generation NEXT-C High Power Ion Thruster**
S. Overton (Aerojet Rocketdyne)

16-128 **Strategic Technologies for Rapid Deep Space Transport**
R. Litchford (NASA/HQ)

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

Advances in GN&C

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 the 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
Neil Dennehy, NASA/GSFC
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Local Chairpersons
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James Cook, Sierra Nevada Corporation
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16-131 **Moving Geolocation Home to the Ground**
J. Boardman (AIG)

16-132 **Observability and Solution Techniques for Range-Only Relative Navigation**
J. Christian, A. Jagat (West Virginia University)

16-133 **Paper Withdrawn**

16-134 **An Advanced Architecture for Optimizing Earth Science Data Collection Based Upon Model Predictive Control**
M. Lieber, C. Weimer, R. Rohrschneider, L. Ruppert (Ball Aerospace)

16-135 **ASTRIX1090 Fiber Optic Gyro success paves the way for future development**
A. Ardan, S. Masson, G. Cros (Airbus Defence & Space), S. Ferrand (IXSPACE), S Kowaltscheck, S. Airey, J. Vandersteen (ESA), G. Delavoipierre (CNES)

16-136 **IRES-C: A New Earth Sensor for Leo Satellites**
F. Boldrini, S. Brogi, D. Procopio, P. Fidanzati, M. Morresi (Selex ES)

16-137 **Strain Actuated Solar Arrays for precision pointing of Spacecraft**
J. Aldrich , O. Alvarez-Salazar (JPL), J. Allison, S. Chung (UIUC)

16-138 **Modelling of Spacecraft with N Reaction Wheels using Arbitrary Attitude Parameterizations**
A. Walsh, D. Zlotnik, J. Forbes (University of Michigan)

WEDNESDAY, FEBRUARY 10th

Session XIV **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
Bill Frazier, JPL/CIT
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Local Chairpersons
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Scott Mitchell, Ball Aerospace & Technologies Corp.
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16-141 **New Horizons Guidance & Control and Propulsion Systems Budgets vs. Performance for the Pluto Encounter**
G. Rogers, S. Flanigan, S. Bushman, C. Hersman, V. Mallder, M. Kirk, H. Ambrose (JHU/APL), L. Young (SwRI)

16-142 **Cassini Navigation: The Road to Consistent sub-kilometer Satellite Encounters**
J. Bellerose, D. Roth, S. Nandi (JPL/CIT)

16-143 **Orion Exploration Flight Test-1 Post-Flight Navigation Performance Assessment Relative to the Best Estimated Trajectory**
R. Gay, G. Holt, R. Zanetti (NASA/JSC)

16-144 **Launch & Commissioning of the Deep Space Climate Observatory (DSCOVR)**
N. Frey, E. Davis (NASA)

16-145 **Celestial Aspects of Mars Science Laboratory ChemCam Sun-Safety**
S. Peters, L. DeFlores, N. Warner, T. Litwin (JPL/CIT)

16-146 **Paper withdrawn**

16-147 **The LIRIS-2 3D Imaging LIDAR on ATV-5**
F. Kolb, M. Windmüller, M. Roessler, B. Moebius (Jena-Optronik), P. Casiez, B. Cavrois (Airbus Defence & Space), O. Mongrard (ESA-ESTEC)

40th Annual AAS Guidance & Control Conference
February 3rd to February 8th, 2017

Chairperson

Reuben Rohrschneider, Ball Aerospace & Technologies Corp.
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