44th AEROSPACE MECHANISMS SYMPOSIUM

Cleveland, Ohio
May 16-18, 2018

Hosted by NASA Glenn Research Center and Lockheed Martin Space
Organized by the Mechanisms Education Association

SYMPOSIUM OBJECTIVES

This symposium is concerned with the problems of design, fabrication, test, and operational use of aerospace mechanisms. Emphasis is on hardware developments. The symposium provides a social and technical forum for personnel active in the field of mechanisms technology, as well as providing a source of information for others interested in this field. The symposium rotates among eight NASA Centers and attracts papers and attendees from all over the world.

SYMPOSIUM LOCATION

The Hilton Cleveland Downtown in Cleveland, Ohio is the site for all technical sessions.

SYMPOSIUM ACTIVITIES

The planned technical and social activities provide an opportunity for attendees to become professionally and personally acquainted. Dress attire is business casual unless otherwise noted.

MECHANISMS COURSES – On Monday and Tuesday, May 14-15, three separate courses will be offered in the same hotel as the AMS. ***Be sure to use the hotel booking link below when you make your hotel reservations.*** Registration for the Aerospace Mechanisms Symposium is **not** included in any class price.

Space Mechanisms Course (May 14-15)
Launchspace is providing a special edition of its internationally popular Space Vehicle Mechanisms course. This course explores the technologies required for successful space mechanisms design and offers a detailed look at many of the key components common to most mechanisms. The materials necessary to achieve high performance are discussed. Examples of the many types of mechanisms are included for illustration. In addition, the mechanisms relationships and interfaces with other vehicle systems are explored. The course includes design and analysis examples to demonstrate principles involved in understanding how mechanisms should work and how design margins should be evaluated during the evolution of a program.
Register at: https://launchspace.com/ams-2018-registration/
The special symposium price for this course is $895. Due to the special pricing (list price for this course is $1595), the textbook, "Space Vehicle Mechanisms: Elements of Successful Design", edited by P.L. Conley, will not be provided but can be purchased commercially by attendees.

ESTL Space Tribology Course (May 14th and 15th)
The European Space Tribology Laboratory presents this course which draws heavily from experimental data generated during its 45 years as Europe's independent center of excellence for space tribology. Attendees will receive a comprehensive overview of the many issues relating to friction, lubrication and wear of spacecraft mechanisms, presented in 4 parts:

Fundamentals of Tribology - in which tribological concepts are introduced and the special considerations for space and vacuum tribology highlighted.
Tribo-component Design and Performance – in which an overview of the different types, characteristics and performances of tribo-components (ball bearings, gears, plain and ball/roller screws, etc.) used in spacecraft applications is provided. This includes a detailed presentation of considerations for design, selection and load capacity verification of ball bearings for space applications.
Lubrication of Spacecraft Components – in which the application-driven considerations for selection of fluid and dry (solid) lubricants are provided. This part includes the considerations and typical performances of dry (solid) and fluid lubricants, respectively. Some practical issues concerning application, handling and preloading of ball bearings are also presented.
Lessons Learned – presenting a selection of the (sometimes painful!) lessons learned on various programs.

Summarizing test data not widely accessible outside Europe, the course, whose two presenters have almost 40 years of space tribological experience, will be valuable both for younger engineers entering the industry and for the more experienced who may wish to refresh or challenge their tribological understanding. Attendees will receive personal paper and electronic format copies of presentation handouts (around 300 slides in total). The symposium price for the course is $1000 and a minimum of 25 delegate registrations is required for the class to be held.

Register via the ESR website:
http://www.esrtechnology.com/centres/estl/Pages/default.aspx.

Shape Memory Alloys – Designing Your Next Mechanism Workshop (May 15)
Sixty years after the discovery of shape memory alloys (SMAs), many actuation and structural applications using these materials have been conceived and developed. SMAs are a unique class of multifunctional materials that have the ability to recover large deformations and generate high stresses in response to thermal, mechanical and/or electromagnetic stimuli. These abilities have made them a viable option for actuation/structural systems in aerospace applications, amongst others. However, designing with SMAs is a paradigm shift from the conventional way we look at metals and mechanisms.
In this course, you will learn how the unique properties of SMAs can be applied to designing mechanisms and the associated benefits. Basic primer will be provided on what they are and why they work with examples of the most successful applications that have been imagined. Common design tool and properties-database will be discussed.
Price is $550 with breakfast included. Register in the registration module of the AMS.

CHECK-IN - On Tuesday evening, May 15, from 6:00-8:00 PM, check in and registration will be in the Hilton Cleveland Downtown Eliot's Lounge located on the second floor. Symposium materials, including symposium proceedings, will be available, along with light refreshments.

RECEPTION - On Wednesday evening, May 16, a reception will be held in the Hilton Cleveland Downtown. Supplier and poster paper displays will be exhibited during the evening along with demonstrations by local high school FIRST Robotics teams. A light buffet dinner will be served. The exhibits will be open for the enjoyment of all attendees and guests.

SYMPOSIUM BANQUET - On Thursday evening, May 17, the symposium dinner will be at the Rock and Roll Hall of Fame. The museum documents the entire history of rock and roll and is alive with the energy, passion and the spirit of music. The museum features seven floors, four theaters for films and ever-changing exhibits.

FACILITY TOURS - On Friday afternoon, May 18, there will be opportunities to go on a tour of NASA Glenn Research Center or NASA Plum Brook Station. The tours are open to all attendees and guests; space is limited on all tours so register early. **Non-US citizens wishing to attend a tour must register for the symposium by March 15**. Bus transportation will be provided.

GUEST ACTIVITIES – Cleveland is a major city in Ohio on the shores of Lake Erie. Landmarks dating to its days as a turn-of-the-20th-century manufacturing center include the Steamship William G. Mather, now part of the Great Lakes Science Center. It's also known for the stately Cleveland Museum of Art. The popular Crawford Auto-Aviation Museum features an excellent private collection of antique cars and airplanes. Close by is Cedar Point amusement park, the roller coaster capital of the world. See Cleveland visitor's guide at http://www.thisiscleveland.com/includes/content/docs/media/ovg.html

PRESENTERS' MEETINGS - Presenting authors are required to attend a complimentary breakfast on the day of their presentation. (Note – only the presenters, not all authors of the paper.) This gathering gives the session participants an opportunity to meet their Session Chair and each other, and to review the session arrangements. The Symposium AV help will be available to discuss presentation requirements.

SYMPOSIUM INFORMATION

REGISTRATION - Advance registration is requested to facilitate planning and commitments. Please register on www.aeromechanisms.com. The registration fee is $750 ($350 for full-time professors, $300 for full-time students and $250 for retirees). **Non-US citizens wishing to attend either of the tours must register by March 15.** Late registration for the symposium may be done at the hotel on Tuesday evening, May 3, and each day of the symposium. **NOTE: If the registration payment is received after 11:59pm EDT (GMT-4) April 13, 2018 the registration fee is $850 for all. Also, any registrations started but unpaid before this deadline will be also be revised to the late registration fee of $850 for all.** This fee covers all sessions, proceedings, break refreshments, reception, symposium banquet, tour, lunch for three days, and specified bus transportation. Guest tickets are $35 for the reception and $70 for the banquet (Late registration, $45 reception, $80 banquet).

Refund Policy – If a registration is cancelled, MEA will refund all fees paid less $50, if cancelled by May 1, 2018. After May 1, no refunds due to monetary commitments by the MEA for the symposium expenses. Alternatively, a registration may be transferred to another employee if the original registrant cannot attend as long as the request for the transfer is done prior to the symposium by contacting our registration POC (Alice Pfeiffer at CTP).

HOTEL RESERVATIONS – A block of rooms has been reserved at the Hilton Cleveland Downtown (http://www3.hilton.com/en/hotels/ohio/hilton-cleveland-downtown-CLEDOHH/index.html). The hotel features wireless internet, 24-hour fitness center, business center, pool and restaurant on site. Rooms at the Hilton Cleveland Downtown are offered at a special rate of $134 (which is the government per diem) for stays from May 12 to May 19 for attendees. Attendees must make their own reservations directly with the hotel. Use the link below

(preferred method) or if you call the hotel, mention the 44th Aerospace Mechanisms Symposium. **Make your reservations by April 13, 2018 to ensure the special rate**. After April 13, reservations may be made at the prevailing hotel rate. Reservation link:

https://aws.passkey.com/gt/214327830?gtid=fed68f263df8d10fe08682fc63823bd1

Hilton Cleveland Downtown
100 Lakeside Ave East
Cleveland OH 44114 USA
(216) 413-5000

TRANSPORTATION – Cleveland is served by Cleveland Hopkins International Airport (CLE)(12 miles away). Taxi/Ridesharing service, car rentals and a train to downtown are at the airport. The train stops at Downtown Cleveland's Tower City Station, which is about a 10-minute walk to the hotel (http://www.riderta.com/airportservice).

DR. GEORGE HERZL AWARD – At each symposium, an award is given to the author(s) of the "Best Paper." The award is based on paper content, presentation delivery, and visual aids. This award was established in honor of Dr. George Herzl of Lockheed Martin, a co-founder of the Aerospace Mechanisms Symposium.

DR. CHARLES COALE AWARD – Each year MEA sponsors a child to attend Space Camp in honor of Dr. Charles Coale of Lockheed Martin. Dr. Coale was the leader of the symposium for more than 20 years and had a special interest in helping children.

GRANTS - Each year MEA awards grants to several high school FIRST Robotics teams. MEA may also provide an AMS attendance stipend to student authors.

PROGRAM:

TUESDAY, 15 MAY 2018

6:00-8:00 CHECK-IN – Eliot's Lounge

WEDNESDAY, 16 MAY 2018

7:00 Wednesday Presenters' Breakfast – Veterans Room B

7:00 CHECK-IN AND REFRESHMENTS – 5th Floor Lobby

8:15 INTRODUCTORY REMARKS – Superior Ballroom, Section A

Damon Delap, Host Chairman, NASA Glenn Research Center, Cleveland, OH
Edward Boesiger, General Chairman, Lockheed Martin Space, Sunnyvale, CA
Marla E. Pérez-Davis, Deputy Director, NASA Glenn Research Center, Cleveland, OH

8:30 SESSION I – INSTRUMENTS
Session Chair: Rius Billing, MDA US Systems, Pasadena, CA

- Scroll Compressor for Mars Atmospheric Acquisition
  John Wilson & Bryce Shaffer, Air Squared, Inc., Broomfield, CO; Ted Iskenderian, Jet Propulsion Laboratory, Pasadena, CA

- The Regolith and Ice Drill for Exploration of New Terrains (TRIDENT); a One-Meter Drill for the Lunar Resource Prospector Mission
  Gale Paulsen et al., Honeybee Robotics Spacecraft Mechanisms Corp, Pasadena, CA/Longmont, CO; James Smith & Jacqueline Quinn, NASA Kennedy Space Center, FL

- KaRIn Alignment Mechanism Design, Development and Testing
  John Wolff, Jet Propulsion Laboratory, Pasadena, CA

- Environmental Chamber Testing of a Rock Sampling Drill for Venus Exploration
  Fredrik Rehnmark et al., Honeybee Robotics Spacecraft Mechanisms Corp, Pasadena, CA; Kristopher Kriechbaum et al., Jet Propulsion Laboratory, Pasadena, CA

10:10 SESSION II – BEARINGS & LUBRICATION
Session Chair: Merritt Webb, Harris Corporation, Fort Wayne, IN

- A Discussion of Friction Anomaly Signatures in Response to Electrical Discharge in Ball Bearings
  William Bialke, Lochridge Farm LLC, Trumansburg, NY

- Efficacy of Lead Naphthenate for Wear Protection in Mixed Lubrication Regime
  Jason Galary, NYE Lubricants Inc, Fairhaven, MA

- Dynamic Behavior of Ball Bearings under Axial Vibration
  Virgil Hinque & René Seiler, European Space Agency/ESTEC, Noordwijk, The Netherlands

- The Design & Development of the Ocean Color Instrument Precision Superduplex Hybrid Bearing Cartridge
  Joseph Schepis et al., NASA Goddard Space Flight Center, Greenbelt, MD; Timothy Woodard, Peter Ward & Michael Lee, The Aerospace Corporation, El Segundo, CA; Alfred Conti, The Barden Corporation, Danbury, CT; Jeffrey Guzek, Design Interface, Columbia, MD

11:50 LUNCH
Lunch for AMS Attendees in the Superior Ballroom, Section D

12:50 SESSION III – SOLID LUBRICATION
Session Chair: Brian Gore, The Aerospace Corporation, El Segundo, CA

- Evaluation of Friction Characteristics and Low Friction Mechanism of Tungsten Disulfide for Space Solid Lubricant at Elevated Temperature in a Vacuum
  Ayaka Takahashi & Josaphat Tetuko S S, Chiba University, Chiba, Japan; Keizo Hashimoto, Teikyo University, Tokyo, Japan

- Performance of MoS_2 Coated Gears Exposed to Humid Air During Storage
  Tim Krantz & Zachary Cameron, NASA Glenn Research Center, Cleveland, OH; Claef Hakun, NASA Goddard Space Flight Center, Greenbelt, MD; Iqbal Shareef, Bradley University, Peoria, IL; Michael Dube, NASA Langley Research Center, Hampton, VA

- An Improved Solid Lubricant for Bearings Operating in Space and Terrestrial Environments
  Arindam Paul et al., University of Akron, Akron, OH

- Hybrid Lubrication of PFPE Fluids and Sputtered MoS_2
  Michael Buttery et al., European Space Tribology Laboratory, ESR Technology Ltd., Warrington, United Kingdom

2:30 BREAK

2:45 SESSION IV - "OH THE NOISE! NOISE! NOISE!"
Session Chair: John Beasley, BEI Precision Systems & Space Division, Maumelle, AR

- Solving a Performance Limiting Resonance Frequency Problem of the SOFIA Secondary Mirror Mechanism by Structural Modifications
  Yannick Lammen, Andreas Reinacher & Alfred Krabbe, Deutsches SOFIA Institut, University of Stuttgart, Stuttgart, Germany

- Enhanced Vibration Isolation Using a Magnetic Linear Gear for Highly Demanding Aerospace Applications
  Jose Luis Perez-Diaz & Efrén Diez-Jimenez, Universidad de Alcalá, Alcalá de Henares, Spain ; Ignacio Valiente-Blanco et al., MAG SOAR S.L, Valdemoro, Spain

- A Mechanisms Perspective on Microvibration – Good Practices and Lessons Learned
  Geert Smet & Sandro Patti, European Space Agency, Noordwijk, The Netherlands

4:00 SESSION V – POTPOURRI OF POSTERS
Session Chair: Joseph Pellicciotti, NASA HQ, Washington, D. C.

- Investigation of Bolt Preload Relaxation for JWST Thermal Heat Strap Assembly Joints with Aluminum-1100 and Indium Gaskets
  Andrew Bartoszyk et al., NASA Goddard Space Flight Center, Greenbelt, MD; Thomas Walsh, Stinger Ghaffarian Technologies, Greenbelt, MD; Jason Krom, Sigma Space Corporation, Lanham, MD; Edgar Hemminger, Ares Corporation, Greenbelt, MD

- Validation and Test Results of the 2.5D Technology for Pancake Slip Rings
  Mélanie Henry & Sandro Liberatoscioli, RUAG Schweiz AG, Nyon, Switzerland

- Quantifying Threaded Fastener Locking
  Daniel Hess, University of South Florida, Tampa, FL; Christopher DellaCorte, NASA Glenn Research Center, Cleveland, OH

- Reliability Calculation Methodologies for Mechanisms and Actuators
  Tanner Horne & Evan Harrington, Avior Control Technologies, Inc, Longmont, CO

- Development of the NEA Mini for Low Load Applications
  John Sudick & Geoff Kaczynski, NEA Electronics, Inc., Moorpark, CA

- Compliant Mechanisms Re-Design based on Additive Manufacturing and Topology Optimization
  Lionel Kiener et al., Centre Suisse d'Electronique et de Microtechnique S.A., Neuchatel, Switzerland

- Non-Pyrotechnic Multi-Point Release Mechanisms for Spacecraft Release
  Ambrosio Mejia, John Sudick & Geoffrey Kaczynski, Ensign Bickford Aerospace - NEA Electronics, Inc., Moorpark, CA

- Validation of a Novel High Performance Magnetic Gearbox for Space
  Ignacio Valiente-Blanco et al., MAG SOAR SL., Valdemoro, Spain; Efrén Diez-Jimenez & José Luis Perez-Diaz, Universidad de Alcalá, Alcalá de Henares, Spain

- Qualification of a Networked Pyrotechnic Initiation System for the CST-100 Starliner Spacecraft
  David Novotney et al., Ensign Bickford Aerospace, Simsbury, CT

6:00 -10:00 RECEPTION – Hilton Cleveland Downtown
Invited component suppliers display current products and provide tutorials along with FIRST Robotics Team demonstrations and a light buffet meal.

THURSDAY, 17 MAY 2018

7:00 Thursday Presenters' Breakfast – Veterans Room B

8:00 SESSION VI – ACTUATORS
Session Chair: Boz Sharif, Cobham Motion Control Solutions, Hauppauge, NY

- Use and Advantages of Direct-Drive Brushless DC Actuators for Precision Instrument Pointing of the Total and Spectral Solar Irradiance Sensor
  Patrick Brown, Andrew Engelmann & Ryan Lewis, University of Colorado, Boulder, CO

- Testing and Maturing a Mass Translating Mechanism for a Deep Space CubeSat
  Alex Few, Tiffany Lockett & Erik Loper, NASA Marshall Space Flight Center, Huntsville, AL; Richard Wilson & David Boling, Jacobs Technologies, Huntsville, AL

- Solar Array Drive Assembly Qualification Lessons Learned
  Jonathan Wood, Lockheed Martin Space, Sunnyvale, CA; Timothy Pargett, Moog Space and Defense Group, Mountain View, CA

- Determining Root Causes of Mysterious Hardware Failures using High Resolution CT Scanning
  Michael Johnson, Jet Propulsion Laboratory, Pasadena, CA

9:40 BREAK

9:55 SESSION VII – CUBESATS
Session Chair: Henk Cruijssen, Airbus Defence & Space, Leiden, The Netherlands

- Testing and Development of the NEA Scout Solar Sail Deployer Mechanism
  Alex Few & Tiffany Lockett, NASA Marshall Space Flight Center, Huntsville, AL; Richard Wilson & David Boling, Jacobs Engineering, Huntsville, AL

- Mechanism Design & Flight Build of Furled High Strain Composite Antenna for CubeSats
  Bruce Davis et al., Roccor, Longmont, CO

- Failure of the Ball-Lock Mechanism on the NanoRacks Cubesat Deployer
  Michael Lewis & Conor Brown, NanoRacks, LLC, Webster, TX

- Lessons Learned from a Deployment Mechanism for a Ka-band Deployable Antenna for CubeSats
  Jonathan Sauder et al., Jet Propulsion Laboratory, Pasadena, CA; Yahya Rahmat-Samii, University of California Los Angeles, Los Angeles, CA; Mark Thomson, Northrop Grumman Astro Aerospace, Carpentaria, CA

- Design and Development of CubeSat Solar Array Deployment Mechanisms Using Shape Memory Alloys
  Allen Guzik & Othmane Benafan, NASA Glenn Research Center, Cleveland, OH

12:00 LUNCH
Lunch for AMS Attendees in the Superior Ballroom, Section D

1:00: SPECIAL PRESENTATION: Restore-L: Enabling a New Era
Ben Reed: Deputy Division Director, Satellite Servicing Projects Division NASA Goddard Space Flight Center
Hear about the mission to robotically refuel Landsat 7 in low earth orbit. Learn about the novel robotic hardware being developed to grab and refuel this satellite that was never designed to be refueled.

2:05 SESSION VIII – DEPLOY AND SOMETHING NEW
Session Chair: David Rohweller, Northrop Grumman Astro Aerospace, Carpinteria, CA

- Lessons Learned in the Flight Qualification of the S-NPP and NOAA-20 Solar Array Mechanisms,
  Dan Helfrich, NASA Goddard Space Flight Center, Greenbelt, MD; Adam Sexton, Ball Aerospace Corporation, Boulder, CO

- Spacecraft Common Deployable Boom Hinge Deploy and Latching Mechanisms
  Paul Lytal, NASA Jet Propulsion Laboratory, Pasadena, CA; Marcel Renson, D.E.B. Manufacturing Inc., Lakewood, NJ

- Precision High-Strain Composite Hinges for Deployable Space Telescopes
  Mark Silver & Michael Echter, MIT Lincoln Laboratory, Lexington, MA

- The Synchronization Mechanism for Solar Array with a Three-Stage Deployment
  Zehong Yan et al., Beijing Institute of Spacecraft System Engineering, Beijing, China; Guowei Zhao, Beihang University, Beijing, China

- Mechanisms and New Space
  Bill Purdy, Purdy Engineering, Poolesville, MD

4:05 BREAK

4:20 INVITED PRESENTATION –Doug Wheelock, Aerospace Engineer and Astronaut
Doug has been launched into space via the Space Shuttle Discovery and Soyuz TMA-19, and spent more than 5 months in space aboard the Space Station. He has made multiple spacewalks to repair equipment and will have stories to tell.

7:00-11:00 BANQUET – Rock and Roll Hall of Fame
Dinner, entertainment and exhibits celebrating music history.

FRIDAY, 18 MAY 2018

7:00 Friday Presenters' Breakfast – Veterans Room B

8:00 SESSION IX – TRANSPORTATION & DOCKING
Session Chair: Brandon Robertson, NASA Johnson Space Center, Houston, TX

- Development of the Multi-Purpose Transportation System for the Space Launch System Core Stage Flight Article
  Sarah Sandridge, NASA Marshall Space Flight Center, Huntsville, AL; Hue Lien et al., Jacobs Space Exploration Group, Huntsville, AL

- Capture Latch Assembly for the NASA Docking System
  Brandon Dick & Nathan Mauch, The Boeing Company, Huntsville, AL; Timothy Rupp, NASA Johnson Space Center, Houston, Texas

- NASA Docking System Block 1: NASA's New Direct Electric Docking System Supporting ISS and Future Human Space Exploration,
  Justin McFatter, The Boeing Company, Houston, TX; Karl Keiser, The Boeing Company, Huntsville, AL; Timothy Rupp, NASA Johnson Space Center, Houston, TX

9:15 BREAK

9:30 SESSION X – TESTING
Session Chair: Peter Stromberg, Sandia National Laboratories, Albuquerque, NM

- High Speed Bearing Wear Rate Measurements for Spacecraft Active Thermal Control Fluid Pumps with a Novel Pin on Disk Apparatus
  Robert Bruckner, NASA Glenn Research Center, Cleveland, OH; Richard Manco II, HX5 Sierra, Cleveland, OH

- Accelerated Testing of Tribological Components - Uncertainties and Solutions
  Simon Lewis et al., European Space Tribology Laboratory, ESR Technology Ltd., Warrington, United Kingdom

- Developmental Bearing and Bushing Testing for Mars Gearboxes
  Dave Suffern & Jonathan Parker, Sierra Nevada Corp, Durham, NC

- Experimental Method for Determining Ball Bearing Lubricant Quantity Factor
  Yoshimi Takeuchi, Peter Frantz & Tim Woodard, The Aerospace Corporation, El Segundo, CA

11:10 SPECIAL PRESENTATION ON NASA GLENN RESEARCH CENTER

11:40 TECHNICAL SESSIONS CONCLUSION
Stu Loewenthal, Deputy Chairman, Lockheed Martin Space, Sunnyvale, CA
• Herzl Award Presentation

11:55 LUNCH
Lunch for AMS Attendees in the Superior Ballroom, Section D

1:00 – 5:00 TOURS
Attendees may go on a special tour of either NASA Glenn Research Center or NASA Plum Brook Station.

1:00	Buses depart hotel for tours
5:00	Approximate time buses return to hotel

SYMPOSIUM ORGANIZING COMMITTEE

Host Chair - Damon C. Delap, NASA GRC
Co-Host Chair - Steven W. Bauman, NASA GRC

General Chairman - Edward A. Boesiger, Lockheed Martin Space
Deputy Chairman - Stuart H. Loewenthal, Lockheed Martin Space

William Caldwell, NASA ARC
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Adam G. Dokos, NASA KSC
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Barry J. Dunn, NASA LaRC
Carlton L. Foster, NASA MSFC (retired)
Lionel Gaillard, ESA/ESTeC
Claef F. Hakun, NASA GSFC
Christopher P. Hansen, NASA JSC
Louise Jandura, JPL
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Ronald E. Mancini, NASA ARC (retired)
Fred G. Martwick, NASA ARC
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Joseph W. Pellicciotti, NASA OCE
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Brandan Robertson, NASA JSC
Joseph P. Schepis, NASA GSFC
Donald R. Sevilla, JPL
James E. Wells, NASA LaRC
Jonathan P. Wood, Lockheed Martin Space

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