2018 CONFERENCE ON ADVANCED POWER SYSTEMS FOR DEEP SPACE EXPLORATION

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Welcome

We are pleased to welcome you to the 2018 Conference on Advanced Power Systems for Deep Space Exploration! As we approach the 6th decade of interplanetary exploration, this conference will provide an excellent platform to discuss where we have been and the challenges ahead. Space power technologies have advanced significantly from the first United States satellite (Explorer 1) launched with primary batteries alone in 1958, to the sophisticated multi-mission radioisotope thermoelectric generator (RTG) and high reliability lithium-ion batteries powering the Mars Science Laboratory today.

As we look to the future, the technical challenges, as well as the opportunities for exploration and discovery are no less significant. These include the proposed exploration of caverns and lava tubes beneath the planets and moons of our Solar System, the return to Earth of an extraterrestrial sample from Mars, and science probes landing on the surface of Europa and one day melting through its icy shell to access and investigate the liquid water below for bio-signatures. In the works are concepts for our first interstellar missions.

The innovations in power systems continue. The recent Juno mission to Jupiter challenged the conventional wisdom that solar arrays could not be used at these extreme distances. This power system was enabled by advances in low-intensity and lightweight solar arrays combined with high energy and long-life lithium-ion batteries. In 2017, humankind passed the unimaginable milestone of the Voyager 1 spacecraft surviving 40 years in space supported by its long lived RTG. A host of other spacecraft such as the 20 year Cassini mission to Saturn, the New Horizons mission to Pluto, as well as the comet and asteroid missions Dawn, Rosetta and Hayabusa have all executed their voyages of discovery supported by a reliable power source. Continued advances in RTG technology are on-going at the National Aeronautics and Space Administration and the European Space Agency, and are complemented by similar enhancements in energy storage technologies, solar arrays, power electronics, and new power system architectures. What advances are on the horizon to enable the next generation of deep space exploration? That is the focus of this conference.

We have planned a comprehensive agenda of talks covering the full gamut of deep space power topics, including mission design, systems engineering, power electronics, power generation, and energy storage geared for the challenging and scientifically intriguing destinations within the Solar System and beyond. This includes speakers from space agencies and organizations around the world, who will provide an international perspective. The intent of this conference is to share information, to build new relationships, and to pave the way for new approaches to deep space power systems. Enjoy your time in Pasadena!
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**Side Meeting Rooms**

We encourage you to meet with your colleagues throughout the week. See the registration desk for availability on side meeting rooms. Space will be scheduled on a first-come-first-served basis.
Monday, 22 October 2018

1115 - 1140  The Role of Power in Deep Space Communications
Stephen Townes, Jet Propulsion Laboratory

1140 - 1250  Networking Lunch - Provided Onsite
Conference Center Lower Level, Room 106

System Perspectives on Deep Space Power II
Session Chair: Richard Ewell, Jet Propulsion Laboratory
Conference Center Lower Level, Room 107

1250 - 1320  Designing Spacecraft Power Systems to Solve Planetary Protection Challenges
Lisa Pratt, NASA Headquarters

1320 - 1350  Overview of NASA Radioisotope Power Systems Program
Leonard Dudzinski, NASA Headquarters

1350 - 1420  Overview of the European Space Nuclear Power Systems Programme
Richard Ambrosi, University of Leicester

1420 - 1445  Power Systems for Avionics and Motor Control in Deep Space Missions
Gary Bolotin, Jet Propulsion Laboratory

1445 - 1515  Break

Powering Ocean Worlds Exploration
Session Chair: Jean-Pierre Fleurial, Jet Propulsion Laboratory
Conference Center Lower Level, Room 107

1515 - 1545  Enabling Technologies for Ocean Worlds Exploration
Andrew Gray, Jet Propulsion Laboratory

1545 - 1610  Solar/Battery Power Architectures for Missions to Jupiter and Beyond
Greg Carr, Jet Propulsion Laboratory

1610 - 1635  Commercial Li-Ion Battery Risk Reduction for Applications to Ocean Worlds Exploration
Kumar Bugga, Jet Propulsion Laboratory

Saturn Solar Cells: State of Art and Development
Andreea Boca, Jet Propulsion Laboratory

eMMRTG Development and Infusion
Joe Giglio, DOE Idaho National Laboratory

Adjourn

Tuesday, 23 October 2018

0715 - 0745  Speaker Meeting for Tuesday's Presenters
Conference Center Lower Level, Room 107

0700 - 1800  Registration Open
Conference Center Lower Level Foyer

NASA and DOE Power System Perspectives
Session Chair: David Woerner, Jet Propulsion Laboratory
Conference Center Lower Level, Room 107

0800 - 0805  Announcements

0805 - 0835  NASA’s Power Capability Leadership Team’s Strategic Priorities in Power
Chris Iannello, NASA Office of Chief Engineer

0835 - 0905  Department of Energy Plutonium Production Updates
Steven Sherman, Oak Ridge National Laboratory

0905 - 0930  Improvements to the Nuclear Launch Approval Process
Peter McCallum, NASA Glenn Research Center

0930 - 1000  Break

Powering Spacecraft in Extreme Environments I
Session Chair: Will West, Jet Propulsion Laboratory
Conference Center Lower Level, Room 107

1000 - 1025  Ultra-Low Temperature Primary Battery Development
Cyrus Rustomji, South 8 Technologies
### Tuesday, 23 October 2018

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<td>1050 - 1115</td>
<td>High Efficiency Multi-Junction Solar Cells for LILT Applications</td>
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<td>LILT Optimized Triple Junction Solar Cells</td>
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<td>1140 - 1205</td>
<td>Low Temperature Characterization of Space Photovoltaics</td>
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**Powering Spacecraft in Extreme Environments II**

Session Chair: Jonathan Granddidier and Andreea Boca, Jet Propulsion Laboratory

*Conference Center Lower Level, Room 107*

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<td>1355 - 1420</td>
<td>Extreme Environments Solar Power Project: Enabling Solar Array Power to the Outer Planets</td>
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<td>1420 - 1445</td>
<td>Design of Solar Arrays for Deep Space Application</td>
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<td>Lithium-Ion Batteries for the Juno Mission</td>
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<tr>
<td>1510 - 1535</td>
<td>Sub-Surface RTG Systems and New Heat Sources</td>
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<td>Understanding Batteries under Extreme Conditions using Advanced Modeling and Simulation Techniques</td>
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<td>Safety and Reliability of Batteries in Deep Space Missions</td>
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<td>Approaches to Fault Tolerance in Deep Space Batteries</td>
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<td>Primary/Rechargeable Batteries for High Reliability Deep-Space Exploration Applications</td>
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<td>Ultralight Radiation-Tolerant Perovskite Solar Cells for Deep Space Applications</td>
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**Adjourn**

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**Powering Small Deep Space Missions**

Session Chair: Terry Hendricks, Jet Propulsion Laboratory

*Conference Center Lower Level, Room 107*

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<td>0805 - 0830</td>
<td>Power Systems for Future Deep Space CubeSat Missions</td>
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Powering Mars Exploration and Connections to Lunar Exploration
Session Chair: Kumar Bugga, Jet Propulsion Laboratory
Conference Center Lower Level, Room 107

0830 - 0855 Power Systems for Drones in Deep Space Exploration
Florence Fusalba, CEA-Grenoble FRANCE and Bruno Samaniego Lopez, Airbus

0855 - 0920 Development and Testing of Batteries for Asteroid Sample Return Missions
Yositsugu Sone, JAXA

0920 - 0945 Small RPS (<40 W_e) Mission Architectures
Young Lee, Jet Propulsion Laboratory

0945 - 1010 1-Watt Radioisotope Power System for Small Spacecraft
Scott Wilson, NASA Glenn Research Center

1010 - 1040 Break

Common Power Options for Crewed Surface Missions and Deep Space Science Probes
Lee Mason, NASA Glenn Research Center

1100 - 1135 Mars Optimized Solar Cells
Paul Stella, Jet Propulsion Laboratory

1135 - 1200 Low Temperature Rechargeable Li-ion Batteries for Mars Sample Return and Small Robotic Missions
Marshall Smart, Jet Propulsion Laboratory

1200 - 1315 Networking Lunch - Provided Onsite
Conference Center Lower Level, Room 106

Emerging and Advanced Deep Space Power Concepts
Session Chair: Erik Brandon, Jet Propulsion Laboratory
Conference Center Lower Level, Room 107

1315 - 1340 Dynamic Radioisotope Power Systems
Salvatore Oriti, NASA Glenn Research Center

1340 - 1405 Chemical Heat Source Power Systems
Alex Rattner, Penn State University

1405 - 1430 Fuel Cells for Mars and Beyond
Thomas Valdez, Teledyne

1430 - 1455 Hybrid Power Storage & Conversion for Deep Space Applications
Greg Semrau, Moog Aerospace

1455 - 1520 Development of the Point Focus Concentrator (PFC) Compact Telescoping Array (CTA)
Mike McEachen, Northrop Grumman Innovation Systems

1520 - 1550 Break

Overview of Systems Engineering Integrated with Technology Development Work to Inform Future RTG Designs
Terry Hendricks and Jean-Pierre Fleurial, Jet Propulsion Laboratory

1615 - 1640 Power for Interstellar Encounter: Analysis of Ultra-Miniature Power Systems for an Interstellar Flyby Probe
Geoffrey Landis, NASA Glenn Research Center

1640 - 1705 Directed Energy Propulsion for Interstellar Precursor Missions
John Brophy, Jet Propulsion Laboratory

1705 - 1730 Power Beaming for Rover Systems
Brett Kennedy, Jet Propulsion Laboratory

1730 Final Announcements and Conference Adjourn
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