

Space Power Workshop

Rapid and agile power systems: Developing new norms for an evolving and contested space environment

TUESDAY, APRIL 23, 2024

7:00 a.m. Registration and Continental Breakfast

8:00 a.m. Welcome Address

Kevin Bell, Senior Vice President, Engineering and Technology Group, The Aerospace Corporation

Keynote Organizer

Arnold Arst, The Aerospace Corporation, arnold.arst@aero.org

Keynote Address

Mark Honda, Chief Engineer, Space Systems Command, Space Systems Integration Office

8:40 a.m. Invited Plenary Speakers

Organizer

Justin Stocker, The Aerospace Corporation, justin.stocker@aero.org

A Need for Speed: Tips for Fielding Responsive Space Systems

Ari Sandberg, Technical Staff in the Tactical Space Systems group, MIT Lincoln Laboratory

Space Development Agency Delivering Capabilities

Devon Lindeboom, Program Manager, Space Development Agency

10:00 a.m. Break

10:15 a.m. Mission and Program Experience

Organizers

Valerie Ang, The Aerospace Corporation, valerie.j.ang@aero.org

Brandon Klefman, NASA Glenn Research Center, brandon.klefman@nasa.gov

Christopher Le, The Aerospace Corporation, christopher.le@aero.org

Europa Clipper Power Subsystem Implementation and Lessons Learned

Brandon Burns, Jet Propulsion Laboratory, California Institute of Technology, brandon.burns@jpl.nasa.gov

Analysis of Glint During the Artemis I Mission

Alexander Jurcago, John Carroll University, ajurcago25@jcu.edu

Carrying It Forward—Iridium NEXT Lithium-Ion Batteries

Mark Toft, Iridium Satellite, LLC., Mark.Toft@iridium.com

iROSA Computational Model Development and Integration for the International Space Station

Steven Korn, NASA Glenn Research Center, steven.korn@nasa.gov

Ovzon-3: First commercial application of ROSA, on a Maxar GEO spacecraft

Harry Yates, Maxar Space Systems, harry.yates@maxar.com

12:00 p.m. Lunch (on your own)

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1:15 p.m. **Energy Storage I—Space Battery Level Topics**

Organizers

Dr. Albert Zimmerman, The Aerospace Corporation, albert.h.zimmerman@aero.org

Alec Jackson, Air Force Research Laboratory, alec.jackson.1@us.af.mil

VL10ES Cell and Battery Qualification update

Dr. Chengsong Ma, Saft, chengsong.ma@saft.com

Recent Results from Li/CFx Battery Cell Development for Robotic Space Missions

Dr. Erik Brandon, Jet Propulsion Laboratory, California Institute of Technology, erik.j.brandon@jpl.nasa.gov

Effects of Pressure Distribution within Battery Cells

Jarred Olson, The Aerospace Corporation, jarred.z.olson@aero.org

Self-Discharge Measurements of Cells in Cycling Li-Ion Batteries

Dr. Albert Zimmerman, The Aerospace Corporation, albert.h.zimmerman@aero.org

Investigation of COTS Li Ion Cell Performance at Low Temperature

Ryan Pritchard, EnerSys Advanced Systems ABSL, Ryan.Pritchard@eas.enersys.com

3:00 p.m. **Break**

3:15 p.m. **Energy Generation I—Space Solar Cell Technologies**

Organizers

Dr. Abby Meyer, The Aerospace Corporation, abby.r.meyer@aero.org

Margaret Stevens, Naval Research Laboratory, margaret.stevens@nrl.navy.mil

Christina Wade, The Aerospace Corporation, christina.wade@aero.org

Addressing Space Power Demands with XTE Plus Family of 3J Technologies and Sitewide Manufacturing Advancements

Dr. Philip Chiu, Spectrolab, Inc., philip.t.chiu@boeing.com

Qualification, Production, and Mission Updates of SolAeros Inverted Metamorphic and Upright Multijunction Solar Cells

Dr. Daniel Derkacs, SolAero Technologies Corp by Rocket Lab, daniel.derkacs@rocketlabusa.com

AZUR SPACE—Enabling Solar Cell Technologies for Today's and Future Space Markets

Dr. Torsten Torunski, AZUR SPACE Solar Power GmbH, torsten.torunski@azurspace.com

Effective Annealing of 1 MeV Electron and 3 MeV Proton Damage in Silicon Solar Cells at 65C and Maximum Power Point Conditions

Diana Aponte, Solestial, Inc., da@solestial.com

Epitaxy-Free, Thin-Film GaAs Solar Cells with Voc Greater than 900 mV

Dr. Phillip Jahelka, California Institute of Technology, pjahelka@caltech.edu

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5:00 p.m. **Poster Session and Networking Social**

Organizers

Alexandra Pettengill, The Aerospace Corporation, alexandra.pettengill@aero.org

Sunny Yu, The Aerospace Corporation, sunny.yu@aero.org

Normal incidence and angle single event effects (SEE) results of a radiation hardened 100V GaN power HEMT

Oscar Mansilla, IR HiRel, an Infineon Technologies Company, oscar.mansilla@infineon.com

Development of Cost-efficient and Ultra-light CIGS Solar Cell for Space Applications

Hiroshi Tomita, Idemitsu Kosan Co., Ltd., hiroshi.tomita.3920@idemitsu.com

Airbus Space Batteries Products

Eric TREHET, Airbus Defence and Space, eric.trehet@airbus.com

Dynovas' Motorless Deployable Array Technologies

Brynn Hall, Dynovas, Inc., brynn.hall@dynovas.com

Development of Engineered Ge Substrate for Space Solar Cells: Project status and outlook

Dr. Kristof Dessen, Umicore, kristof.dessen@eu.umicore.com

Design of Precharge Circuit with Latched Current Limiter for Power Control and Distribution Unit in Low Earth Orbit Satellite

Youngsu Youn, Korea Aerospace Research Institute, ysyoun@kari.re.kr

Lithium Sulfur Energy Storage Development for Space Applications

Dr. Taylor Xu, Navitas Systems LLC, txu@navitassys.com

Main Electronics for Global Access (MEGA) power units: modular and integrated electronics for LEO constellations needs

Marcos Núñez Rodríguez, Airbus Crisa, marcos.nunez-rodriguez@airbus.com

Solar Cell IV Measurement...to the Moon

Scott Ireton, Angstrom Designs, scott.ireton@angstromdesigns.com

Solar Simulation challenges of NASA's Huge Artemis Power and Propulsion Element Solar Arrays

Casey Hare, Angstrom Designs, casey.hare@angstromdesigns.com

High Altitude Balloon Device Characterization Platform

Justin Lorentzen, BlackSky Aerospace Systems, justinlorentzen@gmail.com

Temperature Effect on Hysteresis of Perovskite Mini Modules

Nadeesha Katakumbura, University of Toledo, nadeesha.katakumbura@rockets.utoledo.edu

Radiation Tests of Slot-Die Coated Perovskite Solar Cells for Space Power Applications

Amirhossein Rahimi, University of Toledo, amirhossein.rahimi@rockets.utoledo.edu

JV and EQE Characterization of CdSeTe-based PV Devices Preceding Proton Bombardment

Scott Lambright, University of Toledo, scott.lambright@rockets.utoledo.edu

Multi-Kilowatt Modular Self-Stiffening Array for Advanced Power Generation

Samuel Smith, Opterus Research & Development, ssmith@opterusrd.com

High Energy Dense Li Metal Batteries for Safe and Extended Cycle Life in Aerospace Applications

Frank Fan, 24M Technologies, ffan@24-m.com

7:30 p.m. **Adjourn**

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WEDNESDAY, APRIL 24, 2024

7:00 a.m. Registration and Continental Breakfast

8:00 a.m. Power Systems Architecture

Organizers

Kelsey Dougherty, The Aerospace Corporation, kelsey.s.dougherty@aero.org

Jeffrey Smedley, The Aerospace Corporation, jeffrey.c.smedley@aero.org

Arnold Arst, The Aerospace Corporation, arnold.arst@aero.org

The Necessity of Developing Lighter, Smaller and More Efficient Power Modules for SmallSats // Enhance mission reliability and address the unique challenges posed by the space environment

Jason Stange, Packet Digital, jason.stange@packetdigital.com

Renesas Power Solutions to Address Multi-Mission Requirements

Abigail Eberts, Renesas Electronics America Inc., abigail.eberts.uj@gr.renesas.com

Generic High Power System for manned missions to the Moon and beyond

José María Martínez Cerdá, Airbus Crisa, josem.cerda@airbus.com

The Lunar Surface Innovation Consortium: Collaboratively Developing Lunar Surface Power Systems

Joseph Kozak, Johns Hopkins University Applied Physics Laboratory, joseph.kozak@jhuapl.edu

Purpose of Satellite Dead Bus Architecture

Arnold Arst, The Aerospace Corporation, arnold.arst@aero.org

10:00 a.m. Break

10:15 a.m. Energy Generation II—Modules and Arrays Design

Organizers

Yao Lao, The Aerospace Corporation, yao.y.lao@aero.org

Dr. Christopher Kerestes, Air Force Research Laboratory, christopher.kerestes@spaceforce.mil

Dr. Alexandra Teodor, The Aerospace Corporation, alexandra.h.teodor@aero.org

Results on Solar Array Technology Qualification for LEO SmallSat Missions using semi-automated processes

Ismael Sanchez, DHV Technology, i.sanchez@dhvtechnology.com

Flexible and lightweight solar power modules for LEO satellites and next-generation arrays

Chris Youtsey, MicroLink Devices, Inc., cyouitsey@mldevices.com

SAVER: Evolution and performance of Maxar GEO solar arrays

Harry Yates, Maxar Space Systems, harry.yates@maxar.com

Power Generation Impacts of Spacecraft Albedo During the Artemis I Mission

Spencer Furin, NASA Glenn Research Center, spencer.c.furin@nasa.gov

Active, All-Cell Reconfigurable Strings for Long, High Efficiency Missions

Jay Gordon, Northrop Grumman Corporation, jay.gordon@ngc.com

12:00 p.m. Complimentary Luncheon

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1:15 p.m. **Advanced Concepts**

Organizers

Jeffrey Smedley, The Aerospace Corporation, jeffrey.c.smedley@aero.org

Vien Vu, The Aerospace Corporation, vien.x.vu@aero.org

Ann Delleur, NASA Glenn Research Center, ann.m.delleur@nasa.gov

The Fission Surface Power Project

Andrew Presby, NASA Glenn Research Center, andrew.l.presby@nasa.gov

Creating a Lunar Surface Power Grid

Jeffrey Csank, NASA Glenn Research Center, jeffrey.t.csank@nasa.gov

The Orbitron—A Compact Fusion Power Source for Space

Park Cover Jr., Avalanche Energy, pcover@avalanche.energy

Robust & Resilient Electronics Adaptive Development (RREAD)

David Caldwell, The Aerospace Corporation, david.j.caldwell@aero.org

Fortifying the Future: A Secure US Germanium Supply Chain for Space Solar Cells The Chinese germanium embargo and N. American Sourcing

Jason Merrell, 5N Plus Semiconductors, jason.merrell@5nplus.com

3:00 p.m. **Break**

3:15 p.m. **Workshops (Concurrent Sessions)**

WORKSHOP TOPICS

Energy Storage

Moderator: Jarred Olson, The Aerospace Corporation

The Energy Storage Workshop provides a forum to discuss the opportunities presented and challenges faced by the energy storage community in the context of new norms for the evolving and contested space environment: new & updated technologies, battery standards, acquisition, screening, and selection criteria. To address these topics, this session will cover areas including, but not limited to:

- Leveraging, producing, and improving test standards
- Measurements to support or accelerate electrochemical cycling data
- Enhancement of material and device properties

Energy Generation

Moderator: Yao Lao, The Aerospace Corporation

What are the toughest challenges facing our power generation community that keeps you up at night? Join world leading experts in the field of space power generation for a workshop of round-table discussions aimed at identifying, defining, and brainstorming solutions to the most critical challenges the government, industry, and space power community faces today. This workshop gathers in one room great minds and experts working on or interested in space power generation technologies and offers a collaborative session for brainstorming strategies to propel the space power generation community forward. You're invited to join and engage in insightful dialogue, share expertise, and contribute to shaping the future of space power generation.

PMAD

Moderator: Peter J. Carian, The Aerospace Corporation

Powering Spacecraft within cost and schedule constraints

Customers are buying services from large constellations of spacecraft; this has led to a shift in reliability from individual satellites to group fault-tolerance. However, too many sat failures can mean contract cancellation and even bankruptcy.

We will discuss concepts and strategies compatible with mass-produced & tested Electrical Power Systems that maximize success.

We will also discuss some emerging trends on fault propagation that are impacting new systems.

1. What does Power System reliability look like?
2. Can we rapidly incorporate new components and improvements as part of the process?
3. Can we "push back" against pressures to cut design margin beyond reason?

5:00 p.m. **Adjourn**

Note: all times are Pacific Daylight Time (UTC-7)

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THURSDAY, APRIL 25, 2024

7:00 a.m. Registration and Continental Breakfast

8:00 a.m. Energy Storage III—Advanced Energy Storage Topics

Organizers

Kevin MacDougall, The Aerospace Corporation, kevin.macdougall@aero.org

Martin Dann, Naval Surface Warfare Center, Crane Division, martin.a.dann.civ@us.navy.mil

Aaron Reed, The Aerospace Corporation, Aaron.reed@aero.org

LEO Cycling Performance of Lithium-Ion Batteries with Carbon Nanomaterials

Dr. Elena Bekyarova, Carbon Solutions, Inc., bekyarova@carbonsolution.com

High Performance Li-ion Enabled by Vanadium Oxide Anode: Max Power, Extended Life and Low Temp Charge Capability

Dr. Haodong Liu, Tyfast Energy Corp., haodongliu@tyfast.energy

Lyten's High Energy Li-S Batteries for Aerospace Applications

Dr. Ratnakumar Bugga, Lyten, Inc., kumar.bugga@lyten.com

Liquefied Gas Electrolytes for Next-Generation Batteries for Extreme Cold Temperature Operations

Dr. Ryo Tamaki, South 8, rtamaki@south8.com

10:00 a.m. Break

10:15 a.m. Energy Generation III—Reliability and Characterization

Organizers

Dr. Pilar Espinet Gonzalez, The Aerospace Corporation, pilar.espinetgonzalez@aero.org

Jeremiah Sims, NASA Glenn Research Center, jeremiah.d.sims@nasa.gov

Kyle Virgil, The Aerospace Corporation, kyle.virgil@aero.org

Thermal runaway in space solar cells

Dr. Tetsuya Nakamura, Japan Aerospace Exploration Agency, nakamura.tetsuya@jaxa.jp

Electroluminescence Imaging: A Quantitative Characterization Technique to Measure Dust Occlusion on Solar Cells

Meghan Bush, NASA Glenn Research Center, meghan.bush@nasa.gov

Dosimetry Methods in Beam Fluence Determination for Solar Cell Radiation Ground Testing

Dr. Scott Messenger, Northrop Grumman Corporation, scott.messenger@ngc.com

Results of the Alba mission

Dr. Michael Kelzenberg, California Institute of Technology, mdk@caltech.edu

Survey of Electrical Power Subsystem On-Orbit Anomalies Since 1970 with a Focus on Solar Arrays

Yao Lao, The Aerospace Corporation, yao.y.lao@aero.org

12:00 p.m. Lunch (on your own)

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1:15 p.m. **Energy Storage II—Cell Level Developments for Energy Storage**

Organizers

Dr. Christopher Choi, The Aerospace Corporation, christopher.s.choi@aero.org

Dr. Lloyd Zilch, Naval Surface Warfare Center, Crane Division, lloyd.w.zilch.civ@us.navy.mil

Alexandria Kilzer, Naval Surface Warfare Center, Crane Division, alexandria.r.kilzer.civ@us.navy.mil

Development of Specialized Li-ion Batteries for a Venus Aerobot Mission

Dr. Will West, Jet Propulsion Laboratory, william.c.west@jpl.nasa.gov

Development of the lithium-ion cells for lunar exploration programs

Hiroki Fuse, GS Yuasa Technology Ltd., hiroki.fuse@jp.gs-yuasa.com

GS Yuasa's Generation 4 Li-ion Space Cell Update

Thomas Pusateri, GS Yuasa Lithium Power, tom.pusateri@gsyuasa-lp.com

Domestic Lithium-ion Cell Production and Performance Characteristics

Joe Troutman, Forge Nano, jtroutman@forgenano.com

Studies on Zero-voltage Stability on ALE 4Ah 18650 cylindrical cells for NASA applications

William Hadala, American Lithium Energy Corporation, william.hadala@americanlithiumenergy.com

3:00 p.m. **Break**

3:15 p.m. **PMAD—Power System Design and Analytical Techniques**

Organizers

John Morales, The Aerospace Corporation, john.f.morales@aero.org

Horacio Saldivar, The Aerospace Corporation, horacio.saldivar@aero.org

James Becker, The Aerospace Corporation, james.becker1@aero.org

Innovative COTS Based PCU and Reversible Power Converter Module Solution for Telecommunications Market

Marcos Núñez Rodríguez, Airbus Crisa, marcos.nunez-rodriguez@airbus.com

ESA PLATO Mission Power Conditioning and Distribution Unit

Hans Jensen, Terma A/S, haj@terma.com

Passive Survival of the Lunar Night with Cryogenically-Operable Electronics

Nicholas Ugucini, NASA Glenn Research Center, nicholas.r.uguccini@nasa.gov

Environmental impact on BMS design and Architecture

Richard Coffin, EaglePicher Technologies, richard.coffin@eaglepicher.com

Novel Protection of Half-Bridges in Space Environments

Alex Billings, Apogee Semiconductor, alexb@apogeesemi.com

5:00 p.m. **Adjourn**