SPACECRAFT CHARGING/DISCHARGING TECHNOLOGY

Chair: Dale Ferguson/NASA GRC

Co-Chair: Ralph Carruth/NASA MSFC

SPACECRAFT CHARGING/DISCHARGING TECHNOLOGY

ATTENDANCE

IRA KATZ/MAXWELL TECHNOLOGIES
JOANNE HOPKINS/SRI TECHNOLOGIES
REGAN HOWARD/GSFC ORBITAL
BILLY KAUFFMAN/NASA MSFC
DAVE CHEUETTE/LOCKHEED MARTIN ADV. TECH. CTR.
DON BRENNAN/ORBITAL SCIENCES CORP
M.S. DESHPANDE/ITT RESEARCH INSTITUTE
GEOFF GIFFIN/SUPERHIGHWAY SYSTEMS
STEVE PEARSON/NASA MSFC
DONNA HARDAGE/NASA MSFC
DON WILKES/AZ TECHNOLOGY
RALPH CARRUTH/NASA MSFC
DALE FERGUSON/NASA GRC

SPACECRAFT CHARGING/DISCHARGING TECHNOLOGY

PRESENTATIONS

- SPACECRAFT CHARGING CONTROL DEVICE; IRA KATZ, MAXWELL TCHNOLOGIES
- SHEILD - A SPACECRAFT CHARGING CONTROL DEVICE; GRAEME ASTON, ELP, INC.
- SOLAR TILES-FULLY ENCAPSULATED MODULAR SOLAR ARRAYS; BRIAN REED, BOEING PHANTOM WORKS
- SOLAR ARRAY ARC TESTING PROTOCOLS; DALE FERGUSON AND RALPH CARRUTH, NASA
- THIN FILM FULLY ENCAPSULATED SOLAR ARRAYS; JOE ARMSTRONG, GLOBAL SOLAR ENERGY
- MITIGATION AND TEST PROTOCOLS FOR DEEP DIELECTRIC CHARGING; DAVID CHENETTE, LOCKHEED MARTIN ADVANCED TECH. CTR.
- NEW CONDUCTIVE COATINGS FOR PASSIVE CHARGE CONTROL; DON WILKES, AZ TEK, M. DESHPANDE, IITRI

SPACECRAFT CHARGING/DISCHARGING TECHNOLOGY

TECHNOLOGY NEEDS

- SPACECRAFT CHARGING CONTROL
- SPACE QUALIFIED ELECTRICALLY CONDUCTIVE THERMAL CONTOL COATINGS
- ELECTRICALLY “LEAKY” MATERIALS FOR DEEP DIELECTRIC CHARGING CONTROL

SPACECRAFT CHARGING/DISCHARGING TECHNOLOGY

NEED FOR ON-ORBIT TESTING

- VERIFICATION/VALIDATION OF GROUND TESTING PROCESSES AND PROCEDURES
- VERIFICATION OF TECHNOLOGY FUNCTION IN SPACE ENVIROMENT AS OPPOSED TO GROUND CHAMBERS
- TEST DATA IN ACTUAL SPACE ENVIROMENT

Living with a Star: Space Environment Testbed Program Spacecraft Charging/Discharging Technology

Type of Charge: Surface Charging in MEO/GEO	Title: Surface Charging Control Device
Background: Traditional Spacecraft Charging (in solar charging events) damaged several satellites recently in GTO and GEO orbits/ The proposed device came out of failure investigations on those spacecraft.	
Description of Technology Requirement for On-Orbit Testing: Low power, lightweight electron emitter, driven by solar array voltage, overcomes potential barriers by emitting electrons of 50 eV or more. Requires no fuel, current is self-regulating. On-orbit testing required because potential barriers and low neutral density plasma of MEO/GEO cannot be duplicated in a lab.	
Timeframe Technology is Needed: ASAP Timeframe for Technology Maturity: 2003	Benefiting Mission(s): ALL LWS missions Benefits to LWS Applications Areas: ALL
Flight Requirements: Orbit: MEO/GEO Altitude: Inclination: Power: 10 mW Weight (kg): <0.5 kg Size (cm): 4x2x1 cm Telemetry: Bits per second Environment Measurement: Particle detectors	Name: Ira Katz Phone: 858-496-4148 Email: ira@maxwell.com Organization: Maxwell Technologies

Living with a Star: Space Environment Testbed Program Spacecraft Charging/Discharging Technology

Type of Charge: Surface Charging in MEO/GEO	Title: SHIELD- a Spacecraft Charging Control Device
Background: Traditional Spacecraft Charging (in solar charging events) damaged several satellites recently in GTO and GEO orbits/ The proposed device might have prevented failures on those spacecraft. Based on establish hollow cathode plasma contactor technology.	
Description of Technology Requirement for On-Orbit Testing: Hollow cathode based electron emitter, detects spacecraft charging conditions and turns on the neutralize them. Second stage increases ionization efficiency, lowers xenon flow rate. On-orbit testing required because detection of charging events and low density plasma of MEO/GEO cannot be duplicated in lab.	
Timeframe Technology is Needed: ASAP Timeframe Technology Maturity: NOW	Benefiting Mission(s): ALL LWS missions Benefits to LWS Applications Areas: ALL
Flight Requirements: Orbit: MEO/GEO Altitude: Inclination: Power: 25 W at 28 V DC Weight (kg): < 6 kg Size (cm): 20x30x13 cm Telemetry: Bits per second Environment Measurement: Particle detectors	Name: Graeme Aston Phone: 719-481-4411 Email: ira@maxwell.com Organization: Electric Propulsion Laboratory, Inc.

Living with a Star: Space Environment Testbed Program Spacecraft Charging/Discharging Technology

Type of Charge: Surface Charging in LEO/MEO/GEO	Title: Solar Tiles – Fully Encapsulated Modular Solar Arrays
Background: Spacecraft Charging (either caused by solar substorms in MEO/GEO or high voltage arrays in LEO) has damaged several satellites recently and neccessitated a plasma contactor on ISS. The proposed solar array prevents solar array charging and arcing by preventing the plasma from reaching the array.	
Description of Technology Requirement for On-Orbit Testing: Modular solar array tile uses a large coverslide to completely cover the array. High voltages may be used to increase array efficiency and enable direct-drive electric propulsion. Conductive coverslide coating prevents differential charging. Laboratory testing in LEO plasmas show successful high voltage operation. Space test needed because survival of launch loads and under charging events cannot be duplicated in lab.	
Timeframe Technology is Needed: ASAP Timeframe Technology Maturity: 2001	Benefiting Mission(s): ALL LWS missions Benefits to LWS Applications Areas: ALL
Flight Requirements: Orbit: MEO/GEO Altitude: Inclination: Power: None. Produces power. Weight (kg): Size (cm): 80x80x2 cm Telemetry: Bits per second Environment Measurement: Particle detectors	Name: Brian Reed Phone: 253-657-3011 Email: brian.j.reed@boeing.com Organization: Boeing Phantomworks

Living with a Star: Space Environment Testbed Program Spacecraft Charging/Discharging Technology

Type of Charge: Surface Charging in LEO/MEO/GEO	Title: Thin Film Full Encapsulated Solar Arrays
Background: Spacecraft Charging (either caused by solar substorms in MEO/GEO or high voltage arrays in LEO) has damaged several satellites recently and necessitated a plasma contactor on ISS. The proposed solar array prevents solar array charging and arcing by preventing the plasma from reaching the array.	
Description of Technology Requirement for On-Orbit Testing: Thin film, lightweight solar array uses a thin film insulating coating to completely cover the array. High voltages may be used to increase the (low) array efficiency without arcing worries. Conductive coverslide coating prevents differential charging. Laboratory testing in LEO plasmas promise high voltage operation. Space test needed because survival of launch loads and under charging events cannot be duplicated in lab.	
Timeframe Technology is Needed: ASAP Timeframe Technology Maturity: 2004	Benefiting Mission(s): ALL LWS missions Benefits to LWS Applications Areas: ALL
Flight Requirements: Orbit: MEO/GEO Altitude: Inclination: Power: None. Produces power. Weight (kg): Size (cm): 20x50x1 cm Telemetry: Bits per second Environment Measurement: Particle detectors	Name: Joe Armstrong Phone: 303-289-5103 Email: jarmstrong@itnes.com Organization: Global Solar Energy, LLC

Living with a Star: Space Environment Testbed Program Spacecraft Charging/Discharging Technology

Type of Charge: Surface Charging in LEO/MEO/GEO	Title: Solar Array Arc Testing Protocols
Background: Spacecraft Charging (either caused by solar substorms in MEO/GEO or by high voltage arrays in LEO) has damaged several satellites recently and necessitated a plasma contactor on ISS. One of the unknowns is testing for solar array arcing is how much of the array is involved in an arc. The proposed experiment verifies solar array arc coupling in space and improves ground test protocols.	
Description of Technology Requirement for On-Orbit Testing: Conventional solar arrays biased to high voltages (300 V or more) are separated by up to 10 meters on a space testbed. Arc coupling currents are measured on the array bias supplies. Array area discharged in an arc will yield the total connected capacitance discharged in an array arc, which can then be used in ground tests. Ground test facilities are not large enough or have low enough neutral densities to replace space tests.	
Timeframe Technology is Needed: 2004 Timeframe Technology Maturity: 2004	Benefiting Mission(s): ALL LWS missions. Benefits to LWS Applications Areas: ALL
Flight Requirements: Orbit: LEO/MEO/GEO Altitude: Inclination: Power: 5 W at 300 V. Weight (kg): 20 kg Size (cm): 30x30x1000 cm Telemetry: Bits per second Environment Measurement: Particle detectors	Name: Dale Ferguson, Ralph Carruth Phone: 216-433-2298, 256-544-7647 Email: ferguson@grc.nasa.gov, ralph.carruth@msfc.nasa.gov Organization: NASA

Living with a Star: Space Environment Testbed Program Spacecraft Charging/Discharging Technology

Type of Charge: Surface Charging in MEO/GEO	Title: New Conductive Coatings for Passive Charge Control
Background: The traditional method for passive charge control in MEO/GEO is to use grounded conductive coatings on all exterior spacecraft surfaces. These coatings must not compromise thermal control. ITO, most commonly used, is too thin to survive sputtering if electric propulsion is used for station keeping. New, See survivable conductive thermal control coatings are needed, especially for electrostatic cleanliness.	
Description of Technology Requirement for On-Orbit Testing: Assess on-orbit performance of conductive thermal coatings for spacecraft surface charge control. Test conductivity and optical/thermal properties versus time in orbit. Lab tests cannot duplicate long-term degradation in the space environment. New specs and new lab test protocols can be produced.	
Timeframe Technology is Needed: 2004 Timeframe Technology Maturity: 2004	Benefiting Mission(s): ALL LWS missions. Especially important for electrostatic cleanliness Benefits to LWS Applications Areas: ALL
Flight Requirements: Orbit: MEO/GTO/GEO Altitude: Inclination: Any, but lower is better Power: Weight (kg): N/A Size (cm): Telemetry: Bits per year Environment Measurement: Particle detectors	Name: Donald Wilkes, AZ Tek, M.S. Deshpande, IITRI Phone: Wilkes 256-837-9877x108, Deshpande 312-567-4290 Email: don@aztechnology.com, Mdeshpande@iitri.org Organization: AZ Technology, IIT Research Institute

Living with a Star: Space Environment Testbed Program Spacecraft Charging/Discharging Technology

Type of Charge: Deep Dielectric Charging	Title: Mitigation and test protocols for deep dielectric charging
Background: The high-energy electrons in the radiation belts are known to charge deeply-buried components. Discharges due to this have damaged key spacecraft components. New (probably overly conservation) specifications to mitigate charging have significant mass impacts and will compromised system performance.	
Description of Technology Requirement for On-Orbit Testing: Assess on-orbit performance of charging mitigation materials (leaky dielectrics) for circuit boards and electronic conformal coatings. Test charging levels versus time and versus charging currents. Test material performance versus time in space. Lab tests cannot duplicate charging spectrum or orbit or materials degradation in the space environment. New specs and new lab test protocols can be produced.	
Timeframe Technology is Needed: ASAP Timeframe Technology Maturity: 2004	Benefiting Mission(s): ALL LWS missions. Benefits to LWS Applications Areas: ALL
Flight Requirements: Orbit: LEO Polar/MEO/GTO/GEO Altitude: Inclination: Any, but lower is better Power: Weight (kg): <5 kg Size (cm): Telemetry: Bits per second Environment Measurement: Particle detectors	Name: David Chenette Phone: 650-424-3449 Email: dave.chenette@lmco.com Organization: Lockheed Martin Advanced Technology Center