Flight Experiments for Living With a Star Space Environment Testbed (LWS SET) –

Relationship to Technology

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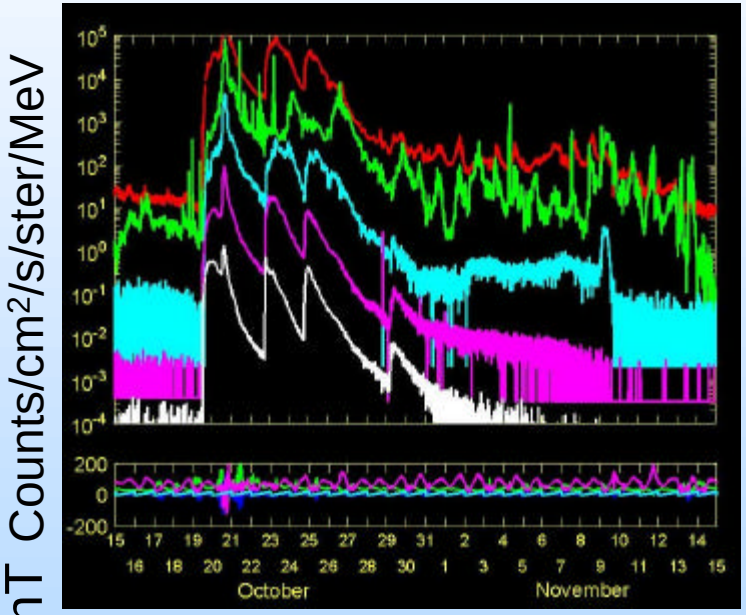
Outline

- Introduction
  - LWS SET overview
  - SET flight experiment goals
  - SET Experiment Services
- Flight Experiments
  - Experiment Selection Process
  - SET Pathfinder (SETPath) Experiments
  - NASA Research Announcement (NRA)
- Collateral programs
- Comments

Proton Fluxes –
99% Worst Case Event



GOES Space Environment Monitor

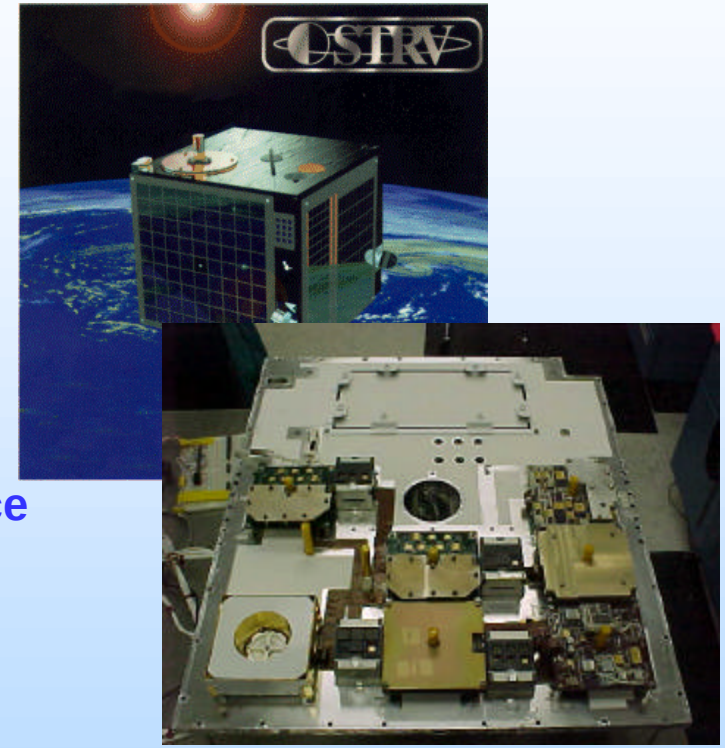
Living With a Star Program:

a pure and applied science program with an engineering application

- **Program Goal –** ***Perform investigations in space to understand solar variability & its effects leading to a reliable predictive capability of solar variability (i.e., space weather)***
- **LWS has three elements**
  - **Science Missions: the what's and why's of the solar variant environment**
    - **Ex., Solar Dynamics Observer**
  - **Theory and Modeling and Data Analysis: the environment models and tools developed from solar-variant data**
    - **A sample product might be: Improved Trapped Particle Models**
  - ***Space Environment Testbeds (SETs): Improve the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design & operations***
    - **A sample of a predecessor: Microelectronics and Photonics Testbed (MPTB)**
- **Continuous program started in FY01**

SET Technologies

- **SET provides opportunities for flight validation experiments on technologies**
  - **Microelectronics**
  - **Photonics**
  - **Materials**
  - **Sensors**
    - **Environment, imaging, etc.**
- **These investigations focus on**
  - **Demonstration of environment tolerance**
    - **Radiation hardening approaches**
  - **Validation of technology ground test methods and performance prediction techniques**
    - **Ex., correlate space dose rates to ELDRS sensitive device performance**
- **Investigations must require exposure to solar-variant environment**

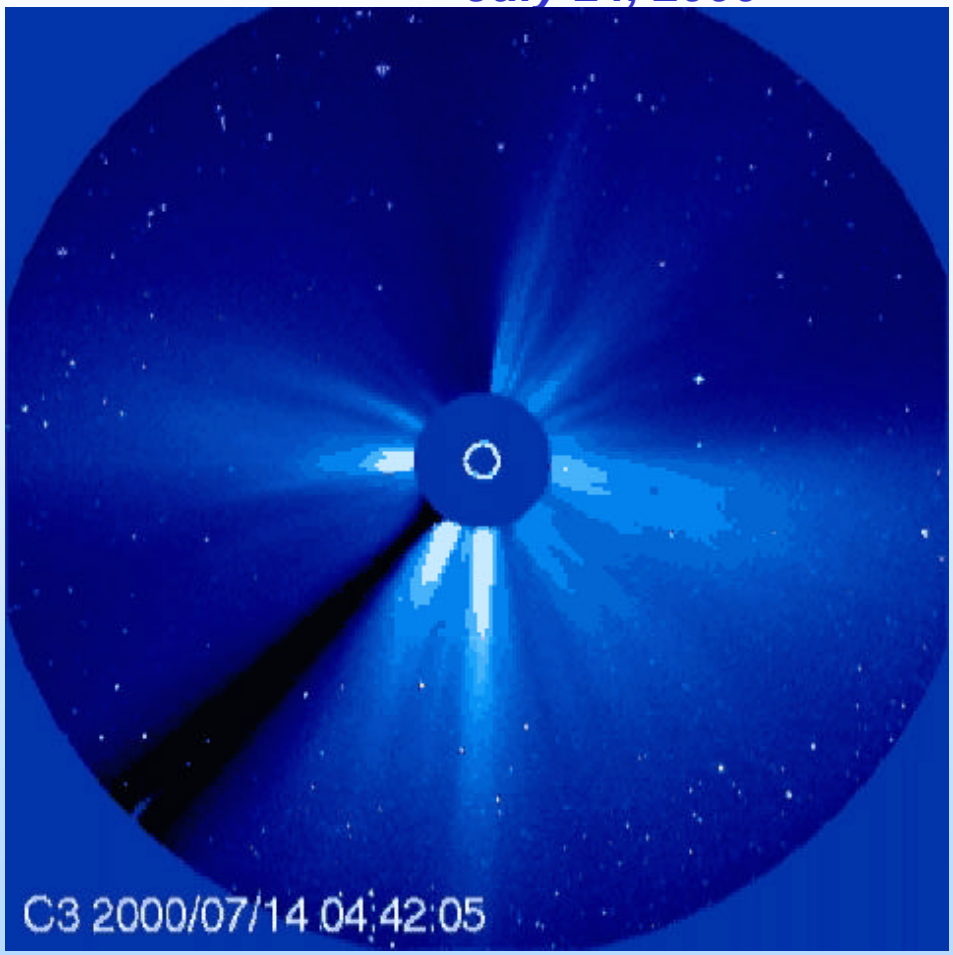


Space Technology Research Vehicle 1-d with NASA experiments

Solar Variant Example:

SOHO/LASCO C3 Coronograph

July 14, 2000

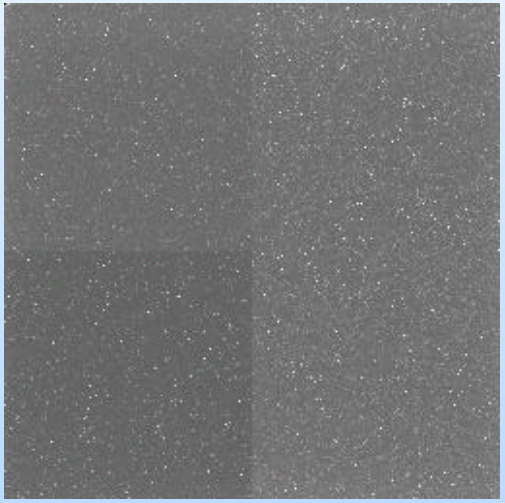


Sample LWS SET Goals:
Understand enough about the technology and the environment to minimize science data outages. Validate cosmic ray rejection methods...

Solar storm induces transients in a Charge-Coupled Device (CCD)
view video at http://radhome.gsfc.nasa.gov/radhome/papers/C3big480C.avi

Sample Solar Variant Technology Effects: Radiation Effects on Spacecraft

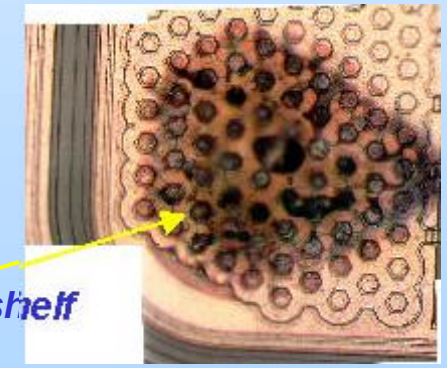
- **Long-term effects: failure/degradation increases with mission lifetime**
  - **Total ionizing dose (TID)**
  - **Displacement damage**
- **Transient or single particle effects (Single event effects or SEE): random strikes by a particle**
  - **Soft or hard errors**



- **Four quadrants, each representing a different design**
- **Particle hits spread among multiple pixels**
- **Ion strikes are minimized by utilization of a non N-well, n+ recessed implant photodetector design**

Active Pixel Sensor courtesy of Photobit Technologies via NASA SBIR and DTRA Sensors Hardening Program

view video at http://radhome.gsfc.nasa.gov/radhome/papers/D3_I030_2100_2199.avi

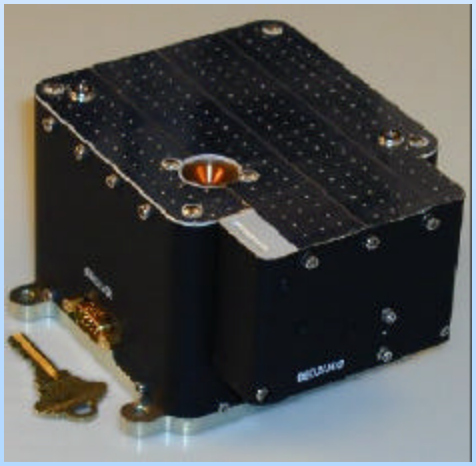


Destructive SEE in a commercial-off-the-shelf (COTS) 120V device, after Howard, 2002

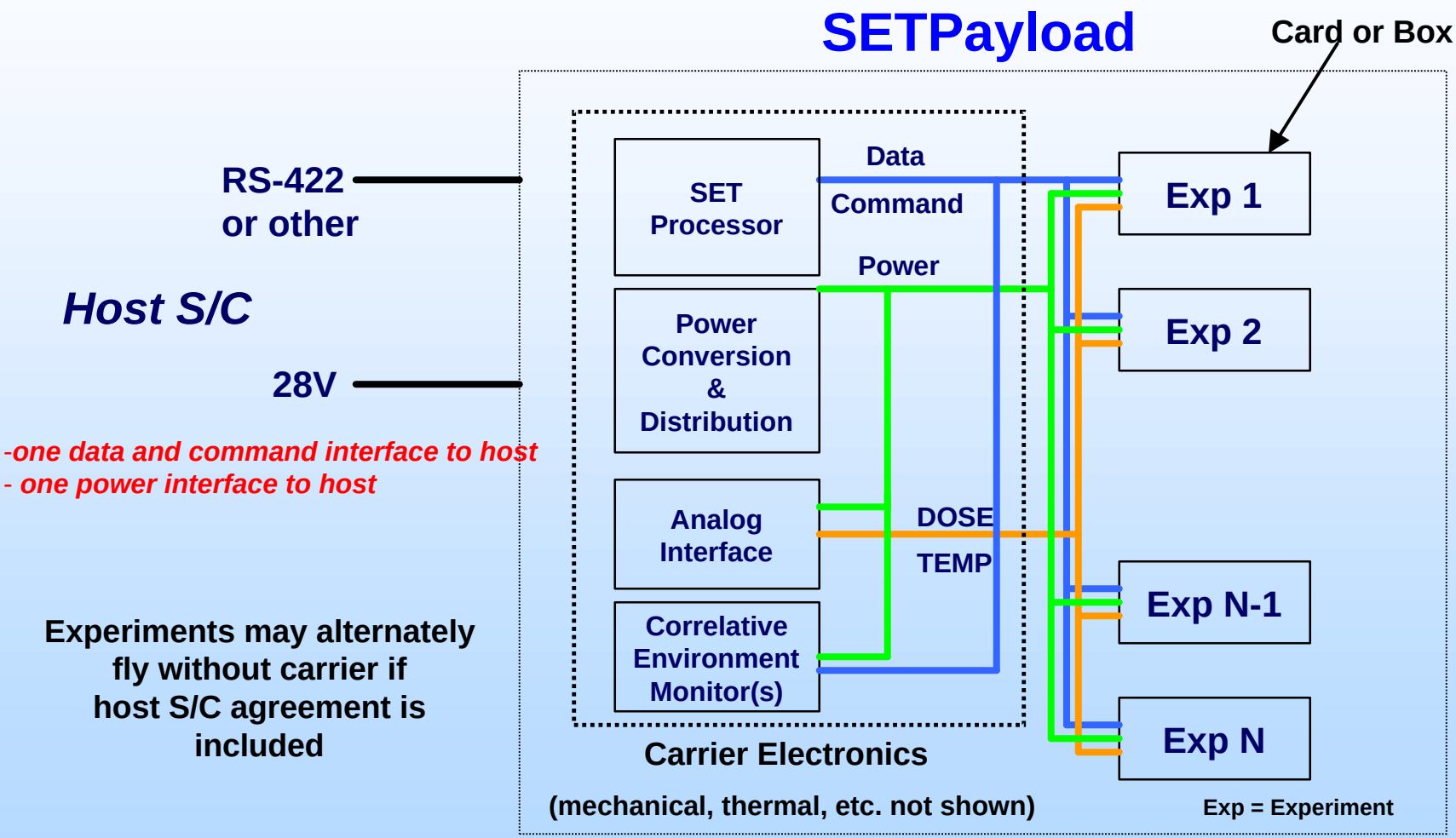
Other Technology Effects of Interest to LWS SET - Examples

- **Spacecraft charging**
  - **May be the single largest cause of space environment induced anomalies**
    - **Can damage solar arrays, electronics, etc**
- **Material degradation**
  - **Brittleness, optical property degradation, thermal effectiveness,…**

CEASE II instrument, www.amptek.com



SET Services Provided to Experiments



Experiments may alternately fly without carrier if host S/C agreement is included

+ NASA and DTRA are collaboratively investigating infrastructure requirements for imaging sensors

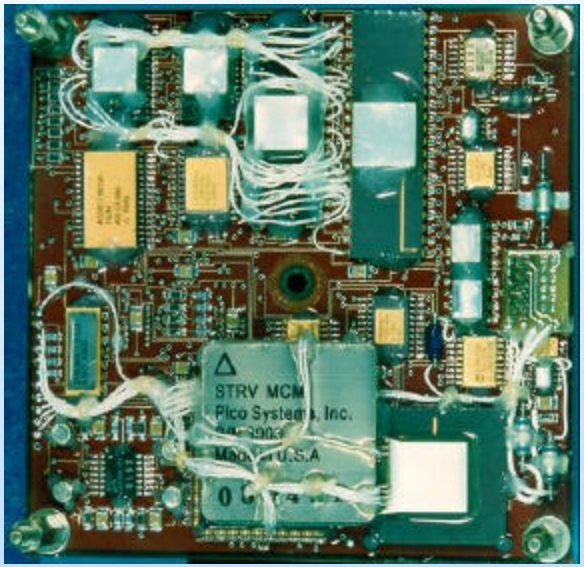
Flight Experiment Selection Process:
Two methods

- **NRA: a competitive action for investigations**
  - **Proposal process**
  - **Must demonstrate need to fly in solar-variant environment**
  - **Must have collateral ground test and/or model development program**
  - **No technology development efforts funded by this NRA**
  - **Data is non-proprietary (may be ITAR)**
  - **No funds exchanged with international entities**

- **Partnering**
  - **Partner may provide investigation(s) outside of the NRA process in exchange for support of the LWS SET Program**
    - **Funding**
    - **Launch opportunity**
    - **Infrastructure, etc…**
  - **Data can be proprietary or secure**

SETPath Experiments Overview

- **SETPath experiments are based on flight investigations originally designed for Space Technology Research Vehicle – 1d (STRV-1d) mission**
  - **No data returned due to spacecraft communications system failure**
  - **Originally selected by a peer team for STRV-1d inclusion**
  - **Some updates provided to original experiment to increase investigation utility**
- **Five experiment cards**
  - **COTS-1a: Linear Single Event Transients (LSETs)**
  - **COTS-1b: Enhanced Low Dose Rate Sensitivity (ELDRS)**
  - **COTS-2a: Digital Commercial-off-the-Shelf (COTS) Electronics**
  - **COTS-2b: Field Programmable Devices**
  - **COTS-3: Optocouplers**



STRV-1d COTS 2a Flight Prototype

COTS-1a:
Linear Single Event Transients (LSET)

Purpose

- Collect data in space to validate single event transient (SET) performance models & test protocols for linear bipolar devices

NASA Benefit

- Provide more consistent performance & lifetime; lower likelihood of LSET anomalies as observed in Cassini, MAP, & TDRSS

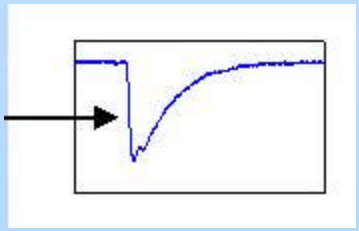
NASA Application

- Linear bipolar devices are common in comparators and operational amplifiers -- basic building blocks in all NASA spacecraft & instruments

History

- Designed for STRV 1-d; will be built by Aerospace Corp

A sample LSET, after Poivey, 2002



Partners

- Aerospace Corp., NASA'GSFC, NAVSEA-Crane, Vanderbilt University, JPL, DoD, Industry, RLP

Leveraging

- The NASA Electronics Parts & Packaging (NEPP) and DTRA supports development of ground radiation tests, protocols, & prediction models
  - **Ground test protocol will be issued in FY 20032 (Poivey/GSFC)**
  - **Supports Vanderbilt model development**
- Devices provided by industry (NSC, et al?)

Development Path

- Modification of existing design (Koga & Crain/Aerospace Corp)

Delivery Date: Jan 2004

Risk of Schedule Slip

- Low; based on existing design

COTS-1b:
Linear Enhanced Low Dose Rate Sensitivity (ELDRS)

Purpose

- Collect data in space to validate ground test protocols for linear bipolar devices that exhibit ELDRS
  - ELDRS is failure at a lower cumulative total ionizing dose in space compared to traditional accelerated ground test dose rates

NASA Benefit

- Provide more consistent performance & lifetime

NASA Application

- Linear bipolar devices are common in comparators and operational amplifiers -- basic building blocks in all NASA spacecraft & instruments

History

- Early experiment concept successfully flown on MPTB by NAVSEA-Crane (COTS-1b experiment developer)

Partners

- NAVSEA-Crane, Vanderbilt University, NASA/GSFC, JPL, DoD, Industry, RLP

Leveraging

- The NASA Electronic Parts & Packaging Program (NEPP) delivers a ground test & technology guideline in FY 2003 (Johnston/JPL)
  - Devices provided by industry (NSC, et al)
- Mil 1019.6

Development Path

- Modification of existing design by NAVSEA-Crane (Turflinger, et al)

Delivery Date: Jan 2004

Risk of Schedule Slip

- Low; based on flight-heritage design

COTS-2a: Digital COTS

Purpose

- Collect data in space to validate single event effect (SEE) & total ionizing dose (TID) performance models for:
  - Commercial fuzzy logic processors;
  - Static random access memories (SRAM); &
  - Field programmable gate array (FPGA) logic devices

NASA Benefit

- Reduce design margins & provide more consistent performance in space

NASA Application

- *Fuzzy logic: Robotics, docking, & constellation management applications*
- *SRAMS: Solid state recorders*
- *FPGAs: Replace custom solutions*

Partners

- NASA/GSFC, CNES, ONERA, TIMA

Development Path

- Modification to existing STRV 1-d flight card for LWS SET carrier interface (NASA/GSFC)

Delivery Date: November 2003

Risk of Schedule Slip

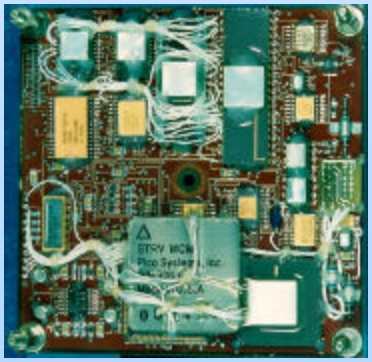
- Low; existing hardware

Ground data availability

- Heavy ion & proton data in hand from Orsay, France

History:

- Built for STRV 1-d but not flown



COTS-2b:
FPGA Technology Concept Validation

Purpose

- Collect data in space to validate single event effect (SEE) and total ionizing dose (TID) performance models & test protocols for COTS and environment-hardened FPGAs

NASA Benefit

- Provide more consistent performance in spacecraft electronics systems.

NASA Application

- Replace custom solutions in electronics system design at a fraction of the cost in virtually all NASA spacecraft; save power, weight, volume, & schedule

History

- Designed for STRV 1-d by NASA/GSFC; *devices will be updated to state of the art*

Partners

- NASA/GSFC, DoD, Industry, (is TIMA interested?)

Leveraging

- The NASA Electronics Parts & Packaging Program supports development of ground test protocols, guidelines, & technology development
- Devices provided by DoD & industry

Development Path

- Existing design (Katz - NASA/GSFC) with mission-specific modifications

Delivery Date

- Jan 2004

Risk of Schedule Slip

- Low – existing design with experienced flight designer

COTS-3: Optocouplers

Purpose

- Collect data in space to validate single event effect (SEE), total ionizing dose (TID), and device displacement damage (DDD) performance models & test protocols for optocouplers
  - Portions of the models may also be applicable to high-speed fiber optic links

NASA Benefit

- Reduce design margins & increase reliability
  - Anomalies on HST, TERRA, & TOPEX/Poseidon)

NASA Application

- Used to isolate electrical signals between spacecraft sub-systems & instruments; ex., power converters

History

- *Designed for STRV- 1d by NASA/GSFC; new optocouplers will be utilized for SETPath*

Partners

- NASA GSFC, JPL, DoD, Industry

Leveraging

- The NASA Electronic Parts & Packaging Program (NEPP) and DTRA deliver a ground test & technology guideline in FY 2003 (Reed/GSFC)
- Devices provided by industry

Development Path

- Existing design; mission-specific interface modifications & newer devices (Buchner – GSFC)

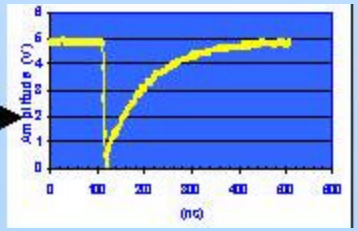
Delivery Date: Jan 2004

Risk of Schedule Slip: Low; based on an existing design

Ground data availability

- Heavy ion & proton data in hand; all new ground data to be funded by NEPP

A sample SET, after Reed, 1998

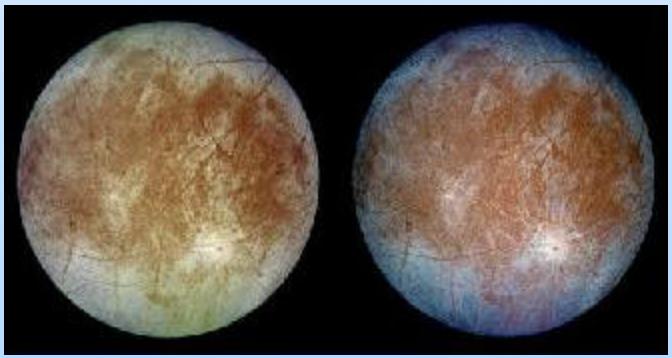


Collateral Programs

- **Ground-test programs are developing protocols or that require validation. Examples include:**
  - **Electronics**
    - **NASA Electronic Parts and Packaging (NEPP) Program**
    - **Defense Threat Reduction Agency's (DTRA's) Radiation Hardened Microelectronics (RHM) Program**
    - **Air Force Space and Missile Command**
    - **ESA**
    - **CNES**
  - **Materials**
    - **Air Force Wright Patterson**
- **Environment-tolerant approaches require validation**
  - **Air Force Research Laboratories**
  - **DTRA**
  - **Industry**

Final Comments

- Ground test methods require validation with in-flight data
  - Must have correlative environment monitors (CEMs) or we can't adequately reduce design margins
- No one likes to be the first to fly a new solution
  - LWS SET can provide that opportunity for new technologies that require solar-variant environment validation
- NRA results due out in near-term
  - Future NRA planning has begun
- Collaboration with others is critical
- Contact for more info
  - kenneth.a.label@nasa.gov
  - http://lws-set.gsfc.nasa.gov
  - http://nepp.nasa.gov



Europa: future challenges for radiation, temperature, and lifetime