

Living With a Star Space Environment Testbeds



***D. A. Brewer, J. L. Barth, and
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World Space Congress 2002
Oct. 17, 2002***

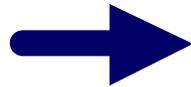
The Sun & Earth Are a Connected System

Variable Star



Interacting

- *Magnetic fields*
- *Plasmas*
- *Energetic particles*



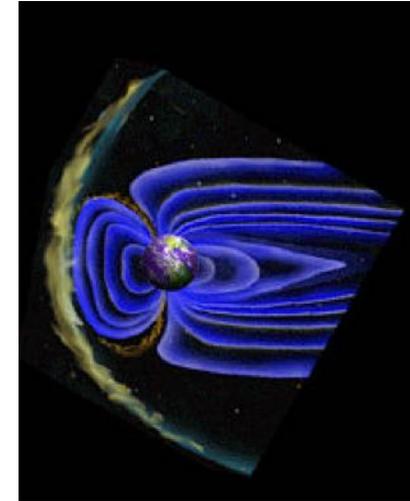
Varying

- *Radiation*
- *Solar wind*
- *Energetic particles*

Interacting

- *Solar wind*
- *Energetic particles*

Earth



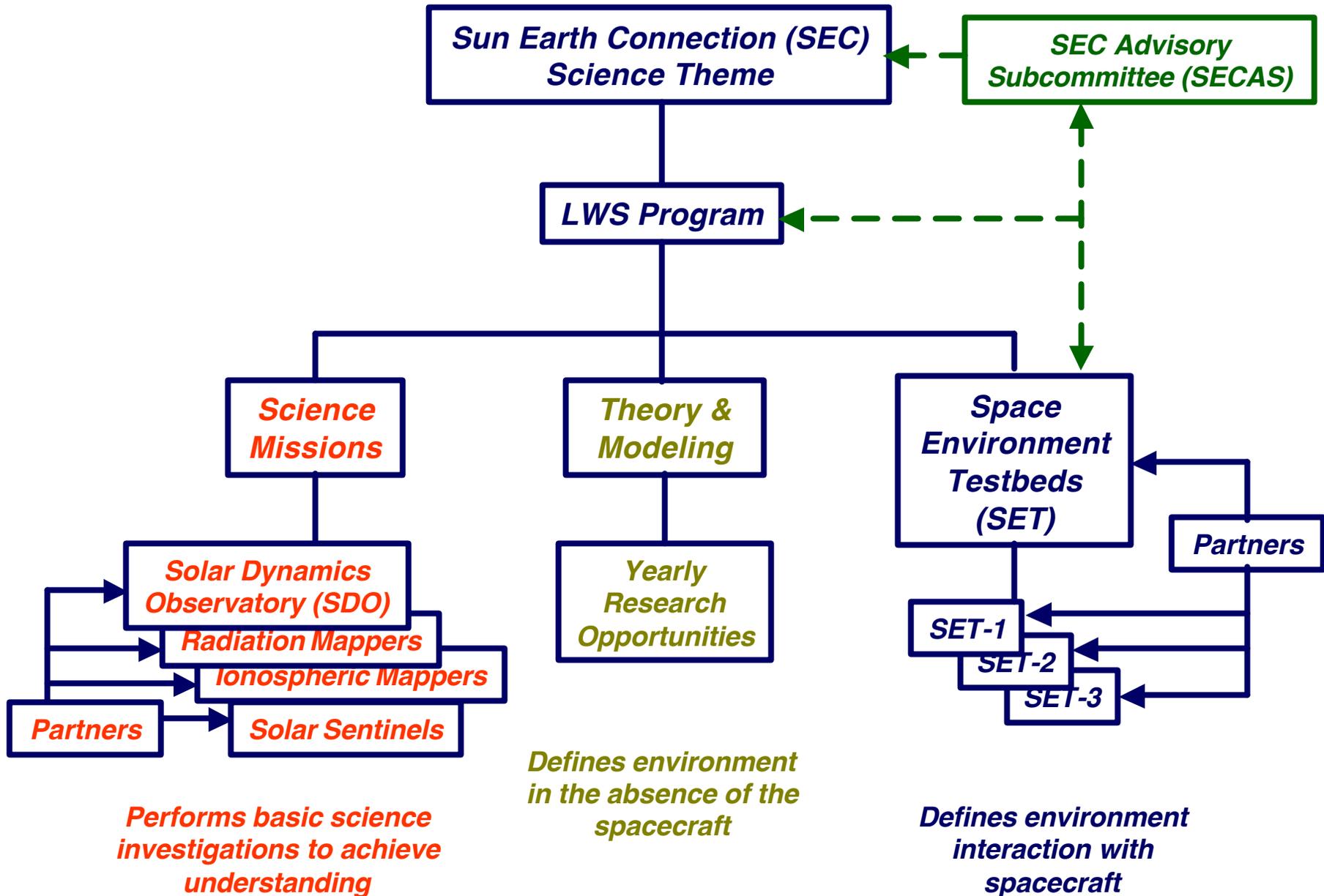
Interacting

- *Magnetic fields*
- *Atmosphere*
- *Plasmas*
- *Energetic particles*

QUESTIONS:

- *How and why does the Sun vary?*
- *How does the Earth respond?*
- *What are the implications to humanity?*

Living With a Star (LWS) Program Architecture



LWS Products:
Bridge the Gap
Between Science,
Engineering, &
User Applications
Communities

Human Radiation Exposure

- Space Station
- Space Exploration
- High Altitude Flight
- Space Utilization & Colonization



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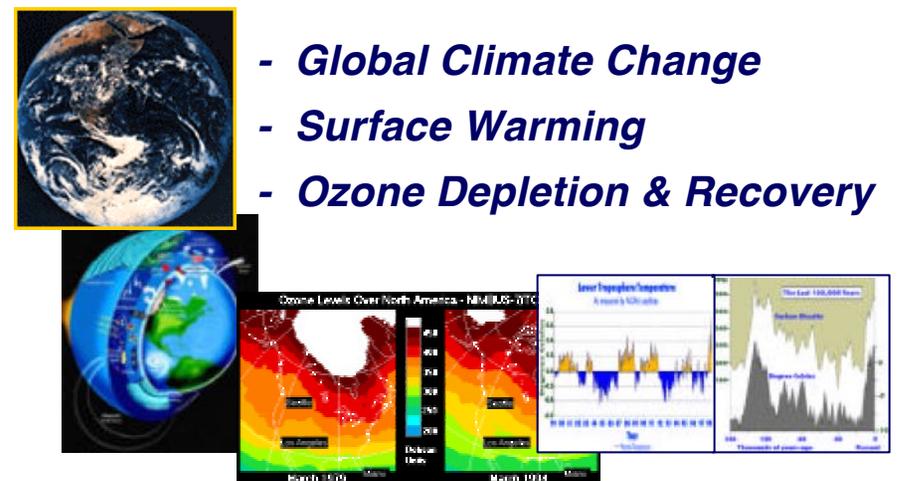
Impacts on Technology

Impacts on Life & Society

- Space Systems
- Communication & Navigation
- Ground Systems



- Global Climate Change
- Surface Warming
- Ozone Depletion & Recovery



Justification for the SET: Changes in the System Design Environment

Events

- ***Demise of market for environment-hardened electronics***
- ***Commercial demand for electronics***
- ***Short mission development times***
- ***Smaller, lighter spacecraft***
- ***More demanding mission requirements***
- ***Desire to operate in more severe environments***

Consequences

- ***Use of commercial off the shelf (COTS) components***
- ***Use of emerging technologies***
- ***More severe environment specifications***

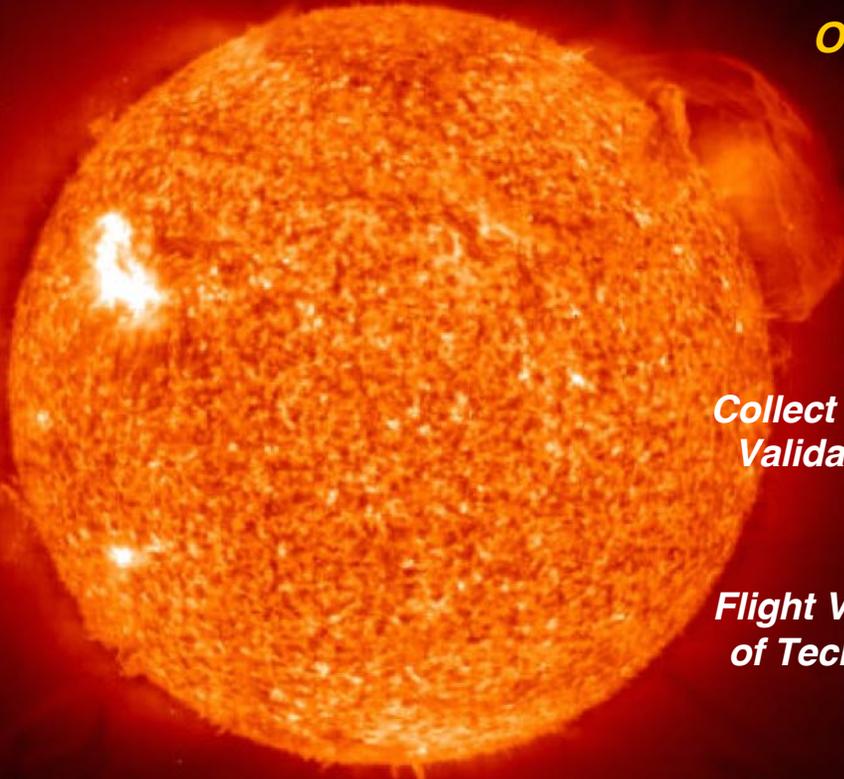
Result

- ***Risk avoidance → Risk management***
- ***Accommodations in Design Phase → Accommodations in Flight***
- ***Eroded operational capability with overhead for environment accommodation***
- ***Increased uncertainty in models that may preclude the use of new technologies***



Space Environment Testbeds (SET)

OBJECTIVE: *Infuse New Technologies into Space Programs Without Adding Risk*



Collect Data in Space to Validate Model/Tool

Collect Data in Space to Validate Ground Test Protocol

Flight Validation of Technology

Technology Application Model/Engineering Tool Development

Ground Test Protocol Development

Technology Development



RESULT: *Improve the Engineering Approach to Accommodate and/or Mitigate the Effects of Solar Variability on Spacecraft Design & Operations*

** Collaborative Efforts*

***Space Environment Testbeds (SETs):
2 Components With Competed
Investigations***

***NASA Research
Announcement (NRA)
8-31: 8 Awards in 3/02***

***NRA 02-OSS-04 for
SET-1 Investigations:
Closes 12/18/02***

SET Data Analysis

Components:

- ***Models, tools, or databases that describe performance variations in space in the presence of a spacecraft that changes due to solar variability***

SET Space Flight Component:

- ***Technology that requires space flight for performance characterization or validation***
- ***Technology for >1 mission***
- ***Technology whose performance changes due to the effects of solar variability***

Appropriate Candidates for the Living With a Star (LWS) Space Environment Testbeds (SETs)

SET Space Flight Candidates:

- ***Technology that requires space flight for performance characterization or validation***
- ***Technology candidates applicable to more than one mission or to a LWS mission***
- ***Technology whose performance changes due to the effects of solar variability***
 - ***Performance changes cannot be minimized by changing the spacecraft design***

SET Data Analysis Candidates:

- ***Data that describe performance variations in space in the presence of a spacecraft that changes due to solar variability***

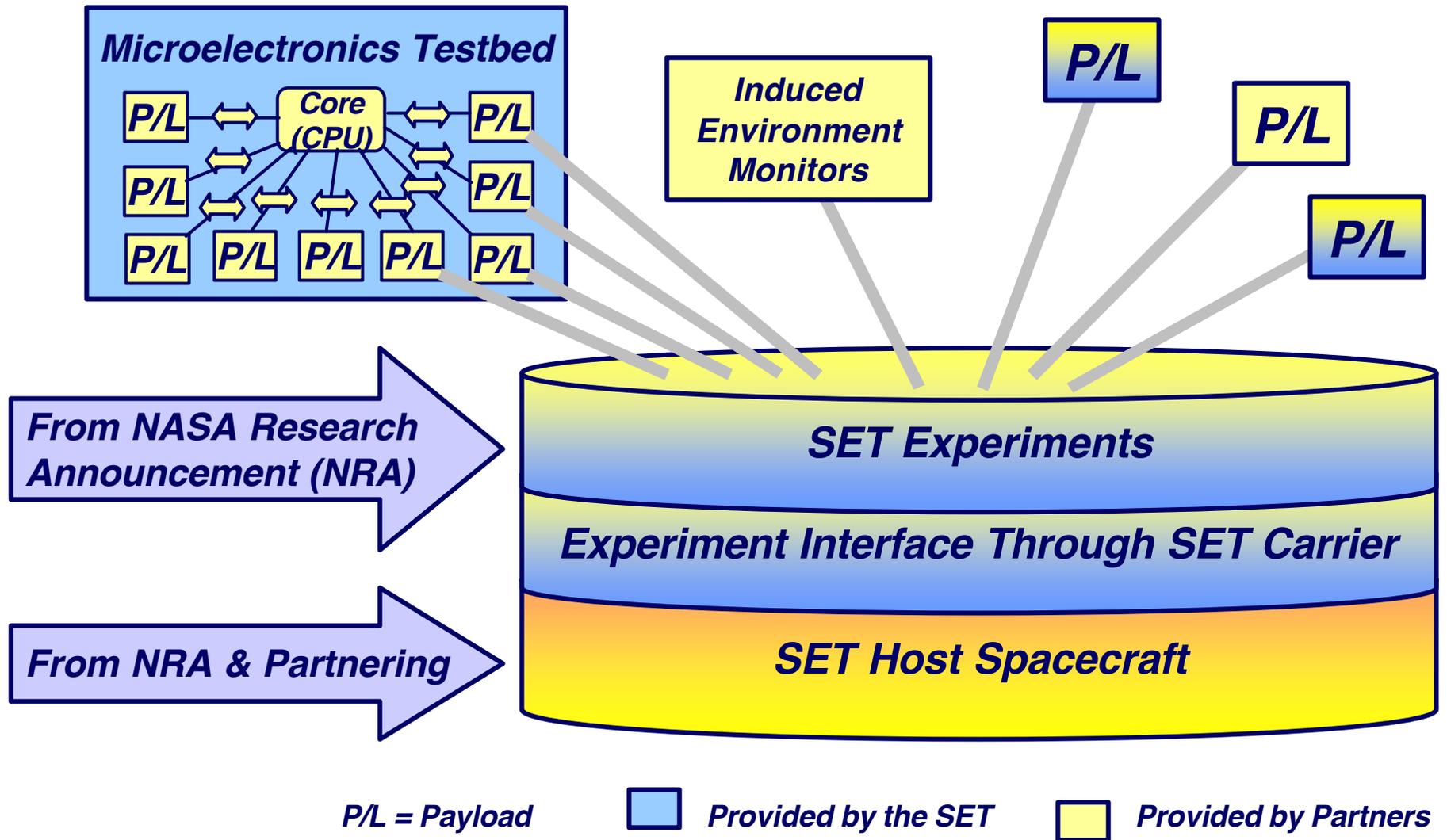
Awards for Analysis Products from NRA 8-31 in Microelectronics & Detectors

- ***Analysis of CRRES Pulse Height Analyzer (PHA) Data for Low-Linear Energy Transfer (LET) Events***
 - *Analysis will pay particular attention to the effects to be expected in photometric sensors flying on satellites*
- ***Solar Variability, the Near-Earth Radiation Environment, and Transient Effects on Microelectronics***
 - *The Enhanced Low Dose Rate Sensitivity (ELDRS) effect in bipolar linear integrated circuits flown in space will be studied using data from the Microelectronic and Photonics Testbed (MPTB) experiment. ELDRS was first observed in the MPTB experiment*
- ***Displacement Damage Effects in Solar Cells - Mining Damage Data from the MPTB Space Experiment***
 - *Develop an improved space solar cell radiation response analysis capability and produce a computer modeling tool which implements the analysis*
- ***Modeling Charge Collection in Detector Arrays***
 - *Develop and validate a detector array charge collection model that can be used to design optical sensor missions*

Awards for Analysis Products from NRA 8-31 in Materials Degradation/Shielding and in Spacecraft Charging

- ***Study of Total Ionizing Dose Effects of High-Z Material Spot Shields on Field Programmable Gate Arrays (FPGA) Using Flight Data from Microelectronics and Photonics Testbed (MPTB) Experiment***
 - *Use MPTB experiment data on spot shielding and environment data to improve the prediction model so that it does not under-predict the total ionizing dose degradation*
- ***Characterization of Magnetospheric Spacecraft Charging Environments Using the LANL Magnetospheric Plasma Analyzer Data Set***
 - *Develop an improved prediction model for environmental causes of spacecraft charging*
- ***Electrostatic Return of Contaminants***
 - *Develop a model that predicts the return flux of ionized contaminants to spacecraft surfaces*
- ***Mining CRRES IDM Pulse Data and CRRES Environment Data to Improve Spacecraft Charging/Discharging Models and Guidelines***
 - *Correlate bulk charging & discharging with high-energy electron flux/energy spectra, develop theoretical determinations of the internal electric fields during such events, and calculate electric fields in the samples as a function of sample resistivity*

Space Environments Testbed (SET) Concept

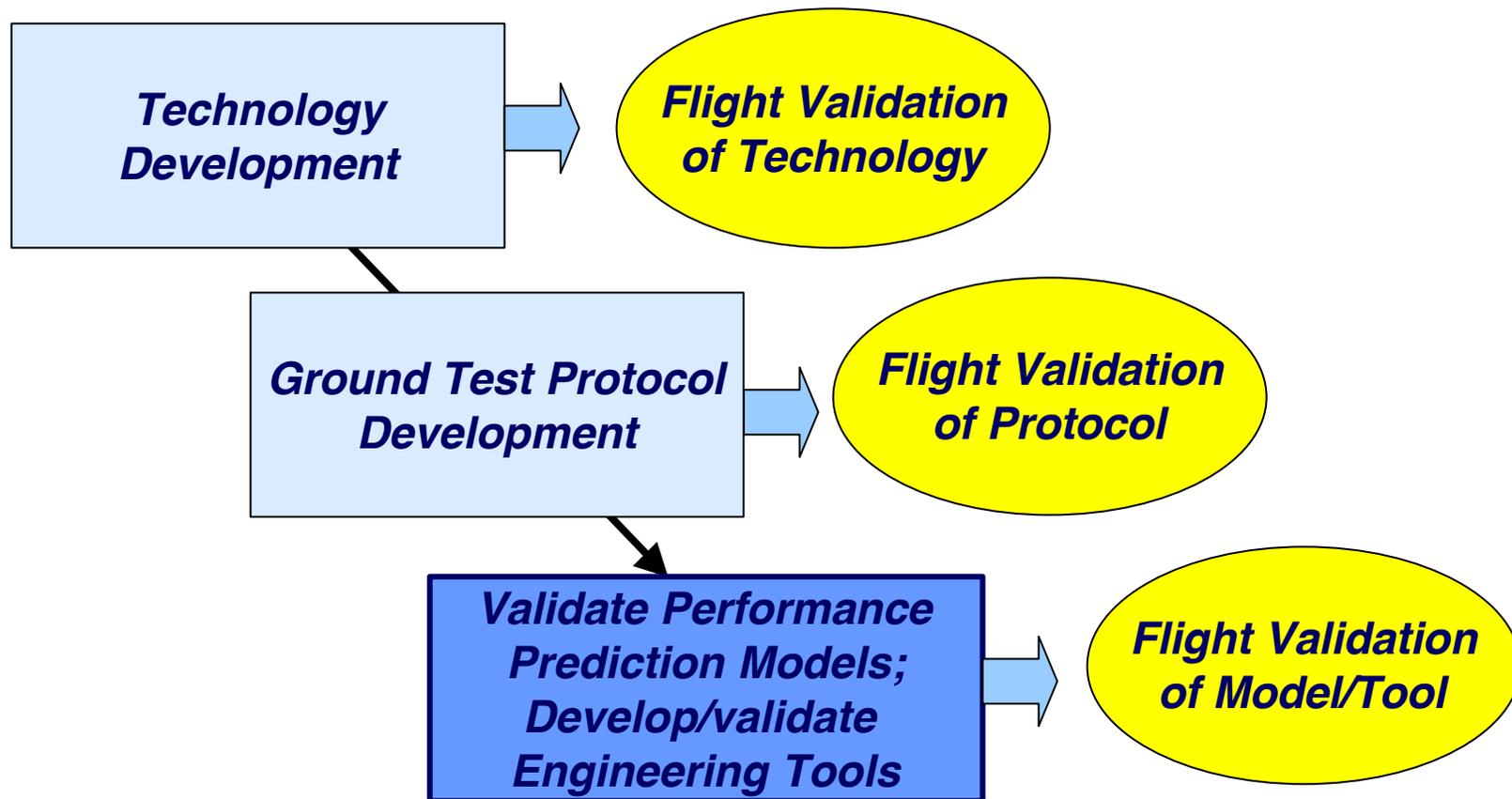


Areas for Investigations in NRA 02-OSS-04 for the First Space Environment Testbeds Project (SET-1)

Five categories of investigations that include space experiments:

- (1) Characterization of the space environment in the presence of a spacecraft***
- (2) Definition of the mechanisms for materials' degradation and the performance characterization of materials designed for shielding from ionizing radiation***
- (3) Accommodation and/or mitigation of space environment effects for detectors/sensors***
- (4) Performance improvement methodology for microelectronics used in space***
- (5) Accommodation and/or mitigation of charging/discharging effects on spacecraft and spacecraft components***

Generic Space Environment Testbed (SET) Technology Flowdown



Not SET Funded

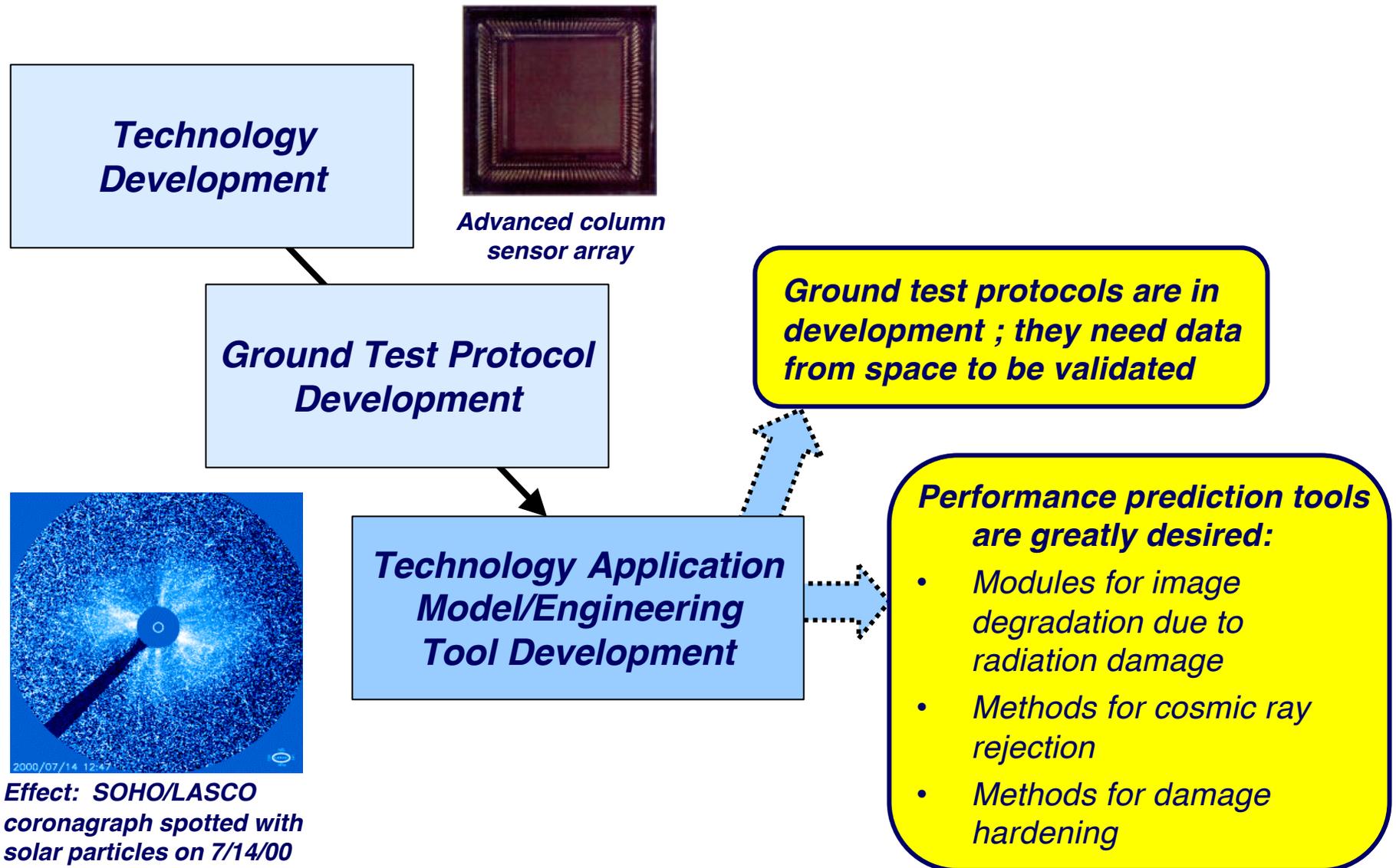


SET Funded



Product

Example: Validation of Performance Prediction Tools & Test Protocols Are Needed for Detectors/Sensors



Example: Characterizing the Causes, Symptoms, & Effects from Spacecraft Charging

Deep dielectric charging & surface charging may be the dominant causes of anomalies in space

Technology Development

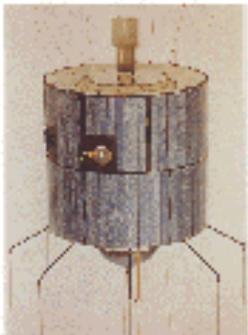
Ground Test Protocol Development

Validated Prediction Tool From Space Data on Materials' Interactions with Plasma & Electrons

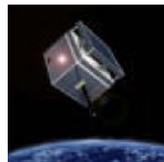
Engineering Tool Development: Predict Occurrence/Effects for Spacecraft Charging

Develop & validate tool to predict effects:

- **Distortion in science measurements**
- **Arcing**
- **Increased contamination**
- **Reduced spacecraft power**
- **Anomalies in electronics similar to single particle-induced effects**



GOES 8



MUNIN 7 - 6 kg

Spacecraft flying in high electron populations can no longer afford to be protected by Faraday cages

What's Next?

- ***Papers describing products from the SET Data Analysis NRA 8-31 should be presented at conferences in the Summer, 2003***
- ***The SET Pathfinder experiments are being rebuilt after loss of the STRV 1d spacecraft***
 - *Experiments will be ready for flight in 2003*
- ***The SET NRA for investigations that include space experiments for the SET-1 project closes on Dec. 18, 2002***
 - *Awards are anticipated in Spring 2003*
 - *Down-selection is anticipated in Fall 2003*
 - *Experiments ready for integration in spring 2005 for flight in early 2006*
- ***Follow-on testbed opportunities every 2-3 years subject to the availability of funds***