Carrier Plus: A Sensor Payload for Living With a Star Space Environment Testbed (LWS/SET)

Cheryl Marshall[1], Steven Moss[2], Regan Howard[3], Kenneth LaBel[1], Tom Grycewicz[4], Janet Barth[1], and Dana Brewer[5]

- **NASA Goddard Space Flight Center**
- **The Aerospace Corporation**
- **Orbital Sciences Corporation**
- **Defense Threat Reduction Agency**
- **NASA Headquarters**

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Outline

- **Living With a Star (LWS) Program**
  - **Space Environment Testbed (SET)**
  - **Natural Space Environment**
- **Carrier Plus**
  - **Goals and Benefits**
- **On-Orbit Sensor Measurements**
- **Carrier Plus Architecture**
- **Participation in Carrier Plus**

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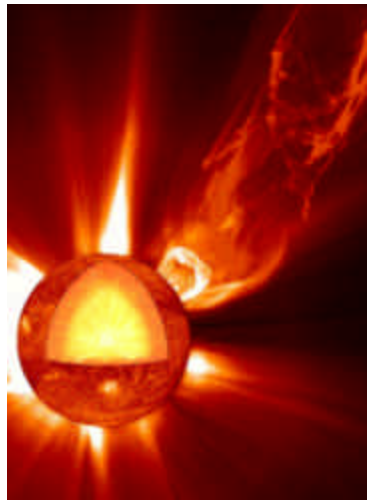
Living With a Star (LWS) Program:

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)**
  - **Continuous program started in FY01**
- **Science Missions: the what's and why's of the solar variant environment**
- **Theory and Modeling and Data Analysis: the environment models and tools developed from solar-variant data**
- **Space Environment Testbeds (SETs): Improve the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design & operations**



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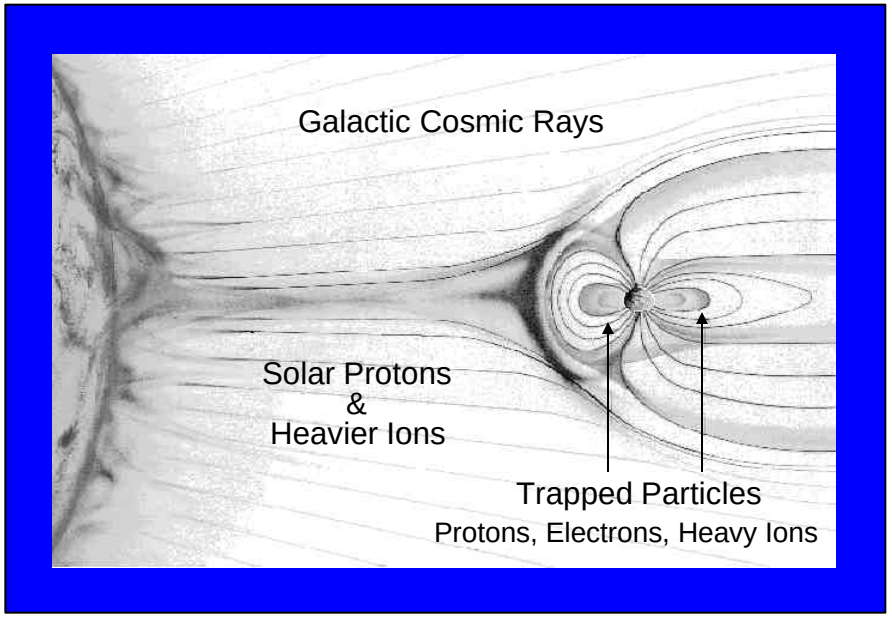
The Natural Space Radiation Environment

- **Particles trapped in the Van Allen Belts**
  - **Energetic proton, electrons and heavy ions**
- **Transient radiation**
  - **Galactic cosmic ray particles**
  - **Particles from solar events**
- **Particles from solar events can drive the total ionizing dose, displacement damage and single event transient effects of a sensor**



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SET Technologies

- **SET provides opportunities for flight validation experiments on technologies**
  - **Microelectronics**
  - **Photonics**
  - **Materials**
  - **Sensors**
- **These investigations focus on**
  - **Demonstration of environment tolerance**
    - **Radiation hardening approaches**
  - **Validation of technology ground test methods and performance prediction techniques**
- **Investigations must require exposure to solar-variant environment**

Space Technology Research Vehicle 1-d with NASA experiments

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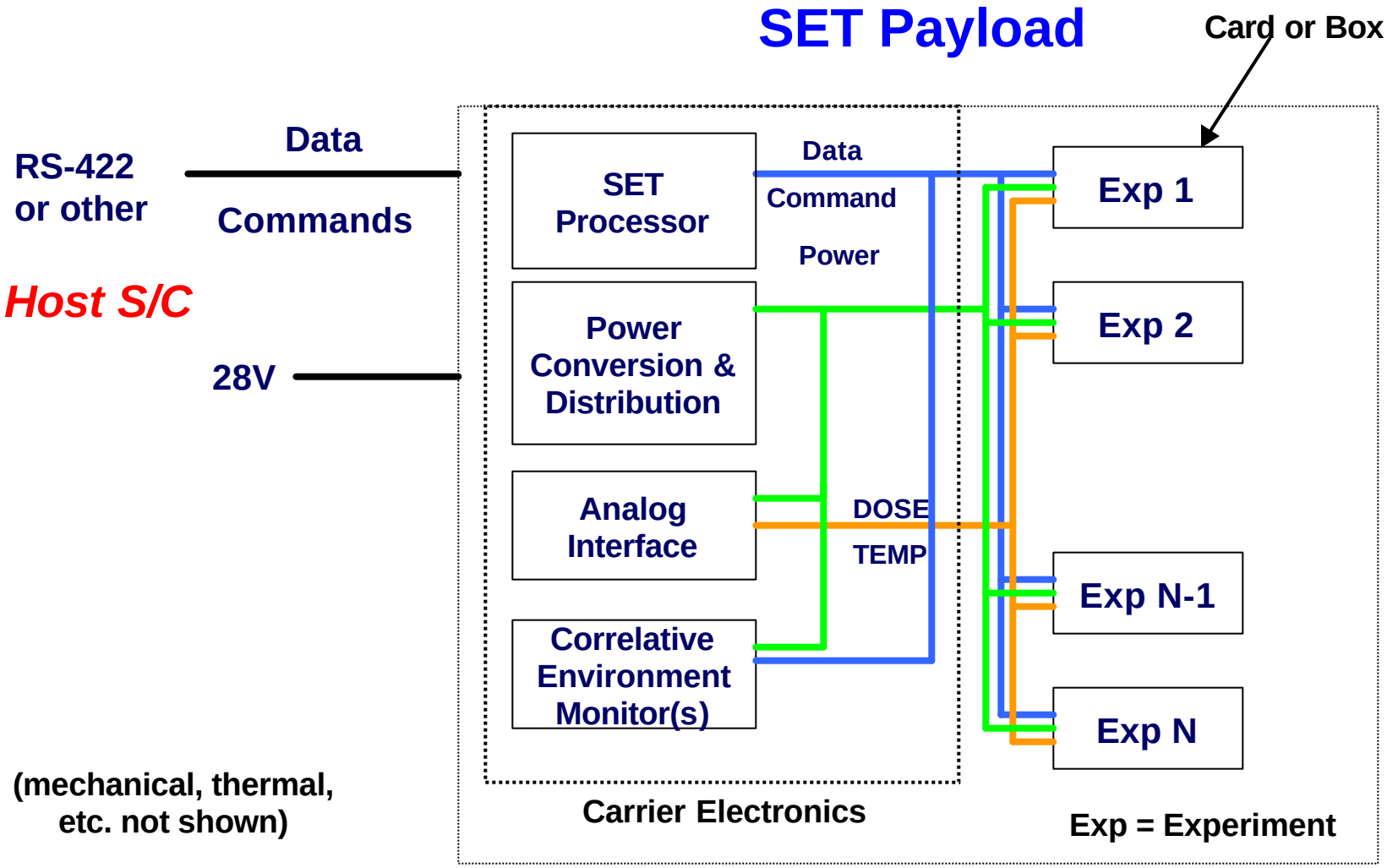
SET Services Provided to Experiments



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Why a Sensor SET Payload?

- **UV/Visible focal plane array (FPA) technologies identified as critical to the NASA mission yet they are inherently sensitive to radiation**
  - **NASA Office of Space Science roadmapping effort**
  - **Charge coupled devices (CCDs) will remain important as well as newer technologies such as active pixel sensors (APS), p-CCDs, Si hybrids, etc.**
- **Science instruments push the state-of-the-art for signal detectibility and precision *even in the absence of radiation*!**
  - **Unfortunately, the greater the performance, the greater the sensitivity to radiation**
  - **CCDs with charge transfer efficiencies (CTEs) in excess of 0.999999 transfer electrons over inches of pristine Si**

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Benefits of Carrier Plus

- **Unlike most microelectronic devices, sensors are highly susceptible to displacement damage effects**
  - **Protons and secondaries create carrier traps that increase the dark current, reduce CTE, and produce hot pixels and transients**
  - **Secondaries are produced in the heavy shielding often required for sensor survivability on-orbit**
- **Models used to predict displacement damage effects have not been validated by careful comparison with on-orbit performance**
- **Hence large radiation design margins (RDM) for a soft technology.**
- **Carrier Plus is expected to reduce the RDMs thereby allowing sensor operation in a scientifically more useful orbit or for a longer mission.**

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Benefits of Carrier Plus, cont.

- **Provides heritage for new sensor technologies.**
- **Validation of ground test based predictions of on-orbit performance.**
  - **On–orbit measurements will correspond with ground testing.**
  - **On-orbit dosimetry is critical for calibration with ground testing.**
- **Better understanding of space radiation effects can help mission planning (key observations tend to be degraded first)**
  - **Hubble loses ~10% observing time due to monthly anneals to reduce hot pixel counts, and CTE loss is a significant problem.**

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Carrier Plus Measurement Suite

- **Sensor dark current**
  - **Both the average and dark current nonuniformity will be characterized between -20 to +20°C +/- 0.02°C.**
  - **Pixel by pixel dark current histograms acquired**
- **Temperature dependent CTE measurements.**
  - **Extended edge pixel response (EPER). First pixel response (FPR), cosmic ray tails, and possibly pinhole centroiding measurements.**
  - **Lower temperatures will permit CTE measurements of damaged FPAs.**
  - **Diagnostic signals can be generated using dark current for biweekly characterizations**
- **Proton and heavy ion transient frames captured**
- **Photometrics may be possible using LED light sources**

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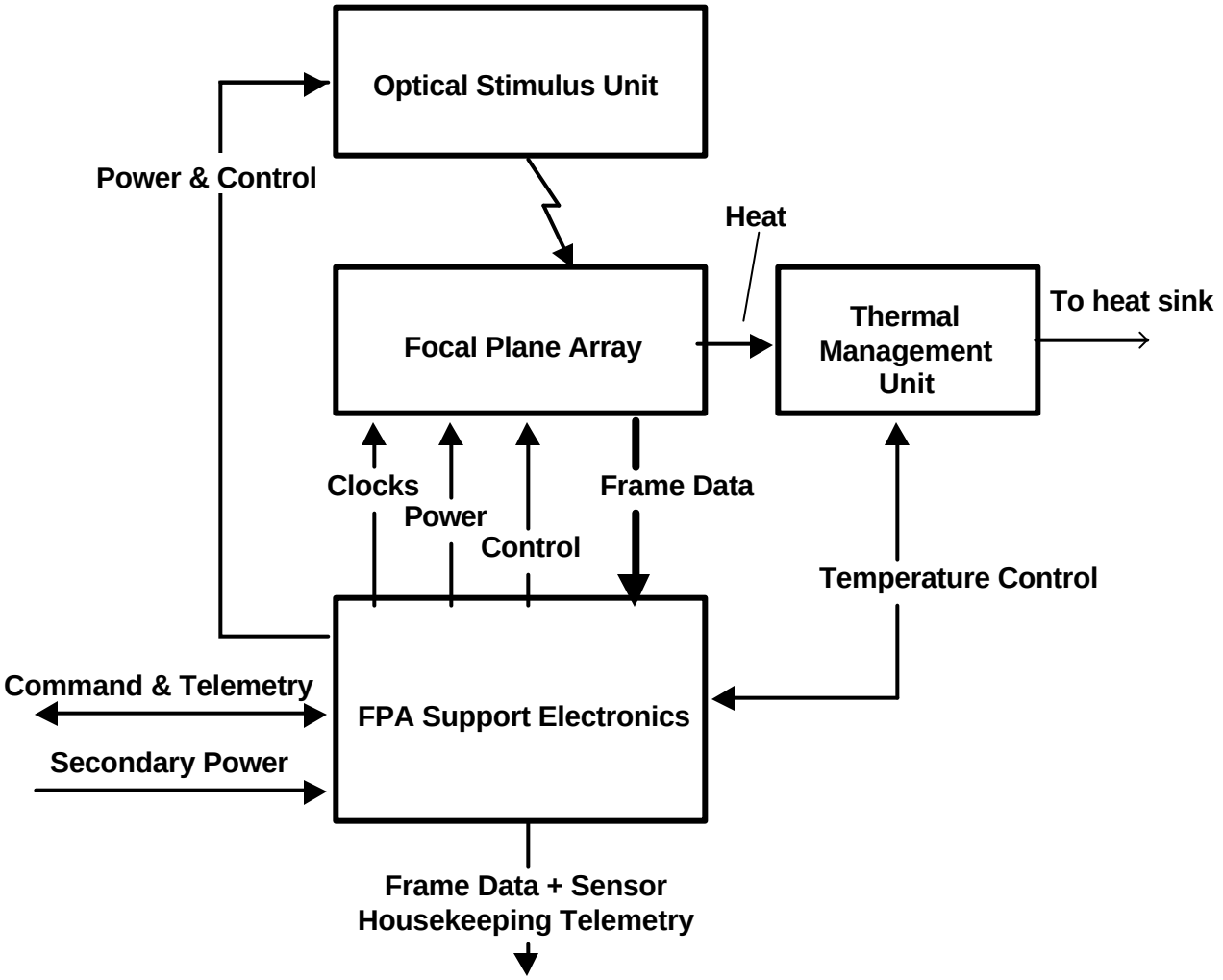
Optical Sensor Head Block Diagram



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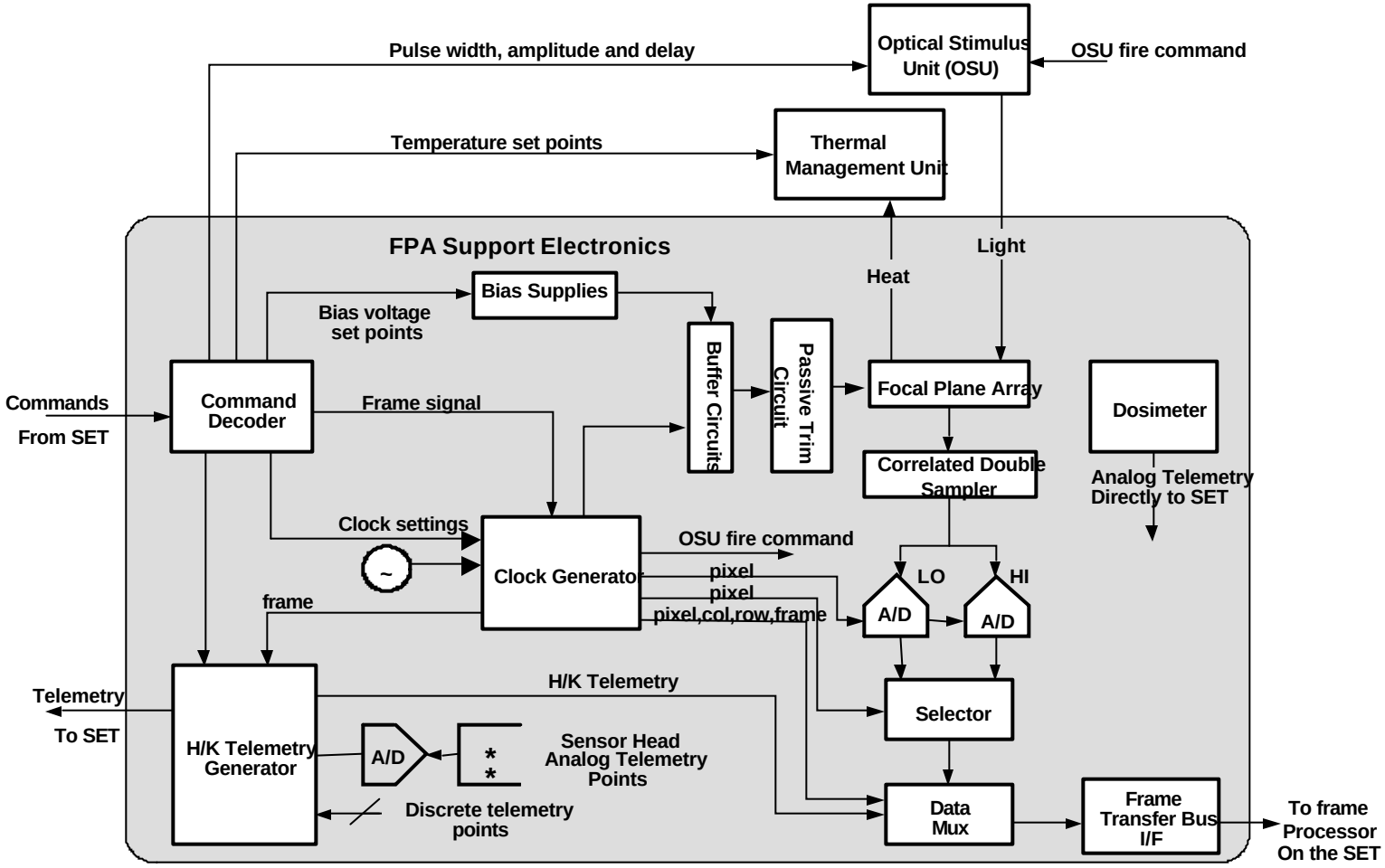
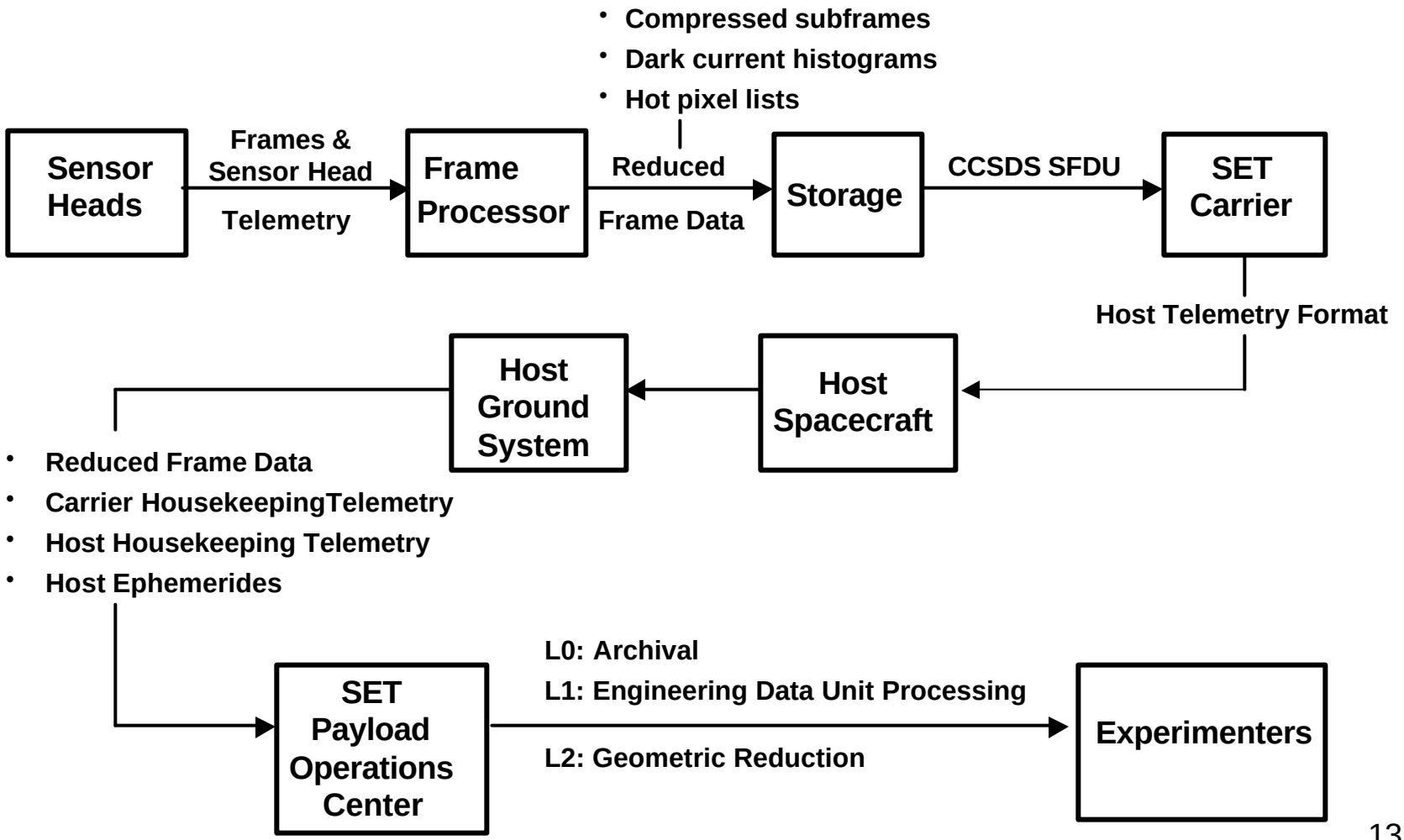


Carrier Plus Data Processing Flow



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**

Summary of Carrier Plus

- **Carrier Plus Goals:**
  - **Validate ground test based prediction of on-orbit FPA performance.**
  - **Reduce uncertainties in methods used to predict on-orbit sensor performance.**
  - **Provide on-orbit heritage of emerging FPA technologies.**
  - **Enhance understanding of various methods now used to assess CTE behavior in flying instruments.**
- **Community participation is encouraged through NRAs.**
  - **Interest in a variety of FPAs including n-CCDs, p-CCDs, APS, Si hybrids, …**
  - **Experimenters are responsible for ground test program.**
  - **NASA may supply FPA support electronics board.**
  - **For more information see http://lws-set.gsfc.nasa.gov and http://lws-set.gsfc.nasa.gov**
- **DTRA is our sensor partner and will identify half of the sensors flown**
  - **For information see Tom Grycewicz at *tom.grycewicz@dtra.mil.***

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