Spacecraft System

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Outline

- Orbits
- Top level and autonomy requirements
- Block diagram
- Sparing philosophy
- Phase A studies
- Technology insertion candidates

Required Orbits

- Leading spacecraft: Lead the Earth at a rate of ~20°/year with a dwell near 20° between 200 and 400 days and one at 45° between 600 and 800 days.
- Lagging spacecraft: Lag the Earth at a rate of ~30°/year with a dwell near 30° between 200 and 400 days and one at 60° between 600 and 800 days.

Spacecraft Requirements

- Conceptually, the instrument suite on each STEREO spacecraft consists of a:
  - Solar Coronal Imaging Package, Radio Burst Tracker, Heliospheric Imager, Solar Wind Plasma Analyzer, Magnetometer, Energetic Particle Detector.
  - In operational mode, instruments operate at 100% duty cycle.
  - The exact instrument compliment will not be known until well into Phase A.
- Solar images are taken simultaneously (±1 sec) from the two spacecraft.
- Support the instrument suite with power, commands, telemetry and unobstructed views for instruments and their radiators.

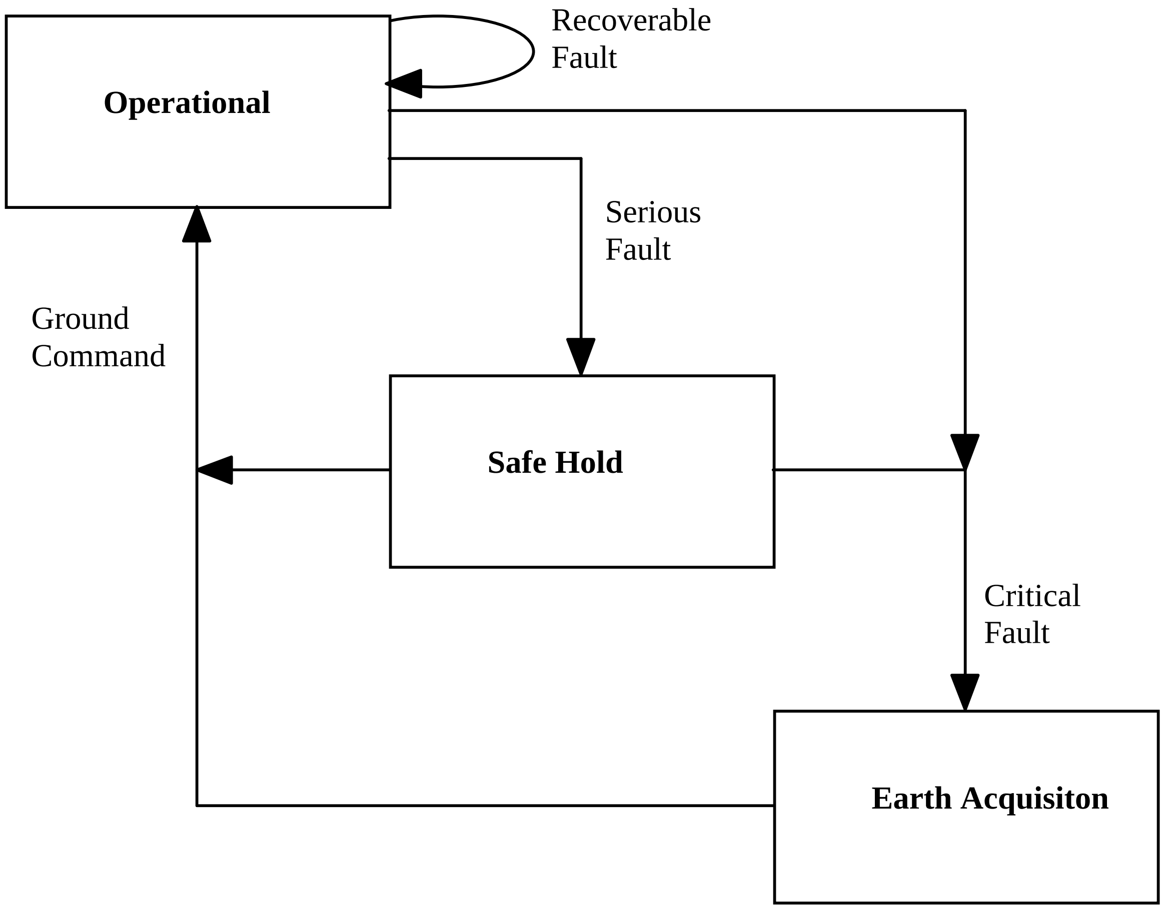
Spacecraft Requirements (Con't)

- The SCIP instrument will provide an error signal to the S/C Attitude Control System. Meet LV interface requirements.
- Spacecraft warns instruments prior to shut off and momentum dump. Instrument survival heaters remain powered.
- Support autonomous LV to operational mode transitioning.
- Maximum time difference of 0.5 seconds between spacecraft.
- Maximum mass 350 kg including 20% margin going into Phase A.
- Maintain full operational mode for Sun/z-axis angle of ±5° or less.

Spacecraft Autonomy Requirements

- The spacecraft will have an autonomous safe-hold mode where the Z-axis is controlled to within 1° of the Sun and the MGA is held within 1° of Earth.
- The spacecraft will have an autonomous Earth-acquisition mode where the Z-axis axis is controlled to within 1° of the Sun and rotation about the Sun line is controlled to 1°/minute ±0.5 min/revolution.
- Provide an autonomous Sun-keep-in capability where the Sun angle is programmable.
- Return to <5° of Sun pointing in <12 minutes from any attitude after any rates have been nulled to zero.
- Capable of autonomously re-positioning the HGA for optimal gain within pre-specified windows. May be overridden or altered from the ground.
- Capable of autonomously momentum dumping within pre-specified windows. May be overridden or altered from the ground.
- Autonomous power management
- Passive thermal control.

Initial Spacecraft State Design



Operational

- Enabled time-tag commands
- All instruments on
- Sun point with all antennas toward Earth
- Telecom over HGA

Safe Hold
(Roll-axis knowledge of assumed)

- Suspend time-tag commands
- Reset spacecraft state (instruments off)
- Sun point with antennas at Earth
- Telecom emergency rates over MGA

Earth Acquisition
(Roll-axis knowledge not assumed)

- Suspend time-tag commands
- Reset spacecraft state (instruments off)
- Sun point and rotate 1 deg per minute
- Telecom emergency rates over MGA
- Recovery initiated with a stop-rotate command

Launch Vehicle

- The baselined launch vehicle for the STEREO mission is the Athena II.

  Launch is separated by two months.
- Each spacecraft will be launched on a separate ELV.
- The shuttle will be studied as an alternative LV. Two spacecraft will be manifested on the same shuttle.
- JHU/APL will make a launch vehicle recommendation at the end of the Pre-Phase A study.

Mission Lifetime

- Designed for a two year mission with expendables designed to last for five years.

  Mission time starts when both spacecraft are on orbit

- Do nothing to preclude a longer mission beyond two years.

  Data rate will degrade past the 200 kb/sec at two years requirement

- Two years is the baseline mission duration.

Reliability/Redundancy

- Reliability: Standard JHU/APL reliability practices
- Redundancy: In order to minimize cost, the STEREO spacecraft will be of a single string hardware design based on the TIMED architecture and hardware.

  Some inherent redundancy exists

Spacecraft Differences

- The two STEREO spacecraft will be form, fit, function and interface identical.
  - Eases build and integration
  - Can take advantage of lessons learned
  - One spacecraft can replace the other in schedule with minimal changes

Radiation

- Spacecraft hardware will be capable of operating for the mission duration in the environment outlined under the reference memo. This includes:
  Component total dose hardness level of 10 Krad.
- All spacecraft electronics will be latch-up immune and SEU tolerant.

Reference: GSFC (Janet Barth) radiation environment analysis and Memo SOR-98048.

Cleanliness

- Handling and I&T Environment

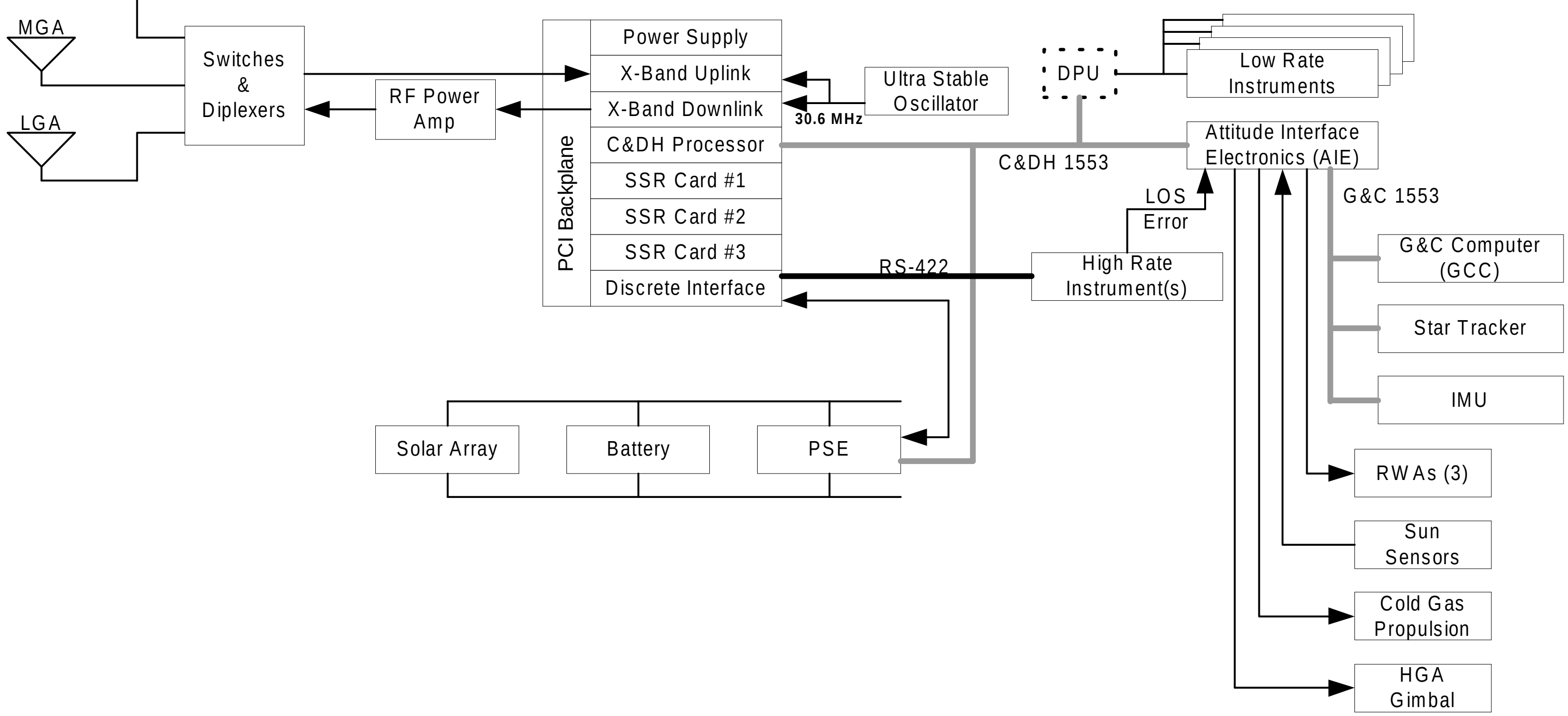
  Class 100,000 during bus integration.
- Instrument selection may dictate the use of more stringent cleanliness requirements
- A Contamination Control Plan will be written after instrument selection and requirements have been defined.

Communications

- Science data volume requirement is 5 Gbit/day.
- Nominally, complete volume will be transmitted to the Earth within 24 hours
  - Data rates will vary with Earth probe distance.
- Maximum DSN pass time is 8-hours (at end of mission).
- Each STEREO spacecraft will support a low rate “broadcast mode” of 500 b/s which will be transmitted at all times, when not transmitting high rate data.

STEREO Block Diagram

The DPU is currently under evaluation. A non-DPU implementation would require all low rate science instruments to transfer data via the 1553 bus.



Flight Spares Philosophy

- Sparing will occur only at the piece part level. There will be no one for one box level or procured hardware spares (except for battery).
- A spare flight board will be fabricated/purchased for all in house boards (except for the SSR). These boards will be left unpopulated. One set of components will be purchased for every two used.
- The goal is to minimize cost without undue schedule risk.
- Additional sparing will be considered on a case by case basis.

Current Requirements Deficiencies

- Transmission gap between day 76 and 125 on the leading spacecraft.
- Minimum data rate at the end of two year mission 0.97 AU (Data rate is 82 kb/s). Day 661 drops below 200 kb/s (34m HEF).
- Jitter requirement–Additional analysis during Phase A required.

Phase A Studies

- G&C/Safing architecture trade

  Removal of AIU processor, RTX-2010 compiler is no longer supported.
- MiniMOCS
- Non rotisserie Safe Mode

  Using low gain antenna in safe mode in conjunction with 70 m DSN.
- Continue Jitter Analysis
- Communications gap

Technology Insertion Candidates

- Momentum dumping via trimmable flaps
- Non-coherent navigation (baselined)
- LiIon battery
- Advanced recorder management
  - File system