Electrical Power System

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Top Level Requirements (1 of 2)

• Energy	Supply Electrical Energy to All Spacecraft Subsystems and Instrument During All Mission Phases
• System Survival	The EPS Shall Not be Damaged by and Shall Be Fully Recoverable From Operational, Electrical and ACS Faults
• Attitude Disturbances	The EPS Shall Minimize Torque Disturbances to the Spacecraft Attitude
• Telemetry	EPS Health and Status Shall Be Provided to Spacecraft Telemetry
• Control Functions	The EPS Shall Provide Control of All Spacecraft Motors and Heaters
• Ordnance	The EPS Shall Provide Electrical Energy to Activate All Ordnance Devices
• Harness	The EPS Shall Provide Signal and Power Connectivity Between All Spacecraft Subsystems and Between the Instrument and Spacecraft Subsystems

Top Level Requirements (2 of 2)

- **Environment** — **The EPS Shall Meet the Environmental Requirements Outlined in the Fame Test Plan NCST-TP-FM001**
- **Parts** — **EPS EEE Parts Shall be Selected, Screened and Qualified Per the GSFC311-INST-001 Document for a Level 2 Program**

Derived Requirements (1 of 7)

- **Energy**

Generate Energy - Solar Array, With GaInP/GaAs/Ge Cells, to Convert Sunlight to DC Power

Store Energy - Battery With Capacity to Handle Longest Eclipse Duration

Distribute Primary Power - Bus Voltage of 30+/-6Vdc to Instrument and All Subsystems

Distribute Secondary Power - +/-5Vdc and +/-15Vdc to IMUs

Charge Control - Automatic Battery Charge Control
- Elimination of Excess Solar Array Energy

Derived Requirements (2 of 7)

- **System Survival**

Operational Faults - Survive All Operator Command Misapplication

Electrical Faults - Sufficient Battery Capacity to Clear Electrical Faults

Battery Overdischarge - Undervoltage Detection at 23.5Vdc Activates Load Shed

Circuit Protection - Remove Harness/Load Shorts

ACS Faults - Sufficient Battery Capacity to Survive Temporary Misalignment of Sun-Solar Array Angle

Derived Requirements (3 of 7)

- **Attitude Disturbances**

Solar Cell String Layout
- Identical on Each Panel
- Thermal Gradients Minimized
- Magnetic Moments Minimized
- Cell Array to be Flat to TBD Requirements

Harness Design - Power and Return Lines Twisted and Paired

Power Switching - Solid State Switching to Replace Electromechanical Switching Wherever Attitude Disturbance Possible

Derived Requirements (4 of 7)

- **Control Functions**

Motors
- Drive Six CG Trim Mass Motors
- Drive Six Radiation Trim Tab Motors
- Instrument Aperture Cover Motors (TBD)

Heaters
- Switch Power to All Primary, Thermostatically Controlled Heaters
- Switch Power to Both Star Tracker Cameras' Cover Heaters

- **Telemetry**

Active Analog Signals
- Voltage
- Currents

Passive Analog Signals
- Temperatures

Bi-levels
- Low Level Status
- High Level Status

Derived Requirements (5 of 7)

- **Ordnance**

Safety - Design to Meet EWRR-127 Requirements

Configuration - Ordnance Control Box Contains:
- **Device Control Circuits**
- **Device Firing Circuits**

Isolation - Source-to-Device Electrical Isolation
- **Source-to-Device Mechanical Isolation**

Devices - EEDs/Non-Explosive Devices for:
- **Solid Rocket Motor Ignition**
- **Solar Array Deployment**
- **Spacecraft/Interstage Separation**

EMI/EMC - Ordnance Lines to Devices Shielded

Derived Requirements (6 of 7)

- **Harness**

Safety - Turn-on-Plugs For:
- **Solar Array**
- **Battery**
- **Ordnance**
- **RCS**
- **Paraffin Actuators**

Minimize Magnetic Moments - Power and Return Lines Twisted and Paired

EMI/MC - Power and High Speed Data Lines Separated

Voltage Drop - Wire Sizing to Meet GSFC311-INST-001 Requirements

High Speed Data Lines - 1553 Compatible Lines

Derived Requirements (7 of 7)

- **Environment**

Temperatures

- EPS Electronic Boxes	0C - +40C
- Battery	0C - +30C
- Solar Array	-100C - +120C

Radiation - EEE Parts to Meet Requirements As Stated in MRD Section 3.2.8.7.3 on Particle Radiation

Vibration - EPS Components Designed to Meet Limits As Stated in the Fame Design and Analysis Plan, NCST-D-FM003

Shock - EPS Components Designed to Meet Limits As Stated in the Fame Design and Analysis Plan, NCST-D-FM003

- **Parts**

All EEE Parts Per GSFC311-INST-001

- Selected	Quality Level 2
- Screened	Quality Level 2
- Qualified	Quality Level 2

Major Trade Studies

- **Battery Chemistry**
  - Lithium-Ion
  - Nickel-Hydrogen
- **Ordnance Box Location**
  - Electronics Deck
  - Interstage
- **Load Switching/Protection**
  - Solid State Relay With Integral Current Limiting
  - Electromechanical Relay With Fuse

Issues

None Identified at This Stage of Design

Back-Up

Load Interfaces, Preliminary

Loads	Input Voltage	Input Avg GEO Power (Watts)	Input Max Power (Watts)	Relay	Fuse
ISC	30	24.1	36.5	No	Yes
IMU 1	+/- 5, +/- 15	20	20	Yes	Yes
IMU 2	+/- 5, +/- 15	20	20	Yes	Yes
Sun Sensor	30	1	1	Yes	Yes
Star Tracker 1	30	20	20	Yes	Yes
Star Tracker 2	30	20	20	Yes	Yes
Receiver 1	30	7.6	7.6	No	Yes
Receiver 2	30	7.6	7.6	No	Yes
Transmitter 1	30	24	24	Yes	Yes
Transmitter 2	30	24	24	Yes	Yes
Power Amp 1	30	58	58	Yes	Yes
Power Amp 2	30	58	58	Yes	Yes
Heaters	30	64	154	Yes	Yes
RCS	30	0.0	TBD	Yes	Yes
Motors	30	0.0	TBD	Yes	Yes
Instrument	30	321	321	Yes	Yes
Survival Heaters (Inst)	30	0.0	60	No	Yes

Equipment List

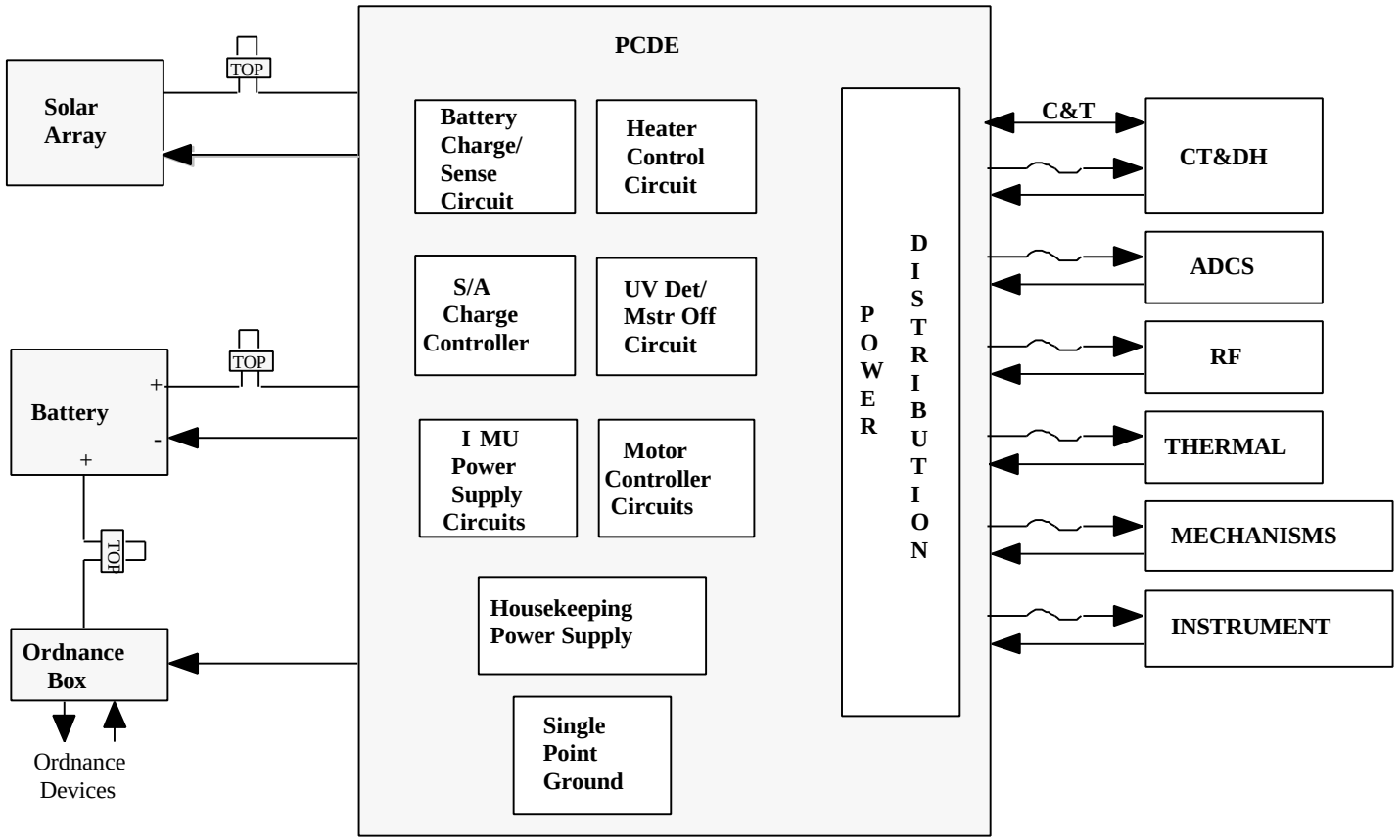
Component	Manufacturer	Heritage
30-35 A-H Battery	Competitive Bids Among 4 Companies	New
GaInP/GaAs/Ge Solar Cells	Competitive Bids Among 3 Companies	New
Power, Control & Distribution Electronics	NRL	New But Based on ICM & Clementine Designs
Ordnance Box	NRL	New But Based on Clementine Design

Status

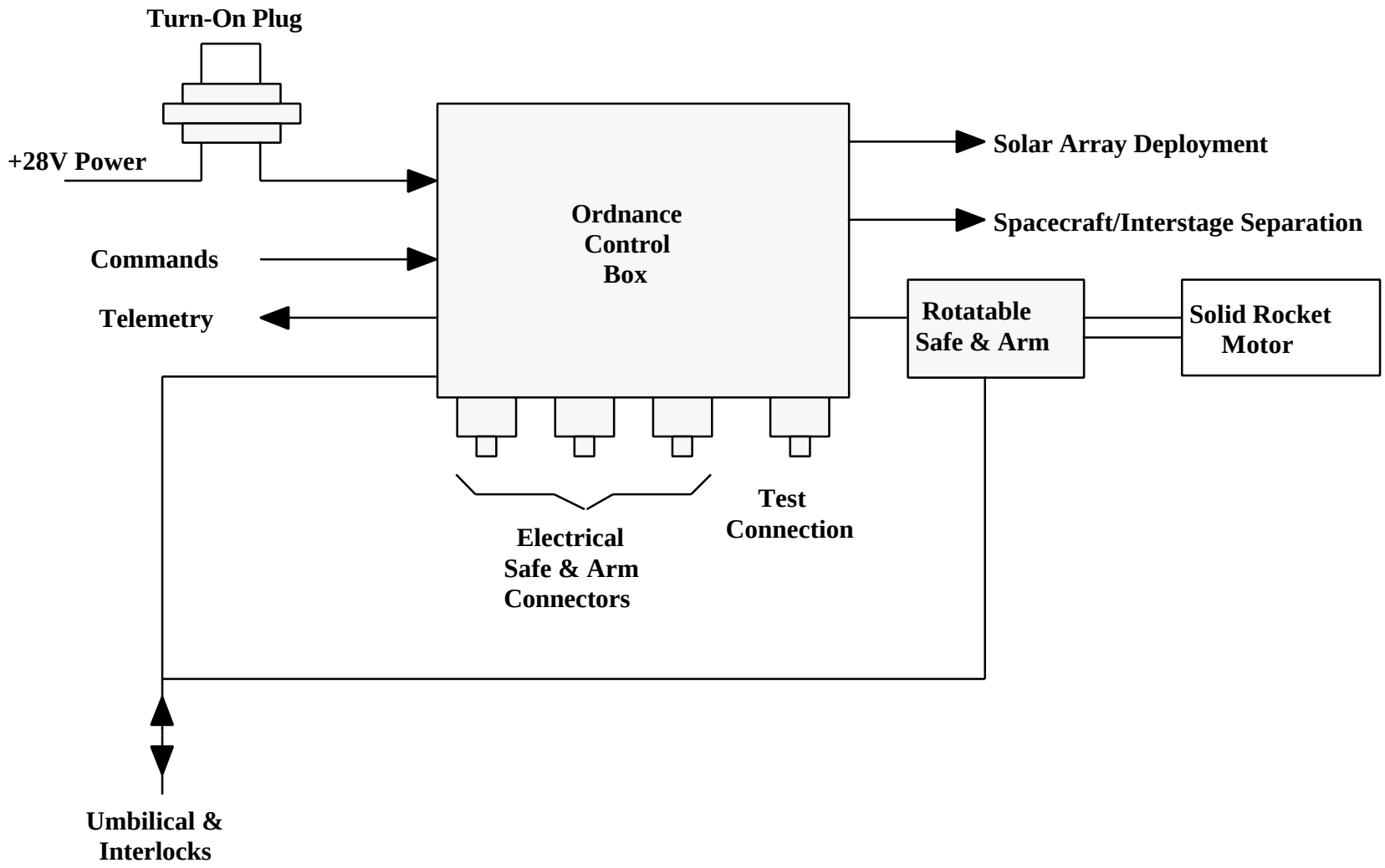
Procurement Items	Specifications	Procurement Stage
Battery	Preliminary Specs Being Identified	Not Started. Possible Vendors Known. Contacts Made
Solar Cells	Preliminary Specs Being Identified	Not Started. Possible Vendors Known. Contacts Made
DC-DC Converters	Not Started	Vendors Being Identified

Design Items	Specifications	Design Stage
PCDE	Not Started	Block Diagram Level
Ordnance Box	Not Started	Block Diagram Level

EPS Block Diagram



OCS Block Diagram



Preliminary EPS, OCS Design Details (1 of 3)

Energy **Energy Balance** **Solar Array Design**	**GaInP/GaAs/Ge Solar Cells, Arranged on Six Deployable Panels Each With Ten Strings and Sixteen Cells Per String, Having Sufficient Energy Production to Support All Phases of a Five Year Mission. This Design Produces 552 Watts BOL and 485 Watts EOL at a 45 Degree Sun Angle. Strings to be Switched Symmetrically About Spacecraft Center of Rotation to Distribute Energy Production Evenly About the Six Panels.**
Excess Energy	**Groups of Solar Array Strings Will be Switched, As Needed, to Satisfy a Selected VT Curve, Leaving Excess Energy at the Solar Array.**
Energy Storage	**Battery With a 30-35 Amp-Hour Capacity**
Battery Charge Limits	**Battery Depth of Discharge Will be Limited to 80% and Battery Overcharge Will be Controlled by Charger V/T Curves.**
Bus Voltage	**All Spacecraft Busses Will be Maintained at 30 +/- 6 Vdc**
System Survival	**Undervoltage Detection of 23.5 Vdc Will Cause Shedding of Non-Critical Loads. Fuses Will be Inserted In-Line With All Non-Critical Loads and Redundant Critical Loads.**
Motor Control	**Motor Drive Electronics to Sequentially Drive Six CG Trim Mass Stepper Motors and Six Radiation Trim Tab Stepper Motors.**

Preliminary EPS, OCS Design Details (2 of 3)

Autonomy	**Overridable Autonomy Shall be Designed Into the Battery Charger/Solar Array Controller Circuits Such That, After a Certain VT Curve is Chosen, Battery Charge and Solar Array Switching Shall Occur Automatically.** **Load Shedding, Due to an Undervoltage Condition, Shall Occur Automatically**
Power Distribution	**Non-Critical Load Switching to be Performed Using Electromechanical Relays.** **Isolated Secondary Voltages of +/- 5Vdc and +/- 15Vdc Will be Provided for the Two Inertial Measurement Units.**
EPS Telemetry	**Current Monitors of Solar Array, Battery and All Loads.** **Voltage Monitors of Battery, Critical Bus and All Secondary Voltages.** **Temperature Monitors of the PCDE and Selective Components.** **Status Monitors of All Relays and Selective Digital Circuits.**
Ordnance Functions	**Provide Ordnance Control Box to House Control and Firing Circuits. Provide Electrical & Mechanical Isolation Between Power Source and EEDs/Non-Explosive Devices. Provide Filtered and Shielded Circuits, Two Independent Inhibits and Safe Plugs, and Required Currents and Pulse Widths for Ordnance and Non-Explosive Devices.**
Ordnance Safety	**Ordnance Design Will Meet Safety Requirements as Specified in NASA Document 127-1 for Non-Manned Flights**

Preliminary EPS, OCS Design Details (3of 3)

Spacecraft Harness	**Harness Will be Designed to Handle Instrument High Speed Data Lines, 1553 Bus Lines, Battery and Solar Array Power Cables, Ordnance Cables and Power, Command and Data Lines from All Subsystems. Connectors and Wires Will be Selected Using Guidelines as Specified in GSFC311-INST-001. Magnetic Moments Will be Minimized by Pairing Power Lines With Their Return Lines.**
Parts Selection	**Electrical Parts Will be Selected Using Guidlines as Specified in GSFC311-INST-001.**
Design Environment	**All Electronic Designs Capable of Performing Properly Over the Flight Temperature Range of 0C to +40C; Solar Array from -100C to +120C; Battery from 0C to +30C.** **All Parts/Designs Will Survive Fame Vibration and Shock Levels as Specified in the Dedign and Analysis Plan, NCST-D-FM003** **All Parts/Designs Will Survive Fame Radiation Levels as Specified in the Mission Requirements Document, NCST-D-FM002**