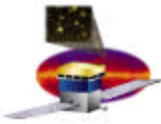


Peer Design Review of the Power System

16 August 2001

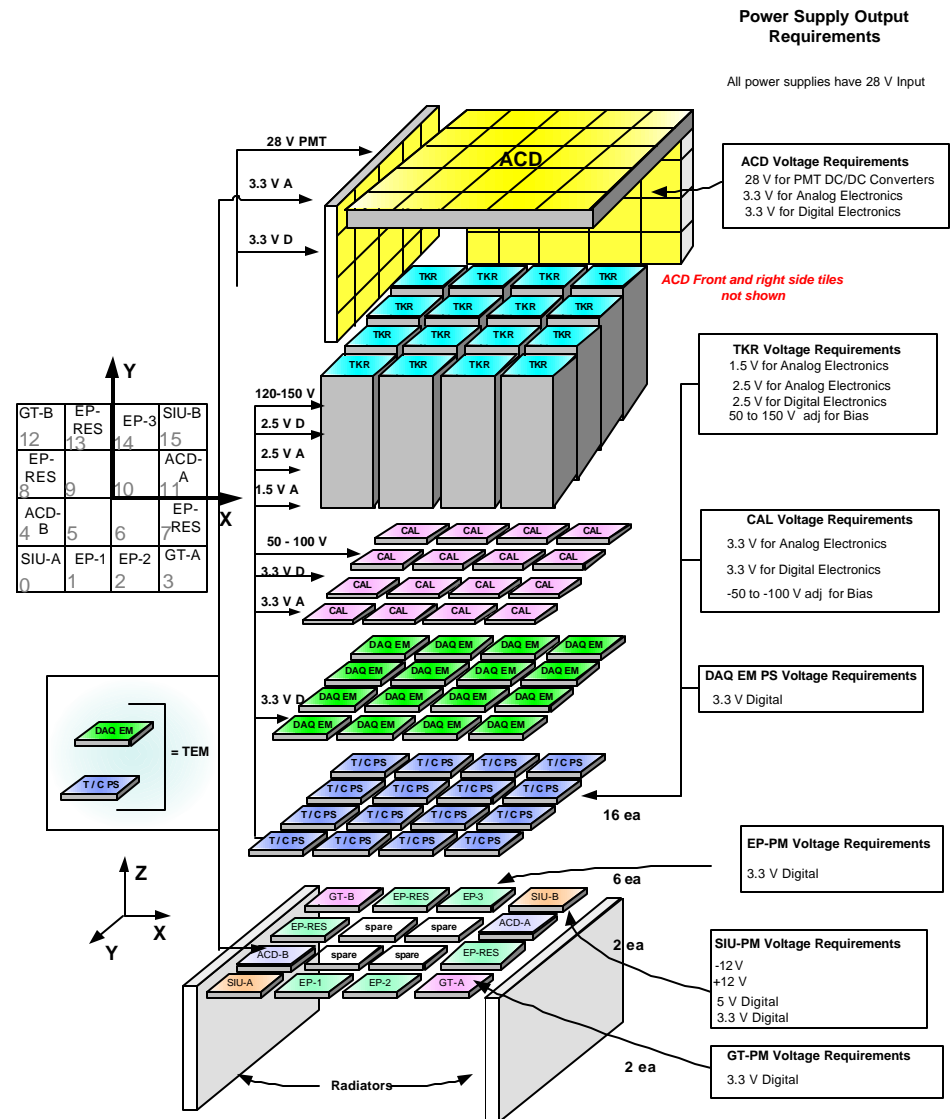
Stanford Linear Accelerator Center
Stanford CA

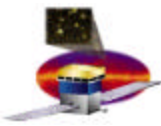


Requirements

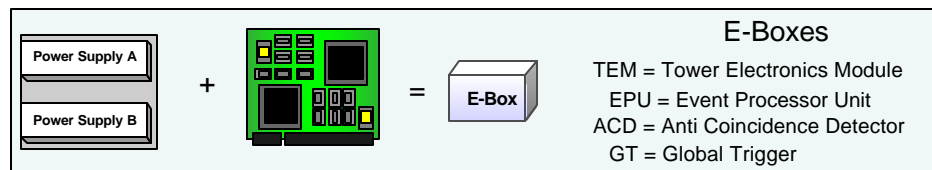
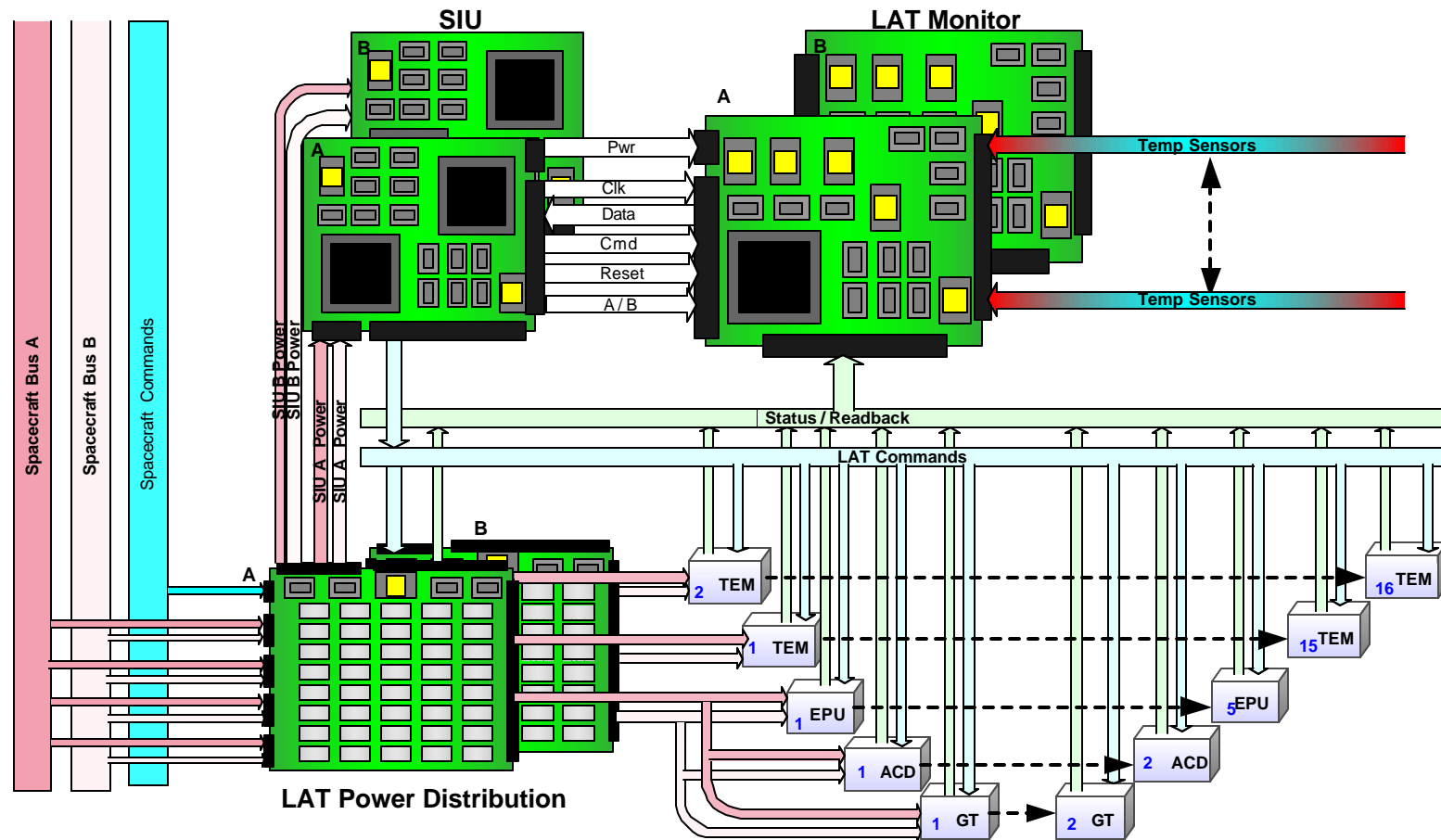
• Documents

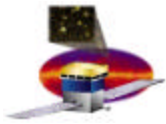
- Level 3 LAT-SS-00136
- Level 4 LAT-SS-00183





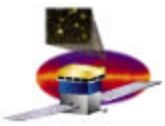
Power System Block Diagram



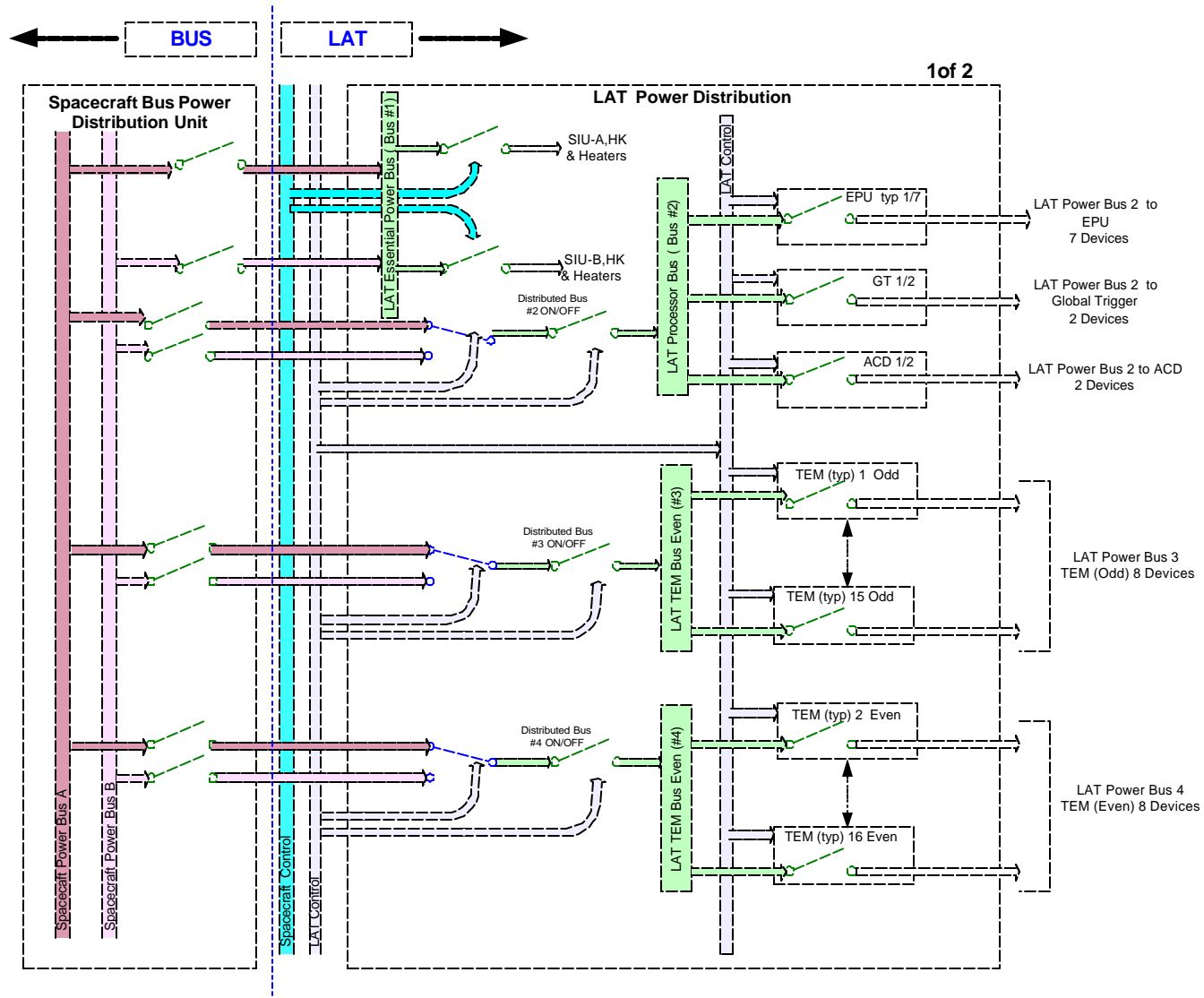


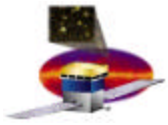
LAT Power Distribution(1)

- 2 LAT Power Distribution Cards (located in the DIST-GLT Assy)
- 10 Switched circuits to each Power Distribution Card
 - 5 Primary Bus A & 5 Redundant Bus B
 - 14 Amp/280 W capability on each Circuit
 - Circuits
 - 1 LAT Survival Heaters
 - 2 LAT Essential Bus
 - 3 LAT Processing
 - 4 & 5 LAT TKR/CAL Instruments & TEMs
 - Load shed priority in descending order
 - Device Control
 - One switched (ON/OFF) Output circuit to each device
 - 1.25 Amp capability to each device circuit



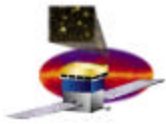
LAT Power Distribution(2)





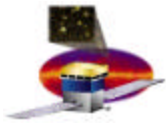
LAT Power Distribution(3)

- **Circuit 1**
 - **LAT Survival Heaters**
 - **Controlled by Bus when LAT is powered down**
 - **<150 W total**
 - **Circuit Margin of 47%**



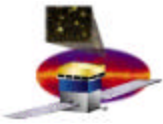
LAT Power Distribution(4)

- **Circuit 2**
 - **LAT Essential Bus**
 - **SIU @ 18.6W**
 - Includes LAT essential monitor & control services
 - **Heaters @ < 100 W**
 - **Normal 120 W**
 - **SIU (18.6 W)**
 - **Heaters (100 W)**
 - **Circuit margin 57%**
 - **Failed**
 - **2 each SIU @ 37 W**
 - **Circuit margin 44%**
 - **Last to be cut in load shedding**



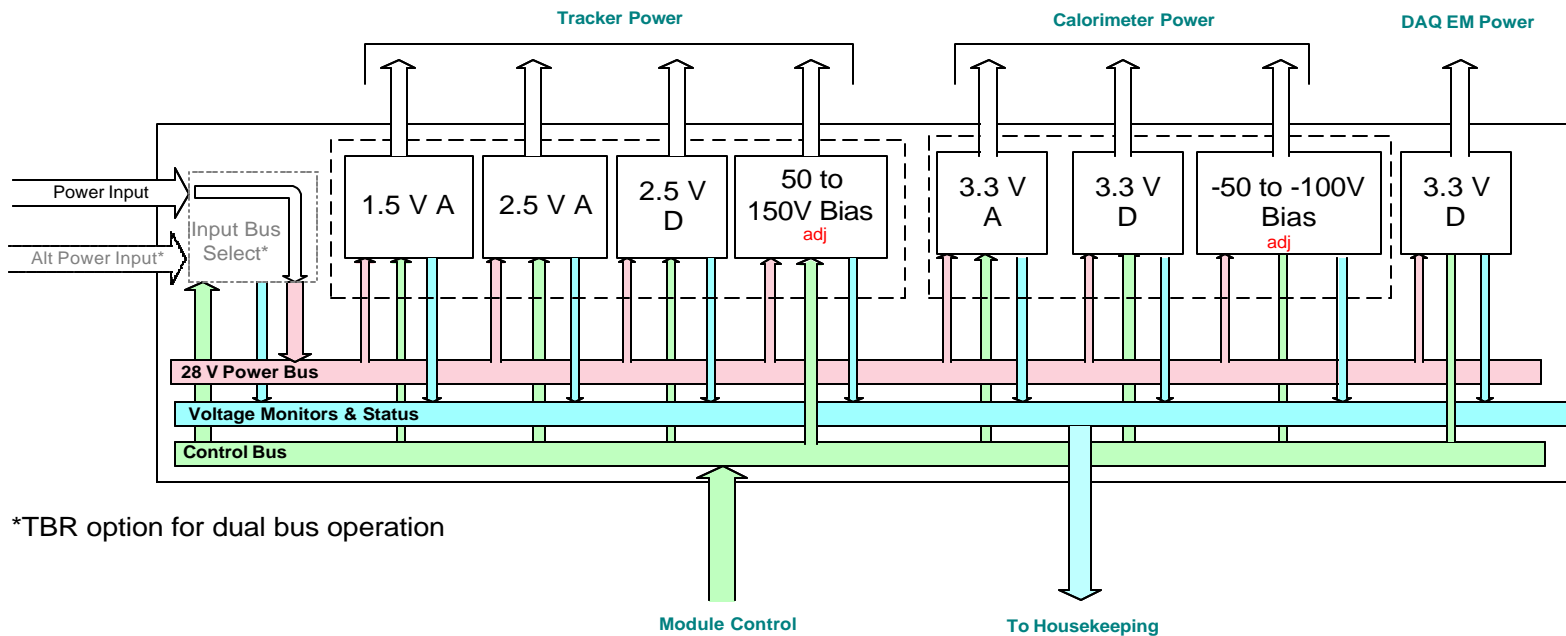
LAT Power Distribution(4a)

- The remaining LAT Power distribution slides are at the end in the Supporting Documentation section

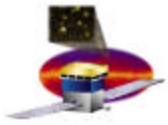


Subsystem Power Distribution(1)

- Tracker, Calorimeter, & T&DF Power supplies

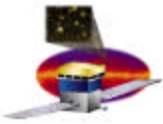


*TBR option for dual bus operation

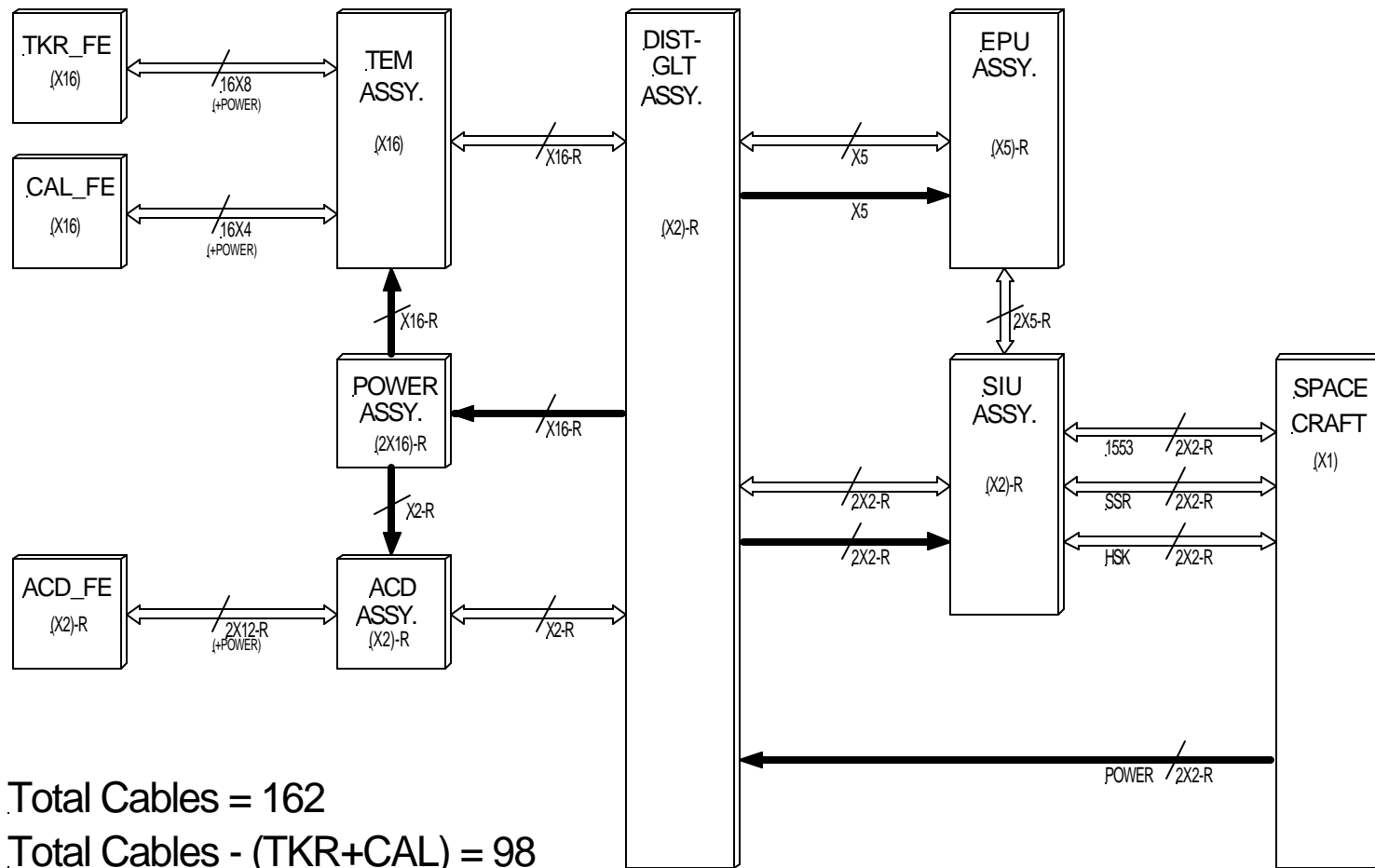


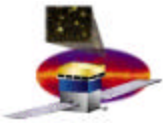
Subsystem Power Distribution(1a)

- **The remaining Subsystem Power Distribution slides are at the end in the Supporting Documentation section**

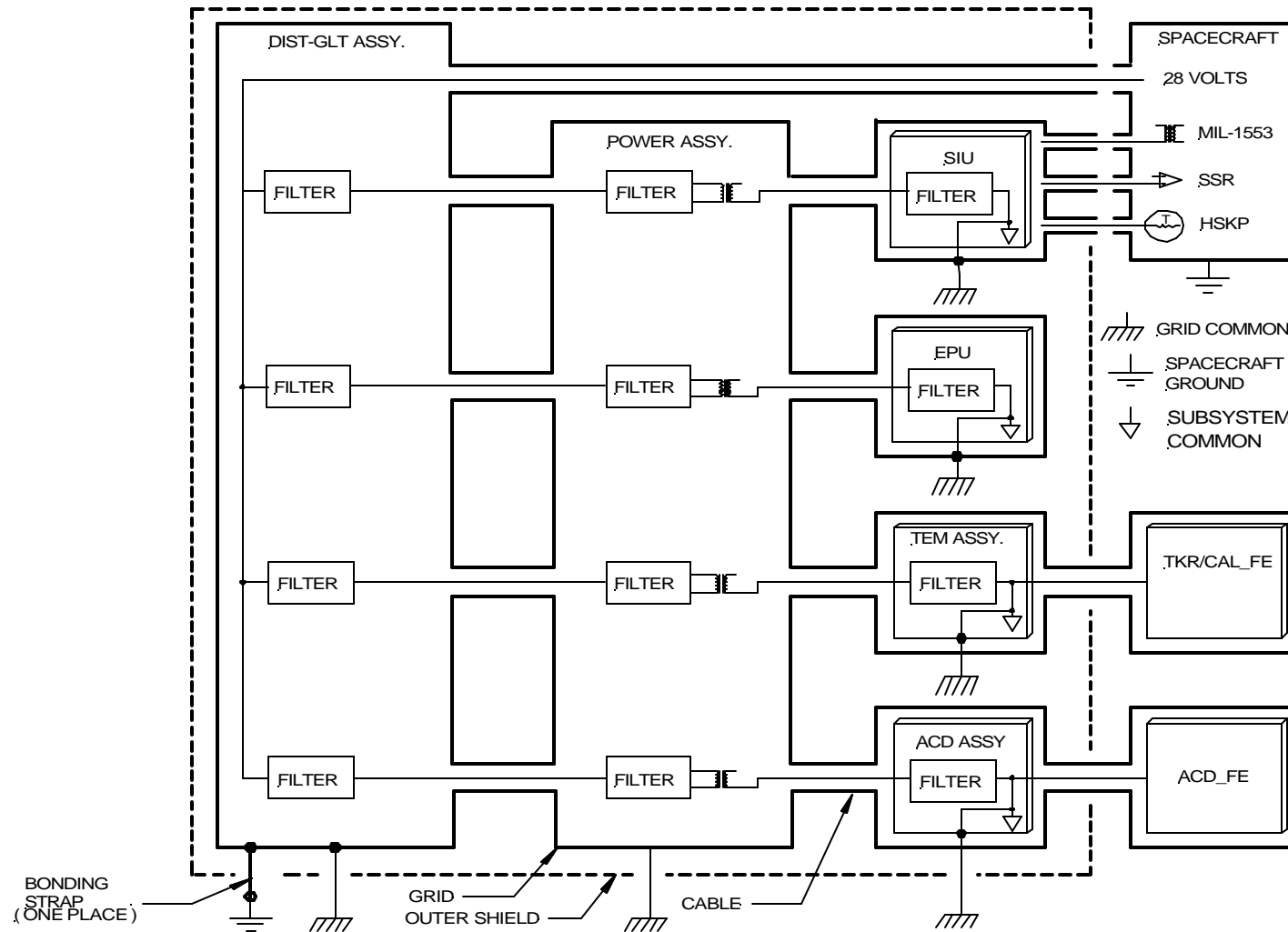


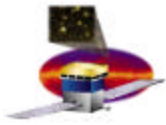
Cable Interconnections (1)





Grounding & Shielding (1)

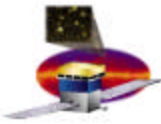




Power System Verification Matrix(1)

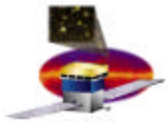
- **Verification Types :**
- **T: Test; I: Inspection; A: Analysis; D: Demonstration; Des: Design**

- **Test /Measurement Types**
- **F: Functional; P/F: Pass/Fail; P: Performance;**
- **Ti: Time; DR: Data Rate; An: Analog; Dg: Digital**



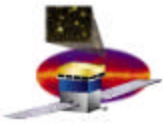
Power System Verification Matrix(2)

| Item | Description | Origin | Verification | Test Type | Metric |
|-----------------------------------|--|--------------|--------------|-----------|--------|
| 5 Requirements | LAT requires a switched redundant source of Direct Current (DC) power from the spacecraft bus to support the operation of the LAT instrument and its subsystems. | LAT-SS-00136 | Des | | P/F |
| 5.1.1 Voltage | The LAT primary power input design reference is 28 Volts (V) DC ± 6 V, unregulated. | LAT-SS-00136 | Des | | P/F |
| 5.1.1.2 Current | The LAT current draw is not to exceed 46 Amps (A) at a bus voltage of 22 V DC at End of Life (EOL). | LAT-SS-00136 | T | F | P/F |
| 5.1.1.3 Power | The LAT will draw < 1000 Watts (W) peak power at EOL. The Average power is to be 650W on a daily orbital average. | LAT-SS-00136 | A | | P/F |
| 5.1.1.4 Impedance | The LAT power input impedance will conform to GSFC 433-IRD-0001, "GLAST Science Instrument – Spacecraft Interface Requirements". | LAT-SS-00136 | T | F | P/F |
| 5.1.1.5 Circuits | The LAT is to have a primary and redundant input power source for each circuit provided. Each primary power circuit is to be isolated to prevent a power subsystem failure within the LAT from rendering any primary power bus inoperable. | LAT-SS-00136 | Des | | P/F |
| 5.1.1.6 Circuit Protection | The bus Power Control Unit (PCU) or Power Distribution Unit (PDU) is to provide primary input power circuit protection for each circuit. | LAT-SS-00136 | Des | | P/F |
| 5.1.1.7 Switching | Each primary power circuit is to be independently switched. Only one circuit source, A or B, is to be powered on at a time. | LAT-SS-00136 | Des | | P/F |
| 5.1.1.8 Control | The spacecraft bus will control selection of the primary bus, powered either A or B. | LAT-SS-00136 | Des | | P/F |
| | The spacecraft bus will provide control of the LAT input power circuits. | LAT-SS-00136 | Des | | P/F |
| | Each of the input circuit feeds may be switched ON and OFF by the bus. | LAT-SS-00136 | Des | | P/F |
| | The LAT will control activation and primary bus selection of the LAT internal power busses. | LAT-SS-00136 | Des | | P/F |
| | The LAT will control equipment ON/OFF on all power busses except the LAT Essential Bus. | LAT-SS-00136 | Des | | P/F |



Power System Verification Matrix(2a)

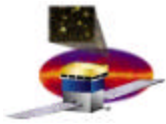
- The remaining verification matrix slides are at the end in the Supporting Documentation section



Power Budget

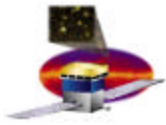
| Bus # | Bus Name | Equipment | Power Required (W) | Note |
|-------|------------------|---------------------------------|--------------------|------|
| 1 | LAT Essential | SIU, Housekeeping & LAT Heaters | 127 | |
| 2 | PROC Farm | EPUs, Global Trigger & ACD | 140 | |
| 3 | TEM Even | Even numbered TEMs | 180 | |
| 4 | TEM Odd | Odd numbered TEMS | 180 | |
| 5 | Survival Heaters | Survival Heaters | 150 | * |
| | | Total Power Consumption | 627 | |

* Note: Not powered when LAT powered



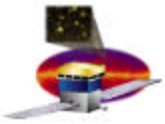
WBS & Deliverables

- **WBS**
 - Presented in the Schedule & Budget
- **Deliverables Flight**
 - LAT Power Distribution cards – 2
 - ACD Power module – 2
 - TKR/CAL Power module – 16
 - T&DF (DAQ) Power module – 8
 - SIU Power module – 2
 - Cables



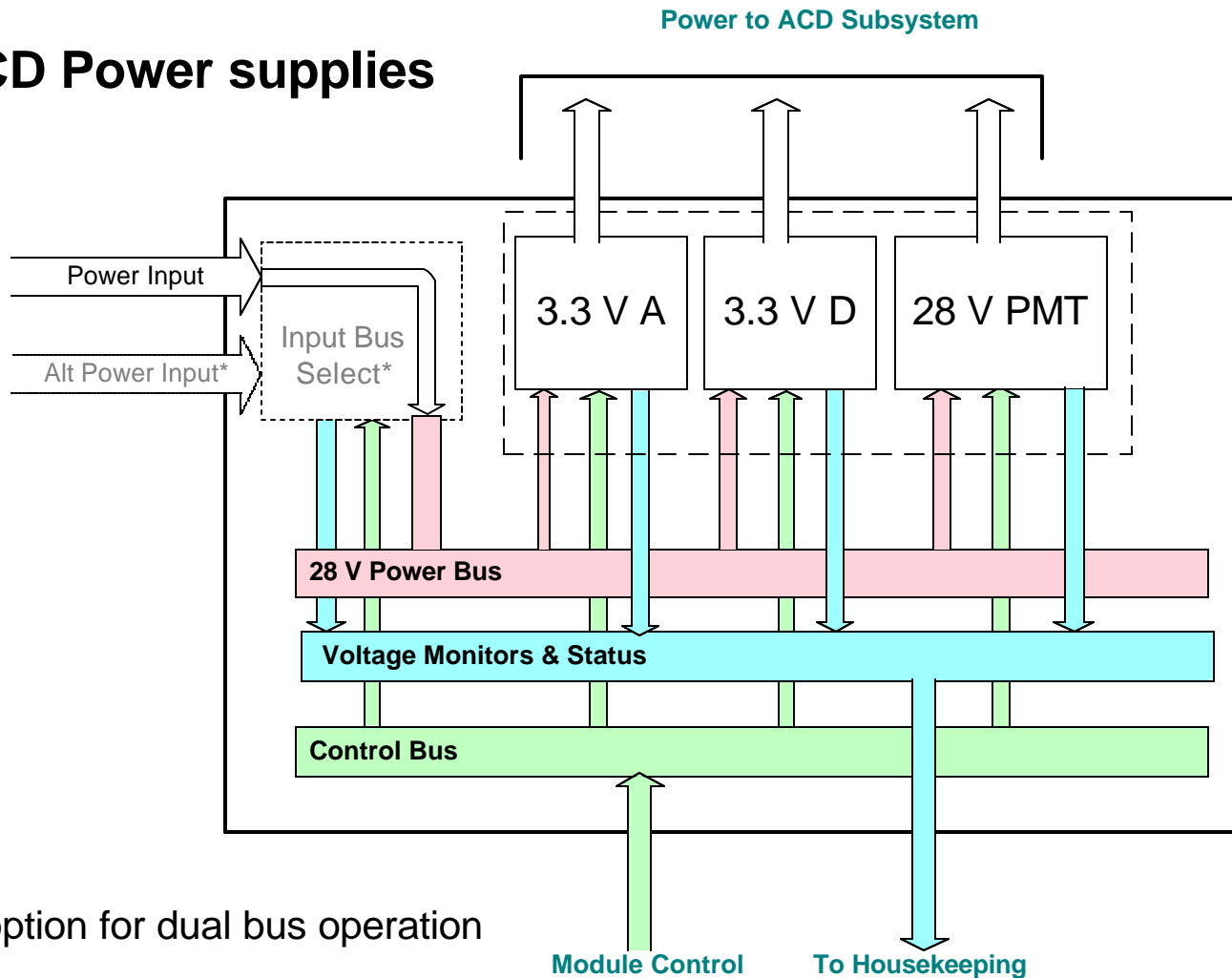
Supporting Documentation

- The supporting documentation follows

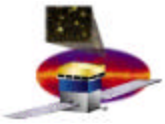


Subsystem Power Distribution(2)

- **ACD Power supplies**

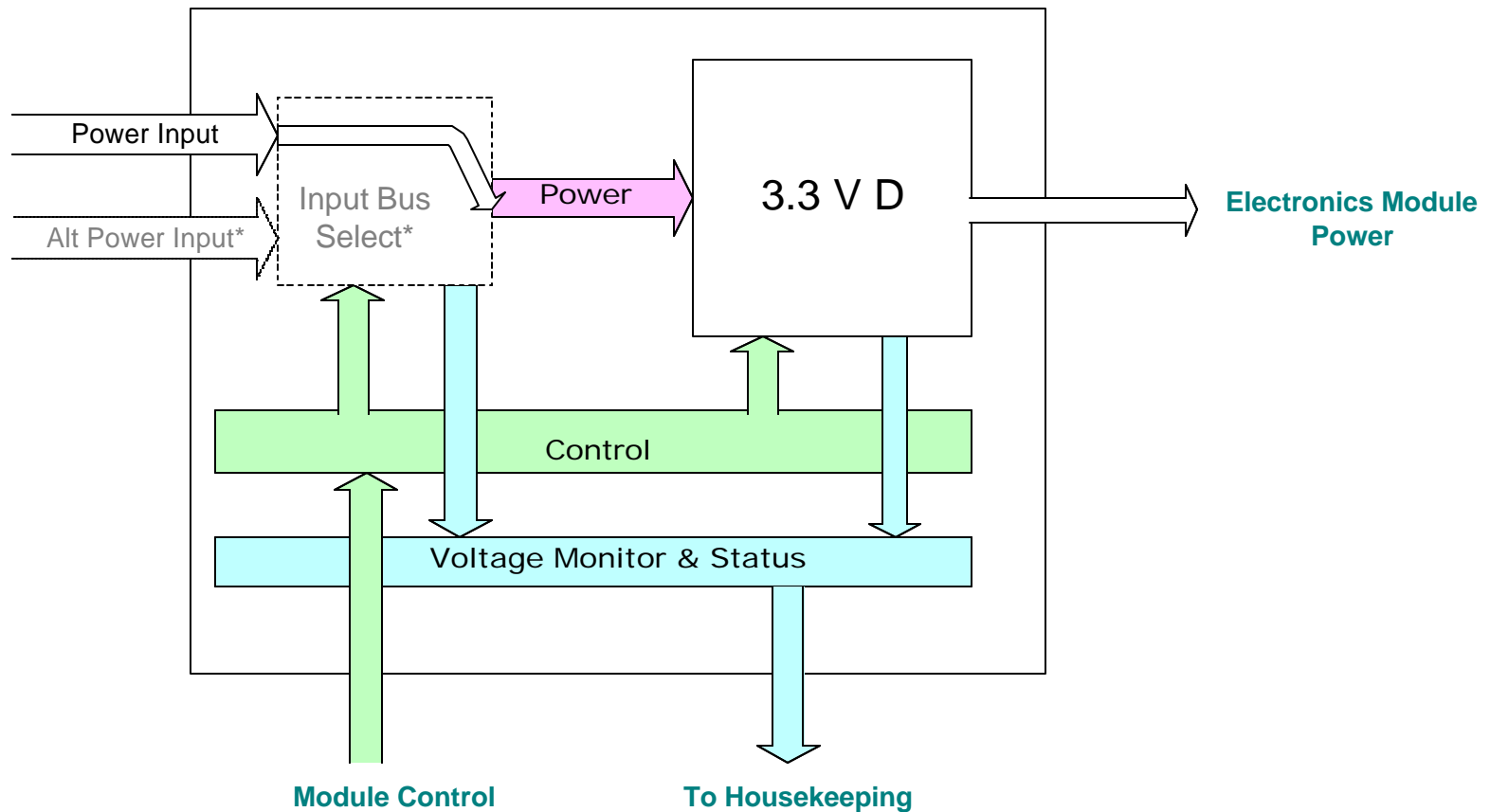


*TBR option for dual bus operation

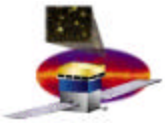


Subsystem Power Distribution(3)

- T&DF Power Supplies

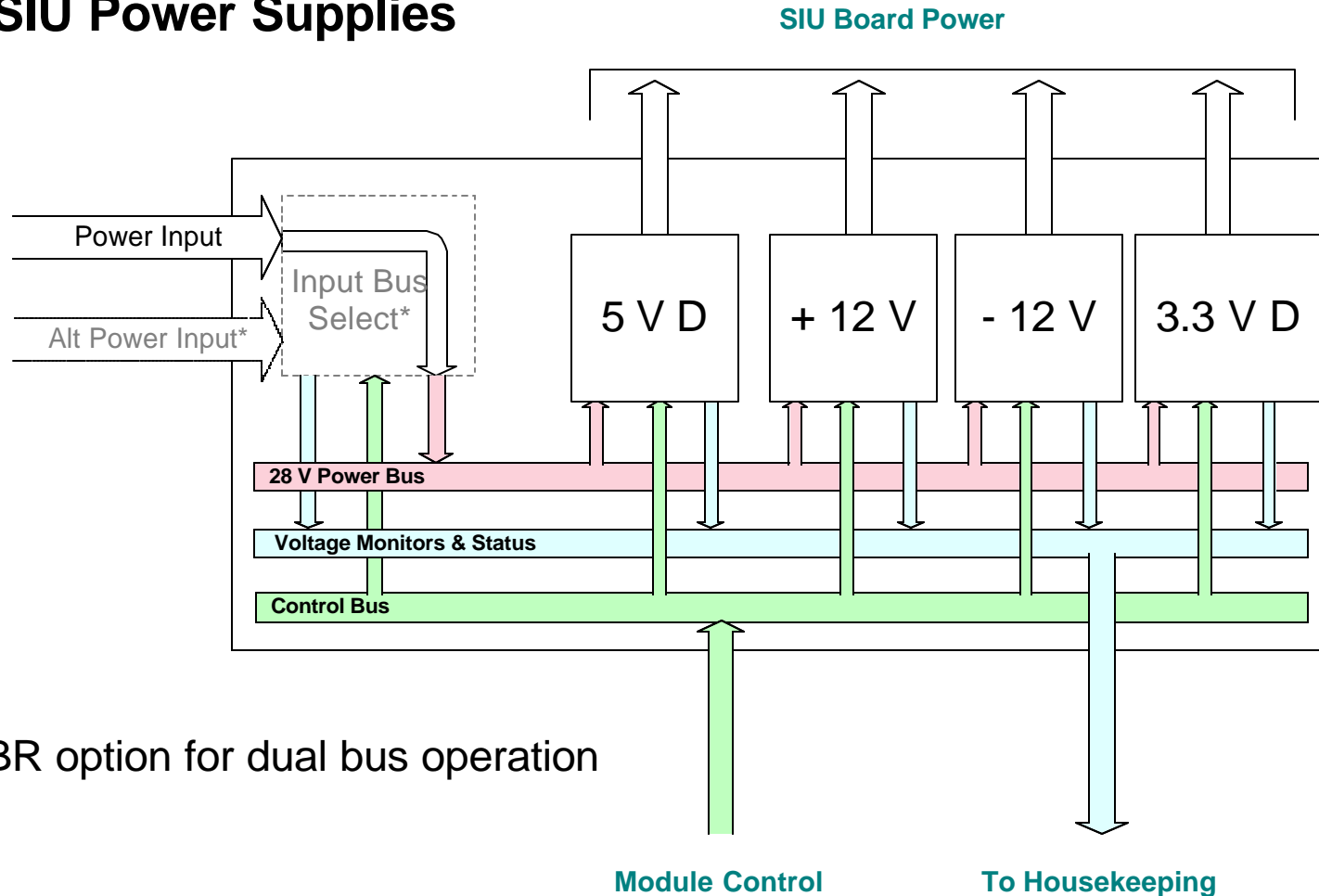


*TBR option for dual bus operation

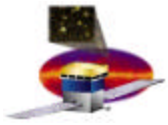


Subsystem Power Distribution(4)

- SIU Power Supplies

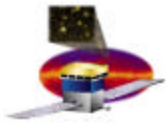


*TBR option for dual bus operation



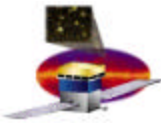
LAT Power Distribution(5)

- **Circuit 3 – LAT Processing**
 - **Event Processors (4 @ 23 W)**
 - **Global Trigger (GLT) (1 @ 23 W)**
 - **ACD (1 @ 5 W)**
 - **Normal Ops @ 140 W**
 - **Circuit margin of 50%**
 - **Failed operation @ 210 W**
 - **4 EPU, 2 GLT, 2 ACD**
 - **Circuit margin of 25%**



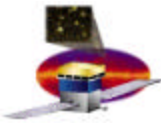
LAT Power Distribution(6)

- **Circuit 4&5 – LAT TEM's**
 - **Each Circuit Powers 8 TEMs**
 - **Split Even/Odd**
 - **Normal (per Circuit) 8 @ 22.5 W (180 W)**
 - **Circuit Margin 36%**
 - **Failed(3 concurrent Failures) 11 @ 22.5W (247.5W)**
 - **Circuit Margin 8%**



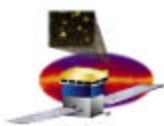
Power System Verification Matrix(3)

| Item | Description | Origin | Verification | Test Type | Metric |
|---|---|--------------|--------------|-----------|--------|
| 5.1.1.9 LAT Distributed Output Power | The LAT will provide power distribution and control to LAT subsystems. The LAT will distribute and control the 28±6 V DC unregulated from the primary power source. | LAT-SS-00136 | Des | | P/F |
| 5.1.1.10 Redundancy | The LAT will provide for redundant power distribution and control capability within the LAT. | LAT-SS-00136 | Des | | P/F |
| 5.2.1 Primary Circuits | The LAT will accept power from 8 primary power circuits (TBR), 4 prime (TBR) and 4 redundant. Each circuit pair is to be capable of 14 A of current. Each circuit pair will correspond to a LAT internal power bus that will power specific subsystems of the L | LAT-SS-00136 | Des | | P/F |
| 5.3 Secondary Power | The LAT will provide distributed power to each of the LAT internal power busses. | LAT-SS-00136 | Des | | P/F |
| 5.3.1 Power Bus Control - General | Each of the secondary power busses is to be capable of being switched between primary and redundant power sources. Each subsystem equipment load is having its power controlled at the source. | LAT-SS-00136 | T | F | P/F |
| 5.3.2.1 Essential Bus | The LAT Essential Power Bus will be controlled by the spacecraft bus. This is the primary LAT power bus and will be the first LAT bus powered on when powering up the instrument. It comprises SIU, Housekeeping & LAT Heaters and requires 127 W of power. | LAT-SS-00136 | T | F | P/F |
| 5.3.2.2 Processor Bus | The LAT will control power on the processor bus. The LAT will select either the primary or redundant input source to power the internal equipment bus. This bus comprises Processor Farm, Global Trigger and ACD. The power required is 140 W. | LAT-SS-00136 | T | F | P/F |
| 5.3.2.3 TEM Even Bus | This will power the TEMs that occupy even numbered positions on the grid. The LAT will control power on this Bus. The LAT will select either the primary or redundant input source to power the internal equipment bus. The power required is 180 W. | LAT-SS-00136 | T | F | P/F |
| 5.3.2.4 TEM Odd Bus | The TEM Odd Bus will power the TEMs that occupy odd numbered positions on the grid. The LAT will control power on the TEM Odd Bus. The LAT will select either the primary or redundant input source to power the internal equipment bus. The power required is | LAT-SS-00136 | T | F | P/F |



Power System Verification Matrix(4)

| Item | Description | Origin | Verification | Test Type | Metric |
|---|---|--------------|--------------|-----------|--------|
| 5.3.3 Equipment Power Control | Each powered component of the LAT will have its power controlled for power bus source and equipment power ON/OFF. There are 52 (TBR) pieces of equipment that require ON/OFF control. | LAT-SS-00136 | T | F | P/F |
| 5.3.3.1 Essential Bus Equipment | The Essential Bus equipment will have its power supplies controlled by the spacecraft bus. There are 2 (TBR) pieces of equipment on the Essential Bus. | LAT-SS-00136 | T | F | P/F |
| 5.3.3.2 Processor Bus | All Processor Bus equipment power supplies will be controlled by the LAT. There are 11 (TBR) pieces of equipment on the Processor Bus. | LAT-SS-00136 | T | F | P/F |
| 5.3.3.3 TEM Even And Odd Power Bus Equipment | All TEM (Even and Odd) Bus equipment power supplies will be controlled by the LAT. There are 8 (TBR) pieces of equipment on each TEM Power Bus. | LAT-SS-00136 | T | F | P/F |
| 5.3.4 Power Conditioning | The LAT will provide noise filtering of the power distributed to the LAT internal equipment. No other power conditioning will be performed by the LAT directly. Distributed power is to conform to the power conditions specified in XXX-433. | LAT-SS-00136 | Des | | P/F |
| 5.3.5 Circuit Protection | The LAT will provide circuit protection for each internal bus and for each powered piece of equipment. No single piece of equipment or component is to be capable of disabling the LAT's ability to provide or control power. | LAT-SS-00136 | Des | | P/F |
| 5.3.6 Distribution | The LAT Electrical Power System will distribute power to all secondary LAT equipment power users. | LAT-SS-00136 | Des | | P/F |
| 5.4 Telemetry | The LAT will itself monitor the internal voltage, power and temperature conditions associated with the LAT and its equipment. This information is to be available for use in controlling the LAT and in ground link telemetry. | LAT-SS-00136 | T | F | P/F |
| 6 Environmental | All LAT electrical power system components shall meet the structural and thermal environment requirements defined in the LAT Mechanical Performance Specification, LAT-SS-TBR. | LAT-SS-00136 | Des | | P/F |
| 7 Grounding | This must conform to recommendations in NASA-HDBK-4001, "Electrical Grounding Architecture To Unmanned Spacecraft". | LAT-SS-00136 | Des | | P/F |



Power System Verification Matrix(5)

| Item | Description | Origin | Verification | Test Type | Metric |
|----------------------|--|--------------|--------------|-----------|--------|
| 8 EMI | This must conform to GSFC-433-RQMT-0005, "EMC Requirements With Respect To Radiated Emissions And Conducted Susceptibility Of Noise". | LAT-SS-00136 | Des | | P/F |
| 9 Reliability | The probability that any of the electrical power system components will experience a complete loss of operation due to the failure of any of its components shall be less than TBD % in 5 years. No single failure is to bring the LAT below the science require | LAT-SS-00136 | Des | | P/F |
| 10 Safety | This should be per Program Safety Policy (TBR). | LAT-SS-00136 | Des | | P/F |