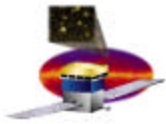


Development, Test, & Failure Modes

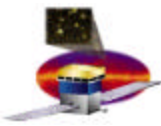
David Nelson

**Stanford Linear Accelerator Center
Stanford CA**

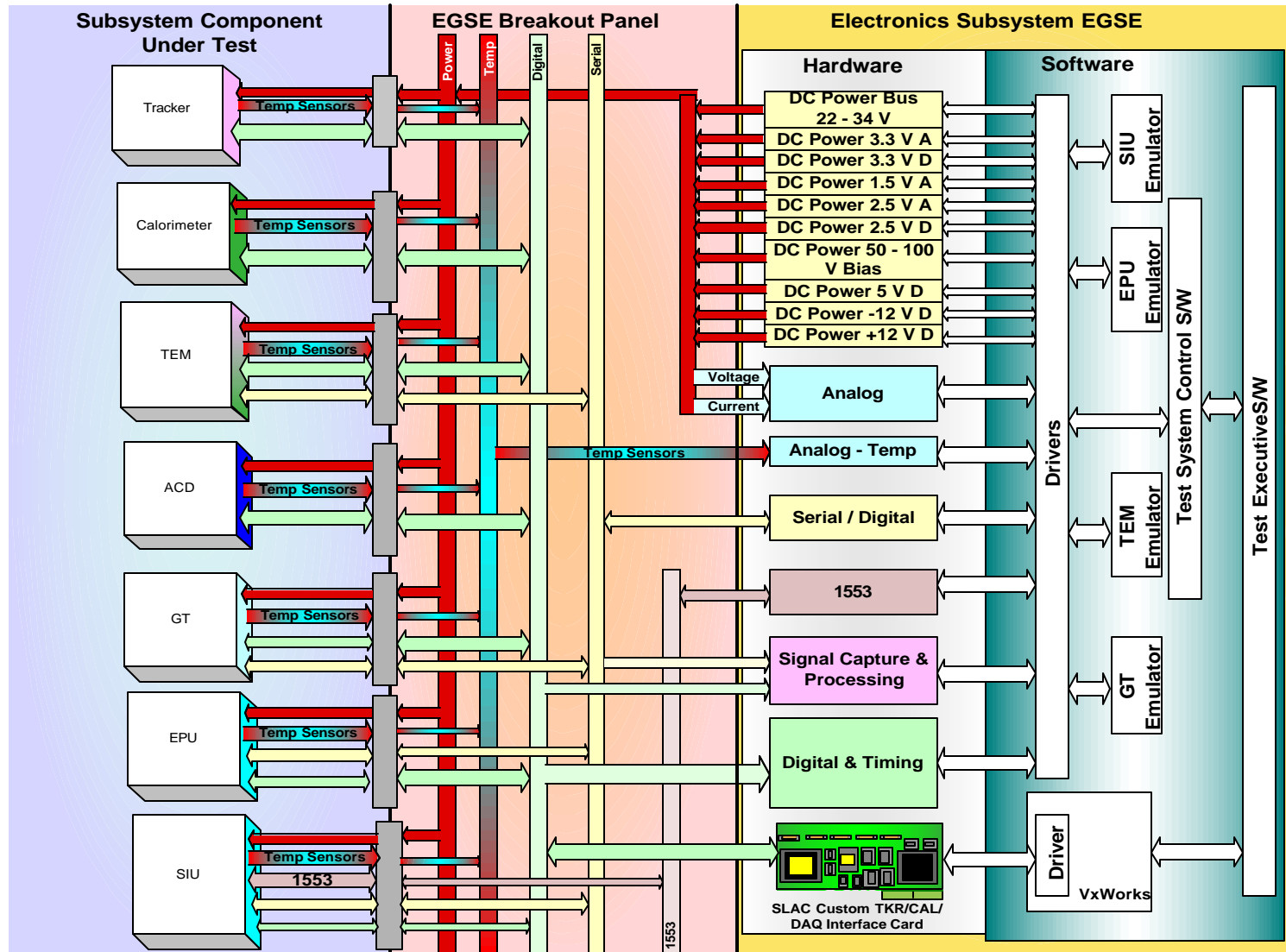


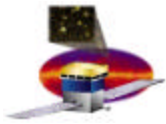
Development Cycles

- **Pre-Engineering**
 - **Fabricate and test each function**
- **Engineering Model 1 (EM1)**
 - **One complete assembly of each type of T&DF electronics using commercial parts**
- **Engineering Model 2 (EM2)**
 - **Complete T&DF electronics using commercial parts**
- **Qualification**
 - **Thermal Vacuum**
 - **Vibration**
 - **Power margin**
- **Flight**
 - **Fully qualified**



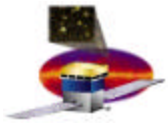
Ground Support Diagram





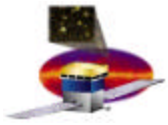
Test Beds(1)

- **Test Hardware**
 - **Sun Sparc/PC**
 - **Power PC Processor card, 603e or 750**
 - **VME/Compact PCI Crate**
 - **VX Works**
 - **LAT VME/Compact PCI Front-End Com Board(s)**
 - **TEM/ACD EM**
 - **Power Supplies**
 - **Programmable**
 - **Spacecraft Interface**
 - **MIL-1553**
 - **Solid State Recorder**
 - **House Keeping**
 - **Discretes**



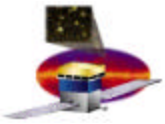
Test Beds(2)

- **Hardware Simulators**
 - **Memory based**
 - Provides for any arbitrary test pattern
 - **Front End Detector**
 - 16 TKR/CAL + Spares
 - 2 ACD + Spare
 - **Front End Detector Simulators**



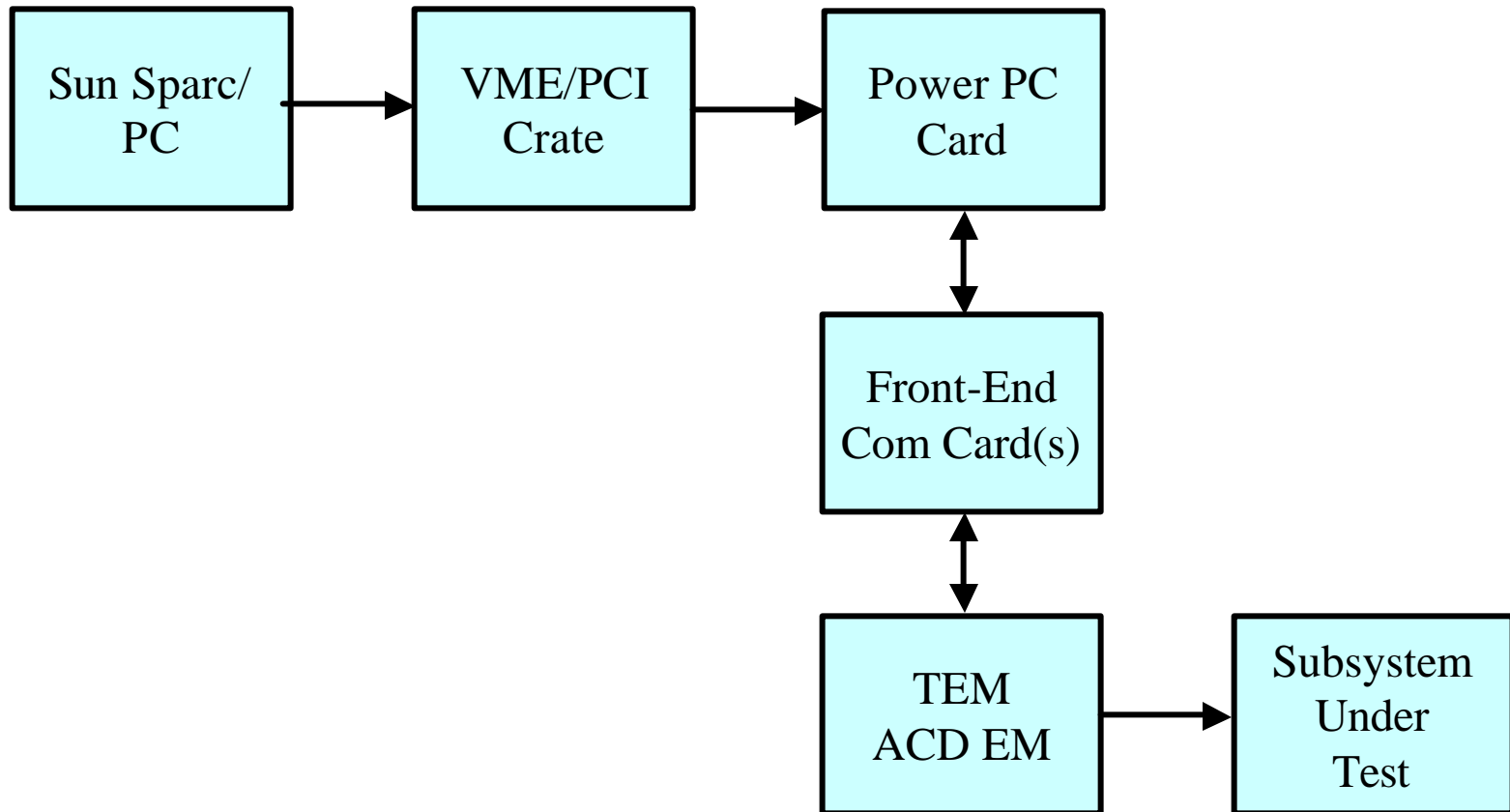
Subsystem Development(1)

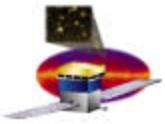
- **Subsystem Support**
 - **Provide subsystems with firmware support.**
 - **Test hardware provided**
 - **Development & Integration software provided**
 - **Power PC based**
 - **Timely**
 - **Technical Support**



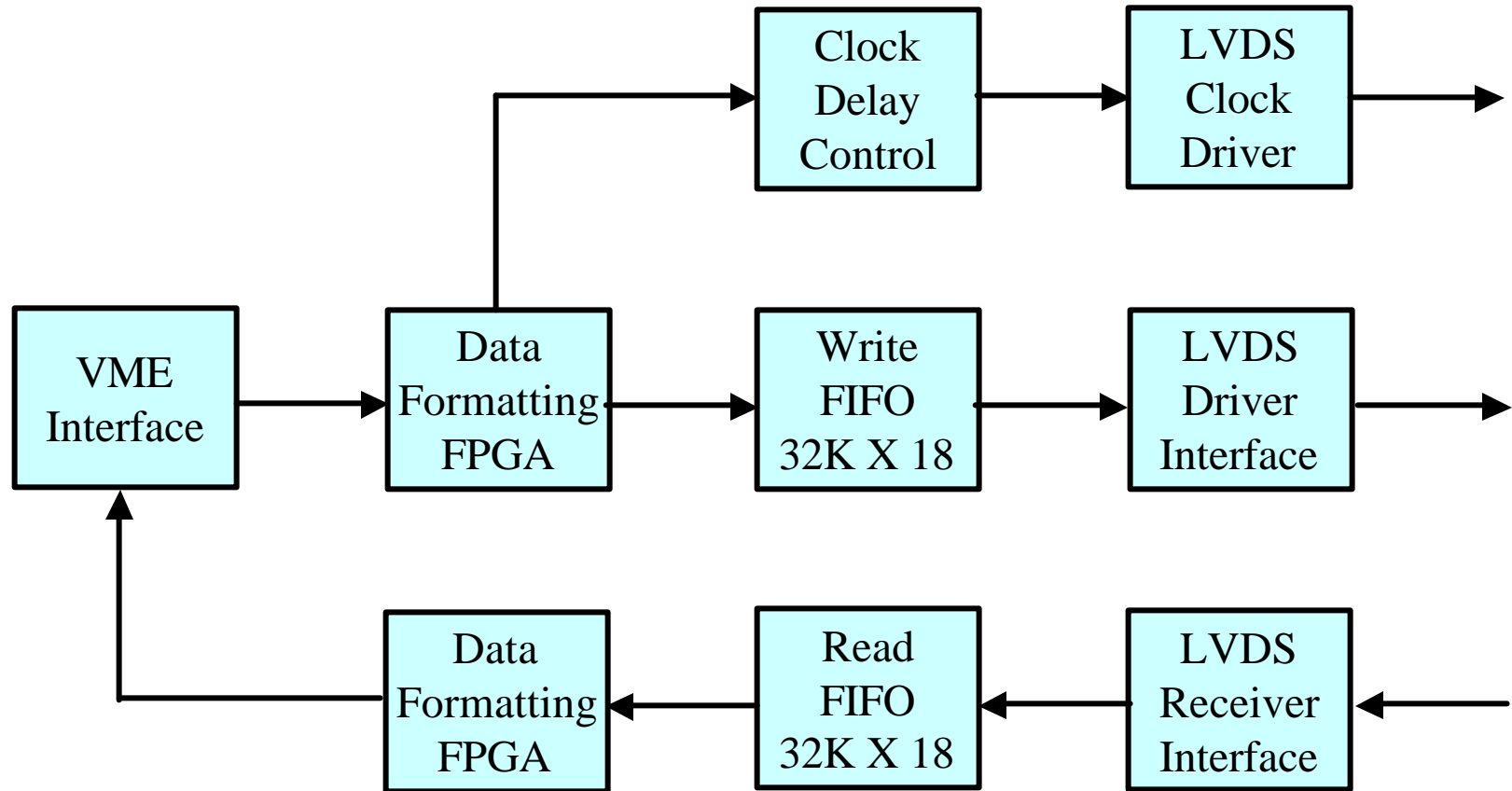
Subsystem Development(2)

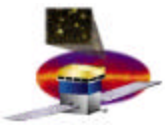
- Test Hardware



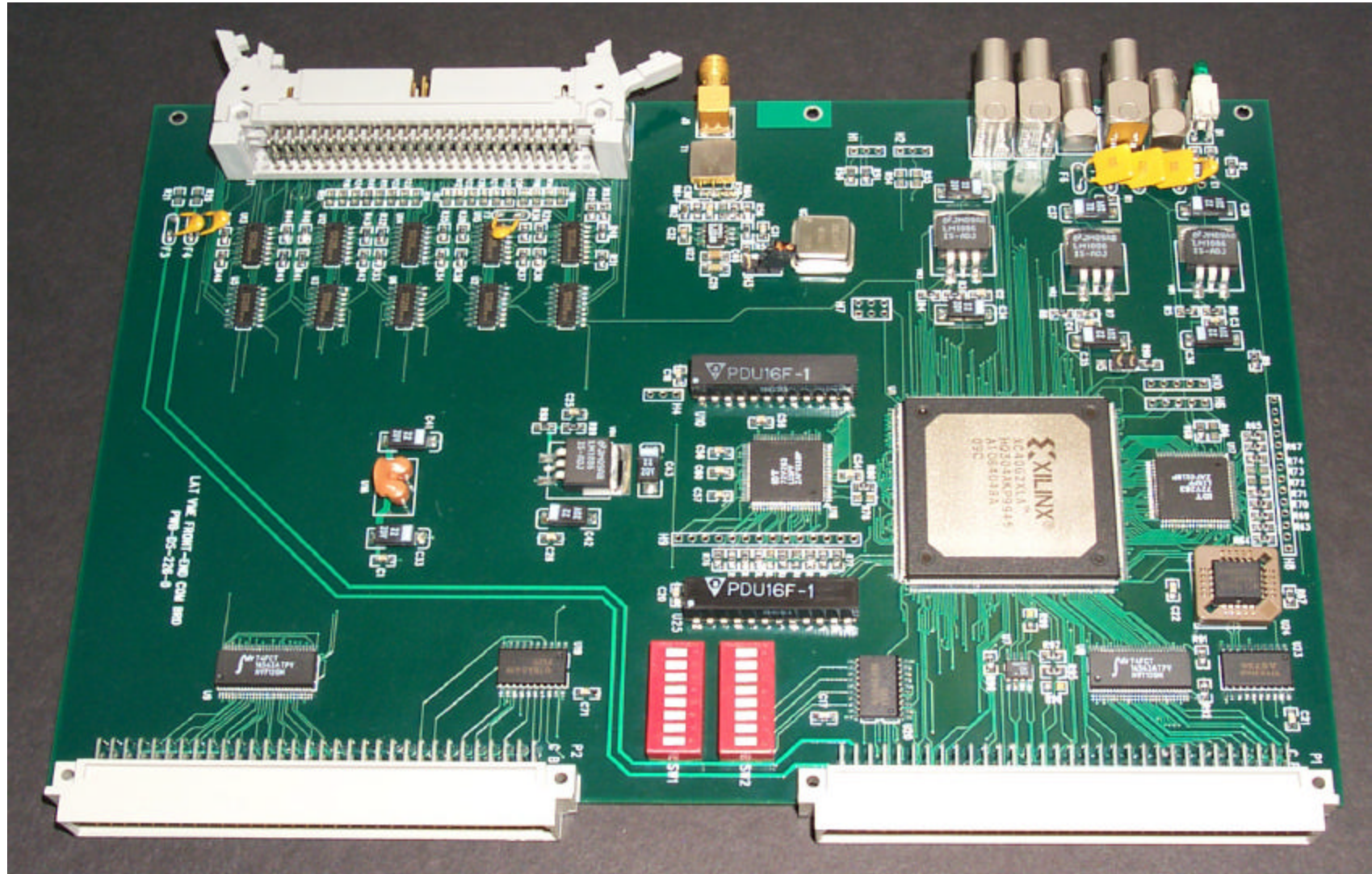


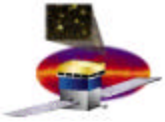
VME Front-End Com Card(1)



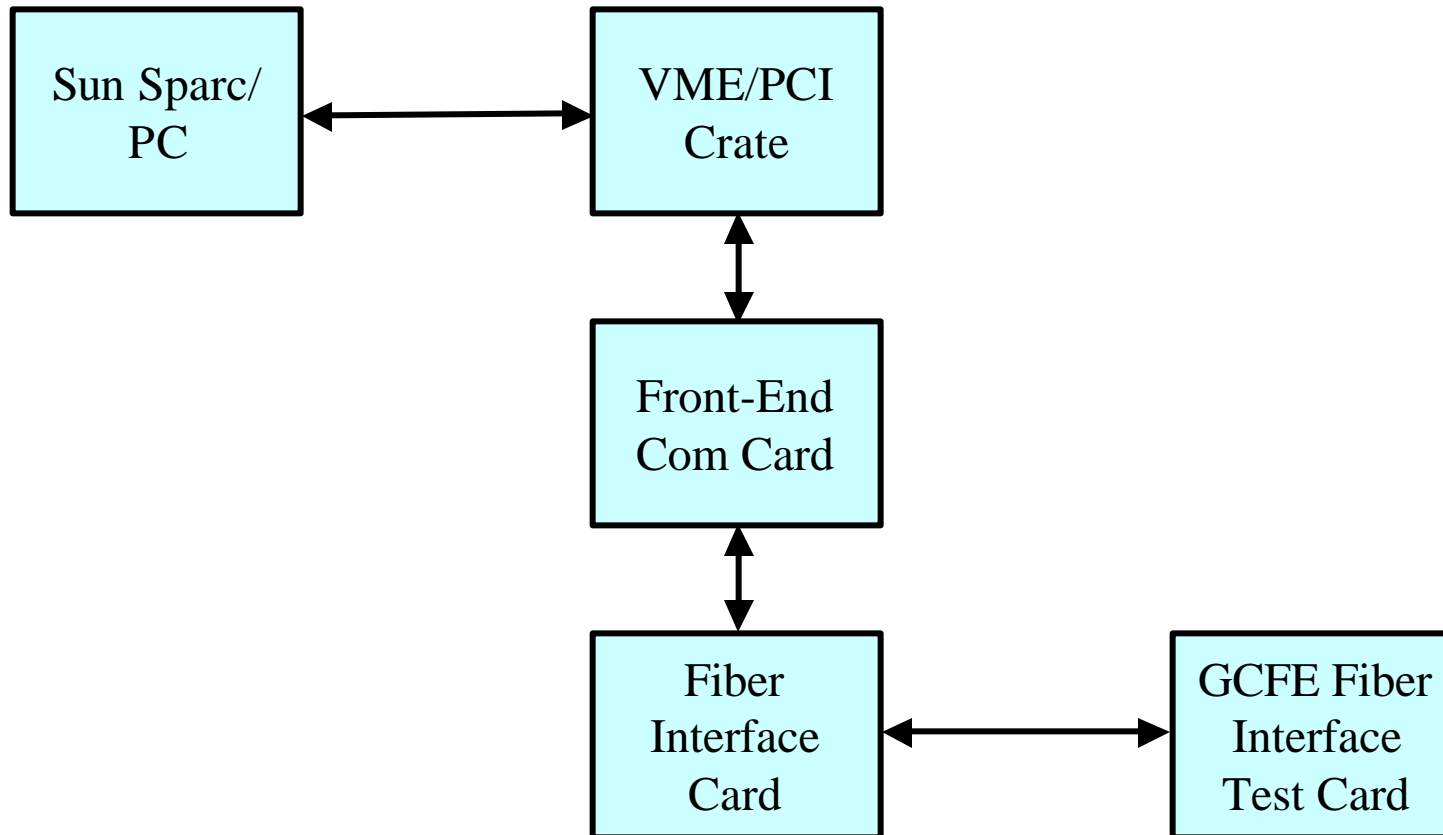


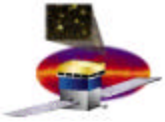
VME Front-End Com Card(2)



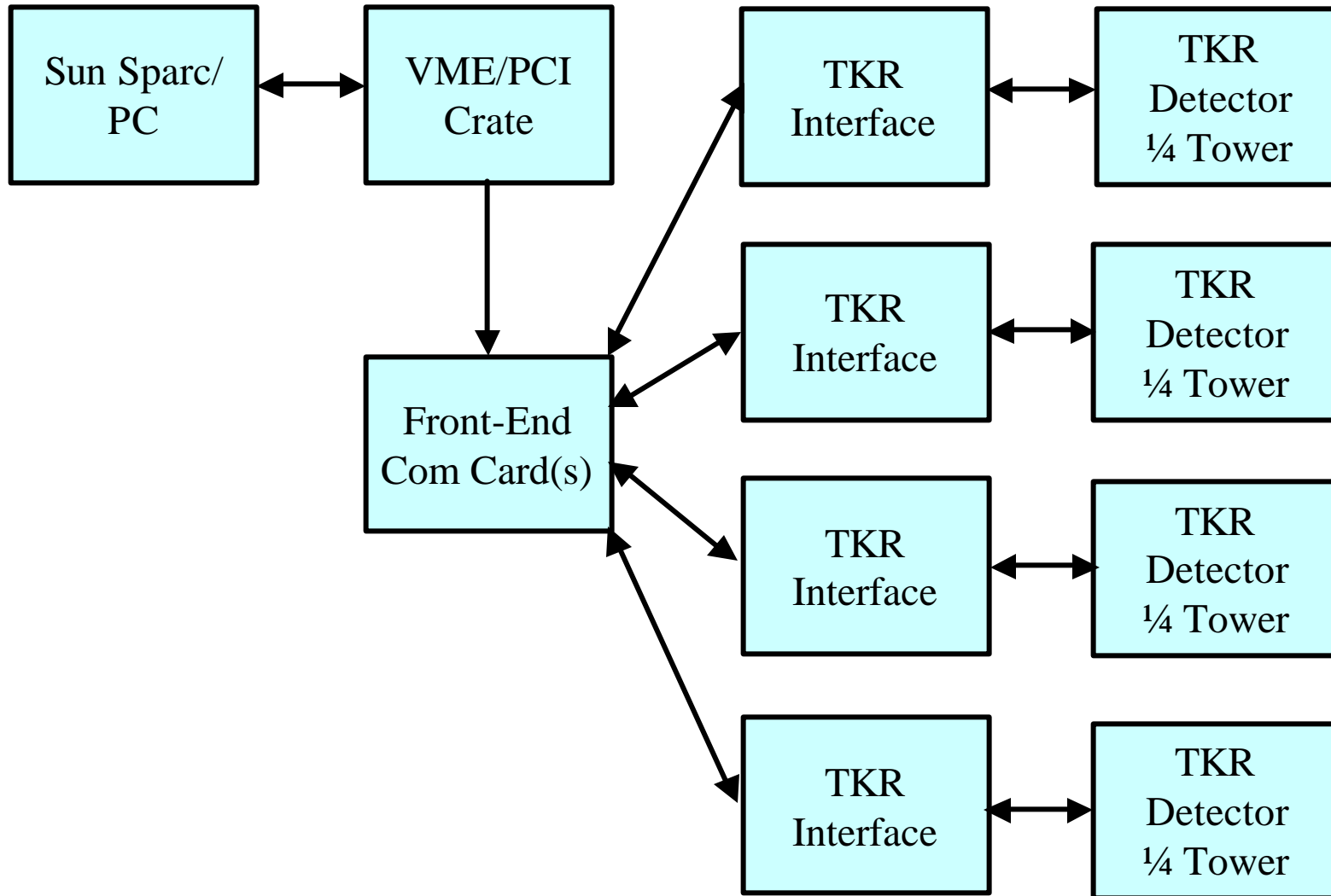


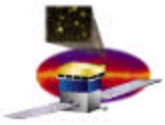
Calorimeter GCFE Test Card





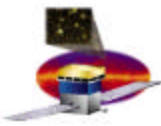
Tracker Tower Front End Test





Test Software

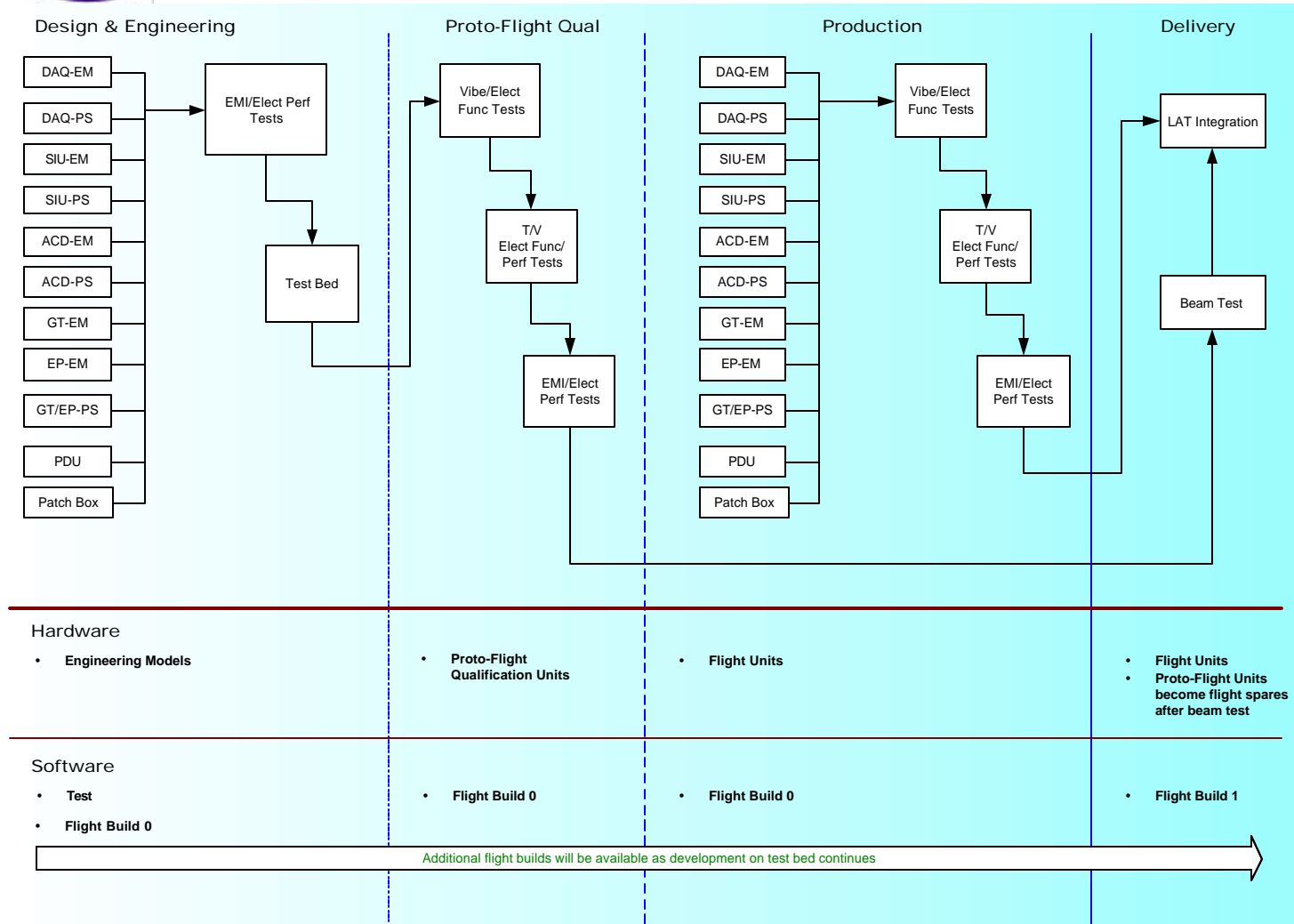
- **Software is provided during development & integration**
 - **This allows software to mature with hardware development**
 - **Allows for solid understanding of hardware by the software engineers.**
 - **Allows for design bottlenecks, both hardware and software, to be addressed**
 - **Drivers and routines can mostly be reused in final design**
 - **Configuration loading and verification**
 - **Housekeeping code**
 - **Calibration routines**
 - **Diagnostics**

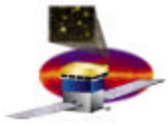


T&DF Integration & Test, I&T



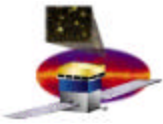
T & D F Integration & Test Plan





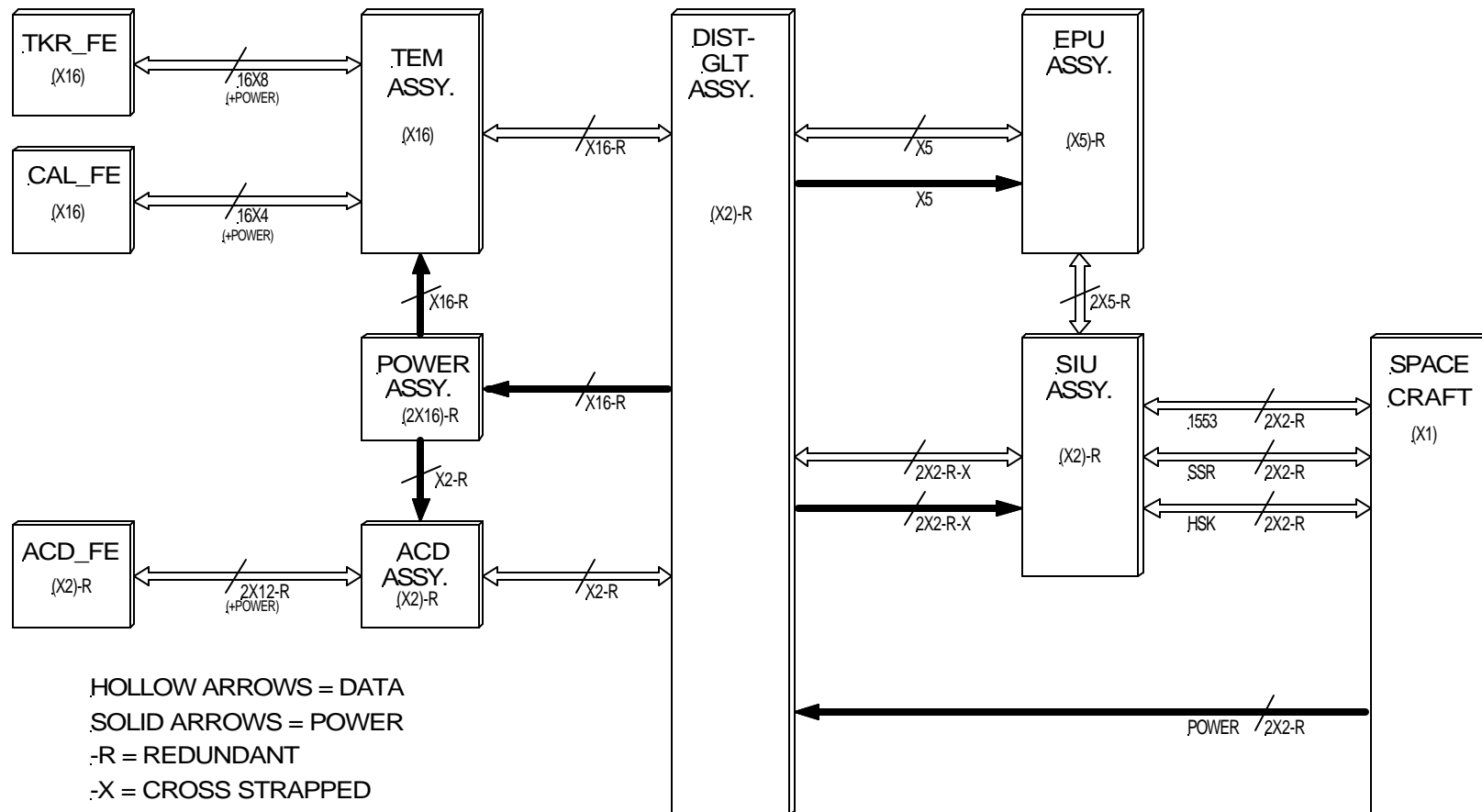
Reliability(1)

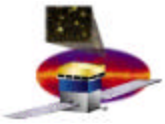
- **Requirements**
 - **No single point failures that degrade the science**
 - **Use redundancy**
 - **Cross strap important components such as the SIU**



Reliability(2)

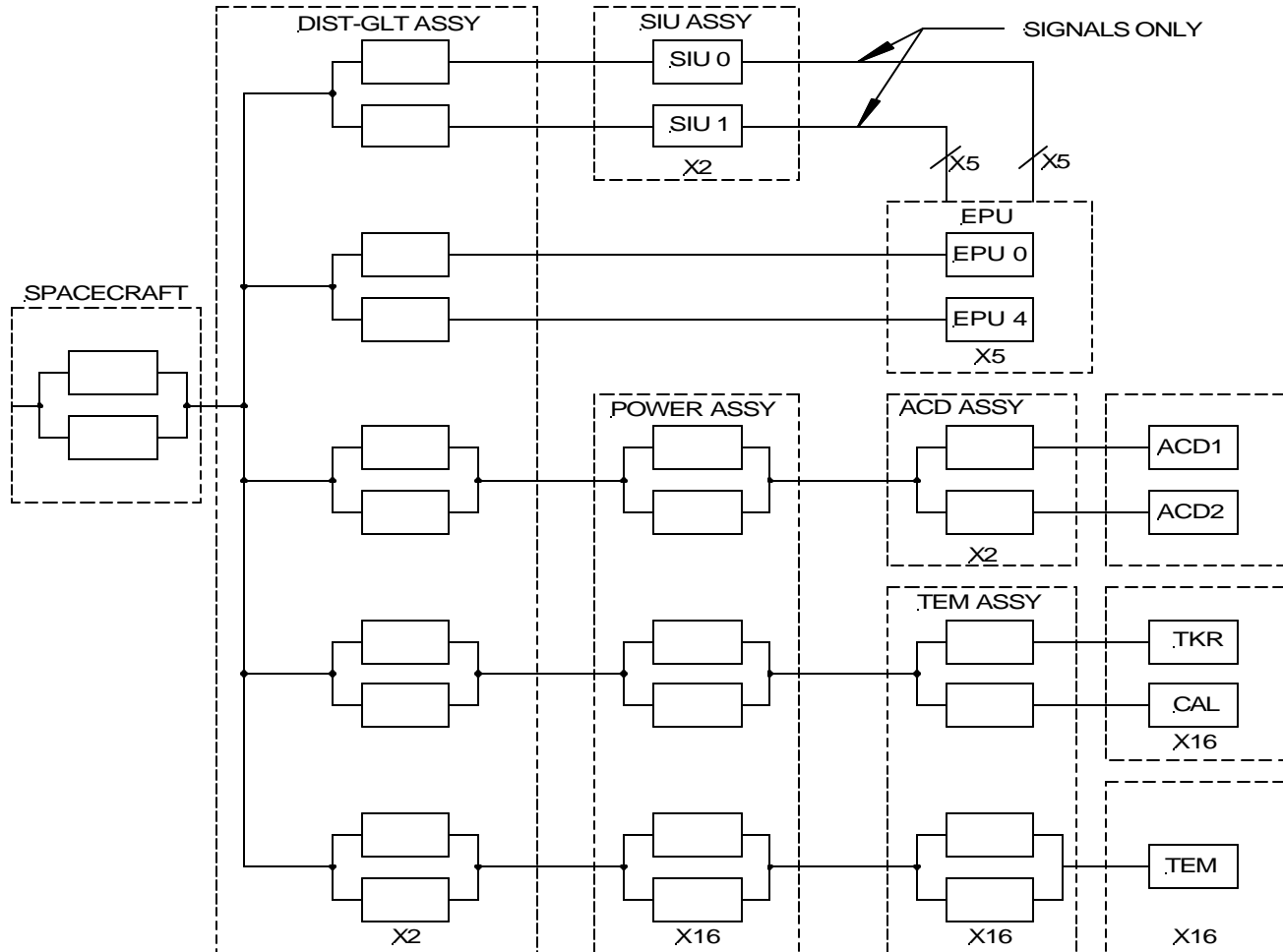
•Redundancy & Cross straps

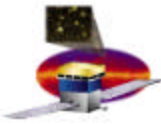




Reliability(3)

•T&DF System Reliability Block

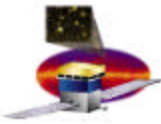




Failure Rates

- **Used MIL-217F Notice 2 Parts Count for calculations**
- **Any Failure = 1 per 2 years**
- **Failure with Fault Tolerance = 1 per 10 years**

Assembly	Failures/10 ⁶ Hours	Failures/10 ⁶ Hours
	Any Failure	With Fault Tolerance
TEM – T&DF interface Redundant	20.48	10.848
ACD – Redundant	0.59	0
DIST-GLT - Redundant	2.08	0
EPU – One Spare for 4 EPU's	3.86	0.0002
SIU – Redundant	2.45	0
Power – Redundant	25.36	0.0006
Cables – Critical Redundant	2.64	0.704
TOTAL	57.36	11.1897



Failure Modes & Mitigation

- Top Level FEMA using “FMEA Facilitator” from Kinetic LLC
- Based on Military Procedure MIL-P-1629A
- Criticality values are only guesses until values are agreed on

Assembly	Possible cause or Failure type	Effects of failure	Criticality	Mitigation if failure occurs	Performance after mitigation	Allowable rate
SIU, DIST-GLT, EPU	Component/ connection/ power failure (C/C/P)	System failure	5	Swap in spare	Complete recovery	Once
Power Assy	C/C/P TEM	1/16 LAT	5	Swap in spare	Complete recovery	Once
	C/C/P TKR	1/16 TKR	5	Swap in spare	Complete recovery	Once
	C/C/P CAL	1/16 CAL	5	Swap in spare	Complete recovery	Once
TEM Assy	C/C/P TEM	1/16 LAT or less	5	None	1/16 LAT	
	C/C/P TKR	1/16 TKR or less	5	None	1/16 TKR	
	C/C/P CAL	1/16 CAL or less	5	None	1/16 CAL	
	C/C/P ACD	1/2 ACD or less	4	Swap in spare	Complete recovery	Once
	Pwr/Sig Conn.	1/16 TKR,CAL	4	Swap in spare	Complete recovery	
		1/2 ACD				
ACD Assy	C/C/P	1/2 ACD or less	4	Swap in spare	Complete recovery	Once
ACD_FE	C/C/P	!2 ACD or less	3	None	Small loss in efficiency	Once
TKR_FE	C/C/P	1/16 TRK or less	6	Some failures recovered	1/16 TKR or less	
CAL_FE	C/C/P	1/16 CAL or less	6	Some failures recovered	1/16 CAL or less	