Peer Review and CDR Preparation

LAT Engineering Meeting
December 17, 2002

Reference
SEMP (LAT-MD-00066)
NASA SRO – Design Review Guidelines (Section 4.3)

Preparation Schedule

- **Subsystems Peer Reviews**
  - ACD — January 7-8, 2003
  - CAL — March 17-18, 2003
  - Elec/DAQ/PWR/Flt SW — March 19-20, 2003
  - TKR — March 24-25, 2003
  - Mech — March 26-27, 2003
  - I&T — March 28, 2003
- **Walk Through Review**
  - Combined LAT IPO and GSFC Project Office chart walk through to be performed in the week of April 8–9
- **CDR**
  - Material available 4/18/03 for transmittal
    - This is 7 work days prior to review date per CDRL 306
  - Review Dates 4/29 – 5/2/03 (1 month after completion of last Peer Review)

GSFC CDR Guideline

- **Paragraph 4.3 from the GSFC System Review Office Guideline**

4.3 CRITICAL DESIGN REVIEW (CDR)

The CDR is held near the completion of an engineering model, if applicable, or the end of the breadboard development stage. This should be prior to any design freeze and before any significant fabrication activity begins. The CDR presents a final detailed design using
substantially completed drawings, analyses and breadboard/engineering model evaluation
testing to show that the design will meet the final performance and interface specifications and the required design objectives. The CDR should represent a complete and comprehensive presentation of the entire design. It should present the final design and interfaces by means of block diagrams, power flow diagrams, signal flow diagrams, interface circuits, layout drawings, software logic flow and timing diagrams, design language, modeling results, breadboard and engineering model test results and changes required to the design presented at the PDR. Final estimates of weight, power, and volume are to be presented. Final calculations for mechanical loads, stress, torque margins, thermal performance, radiation design and expected lifetime are to be presented. Final software requirements and updated system performance estimates should also be presented. Parts selection, de-rating criteria and screening results, calculated reliability and the results of a FMEA are to be presented. The CDR should include all of the items specified for a PDR, updated to the final present stage of development process, plus the following additional items:

- Evolution and Heritage of the Final Design
- Combined optical, thermal, and mechanical budgets or total system performance
- Closure of Actions from the Previous Review
- Interface Control Documents
- Final implementation plans including: engineering models, prototypes, flight units, and spares
- Engineering Model/Breadboard Test Results and Design Margins
- Completed design analyses
- Qualification/Environmental Test Plans and Test Flow
- Launch Vehicle Interfaces
- Ground Operations
- Progress/status and control methods for all safety hazards identified at, but not limited to, the PDR
- Reliability analyses results: FMEA, Worst Case Analysis, Fracture Control
- Plans for shipping containers, environmental control and mode of transportation
- Problem Areas/Open Items
- Schedules

Completion of the CDR and resolution of all the action items generated by it constitutes the baseline design for the item to be built. Following the CDR, drawings are released and formal configuration control begins .

Entrance & Exit Criteria

Design Status

- Demonstrate evolution & heritage of "Final Design"
- Demonstrate compliance of system performance
- Closure of Actions from PDR & ΔPDR
- Complete ICDs
- Final implementation plans
  - EM
  - Prototype
  - Flight Units
  - Spares
- Complete design analysis

Fabrication Status

- Qualification/Environmental Test Plan and Flow
- Ground Operations
- Control methods for all safety hazards identified
- FMEA
- Worst case analysis
- Fracture control
- Shipping environment and mode of transportation

CDR Check List

- **PDR – CDR Check List Comparison (reference GSFC SRO Checklist)**

PDR	CDR	Checklist Category
Closure of Action Item from Previous Reviews	Closure of Action Item from Previous Reviews	Action Item Database
Science/Technical Objectives, Requirements, General Specificaiton Performance Requiremens	Evolution & Heritage of the Final Design	Design Specifications
Error budget determination Weight, Power, Data rate, Commands, EMI/EMC System Performance budgets	Combined optical, thermal, and mechanical budgets or total system performance	System Performance Analysis/Allocation
Interface Requirements	Interface Control Documents	Design Specifications
Mechanical/structural design, analyses, and life tests Electrical, thermal, optical/radiometric design and analyses Software requirements and	Complete design analyses Engineering Model/Breadboard Test Results and Design Margins	Analysis/Modeling/EM Test Reports
Design verification, test flow and calibration/test plans	Qualification/Environmental Test Plans and Test Flow	Plans
Mission and ground system operations	Ground Operations	Plans
Launch Vehicle interfaces	Launch Vehicle interfaces	Design Specificaitons
Parts selection, qualification, and Failure Mode and Effects Analysis plans	Reliability analyses results: FMEA, Worst Case Analysis, Fracture Control	Analysis/Modeling/EM Test Reports Support Materials
Ground Support Equipment design	Plans for shipping containers, environmental control and mode of transportation	Support Materials
	Problem Areas	N/A
	Schedule	CMS

Breakdown of the CDR Check List for each Subsystem

Check list is designed to provide a quick look of the project readiness for CDR

CDR Check List	Sys (4.1.2)	TKR (4.1.4)	CAL (4.1.5)	ACD (4.1.6)	Elect/ DAQ/Pwr/ Flt SW (4.1.7)	Mech (4.1.8)	I & T (4.1.9)
• Plans (Updates)							
LAT Verification Plan	LAT-MD-408						
LAT Subsystem Test/Verification Plan							
Subsystem Fabrication & Test Plans							
Transportation and Handling Plan	LAT-MD-649						
EEE Parts Program Plan	LAT-MD-99						
Mechanical Parts Plan	LAT-SS-107						
Contamination Plans/Processes	LAT-MD-404						
Configuration Mgt Plan	LAT-MD-68						
Instrument Operation Plan							
• Design Specifications							
Level II (LAT Level)	LAT-SS-10						
Level III (Subsystem Spec)		LAT-SS-17	LAT-SS-18	LAT-SS-16	LAT-SS-19 LAT-SS-136	LAT-SS-115	LAT-SS-456
Level IV (Subassemblies Spec)		% completions	% completions	% completions	% completions	% completions	% completions
Subsystems Drawing Tree (Including Level V Drawings / Processes)		% completions	% completions	% completions	% completions	% completions	% completions
LAT/Subsystem ICDs - Drawing		LAT-SS-TBD	LAT-DS-233	LAT-SS-241	LAT-SS-294	LAT-DS-38	
LAT/Subsystem ICDs - Spec		LAT-SS-138/176	LAT-SS-238	LAT-SS-363	LAT-SS-291/293	LAT-DS-365	
LAT Software ICD							
• System Performance Analysis/Allocation Assessments							
System Performance Analysis (Sim)							
Mass	LAT-TD-125						
Power	LAT-TD-125						
Processor (CPU Cycle Margin)							
Memory Utilizations							
Reliability/Operability Analysis	LAT-TD-359	LAT-TD-178					
Worst Case Analysis							
FMEA	LAT-TD-359	LAT-SS/TD-178	LAT-TD-464	LAT-TD-523	LAT-TD-295		
• Analysis/Modeling/ EM Test Reports							

CDR Check List (continued)

CDR Check List	Sys (4.1.2)	TKR (4.1.4)	CAL (4.1.5)	ACD (4.1.6)	Elect/ DAQ/Pwr/ Flt SW (4.1.7)	Mech (4.1.8)	I & T (4.1.9)
Thermal Analysis (Final)						LAT-TD-280	
Structural Analysis (Final)						LAT-TD-109/116/234	
Electrical/Electronics Analysis (Final)							
Radiation Analysis (Final)							
Micrometeoroid Shield Analysis (Final)							
EM Test Reports (Drafts)							
Calibration (Ground)							LAT-SS-446
• Support Materials							
Mechanical Parts List	LAT-DS-405	LAT-SS-172					
Electrical Parts List	LAT-TD-401	LAT-SS-179					
Limited Life/Critical Item Lists	LAT-TD-523			LAT-TD-524			
Flight Qualification List							
Transportation/Handling Procedures							
Safety Hazards Analysis	LAT-MD-366						
Material & Processes List	LAT-DS-405						

CDR - CDRL List				
Number	306	Technical Review	Deliever Review Material and Hand-outs	7 work days
	307	Instrument Performance Verification Plan	Deliver final draft of I-PVP along with Instrumentation Plan	20 work days
	327	O&SHA	First draft	30 days
	330	Ground Operation Plan	Draft (update)	45 days (spacecraft PDR)
	334	Part Stress Analysis	EEE parts stress analyses	30 work days
	335	Flight Software Specification	Details the requirement for each CSCI	30 work days
	340	Software/Algorthim Design Doc	Describe detail architecture, structure, and organization for each CSCI	30 days

Not Applicable

Preparation Examples

- ACD has provided a website of their CDR preparation status
- I encourage everyone to view posted material, including the CDR Dry Run charts

  http://lhea-glast.gsfc.nasa.gov/acd/cdr/index.html

- The following slides are examples for each Check List category presented in the ACD charts

Closure of Action Items

- Identified action items from PDR and ΔPDR
- Show status and closure of NASA GSFC action items

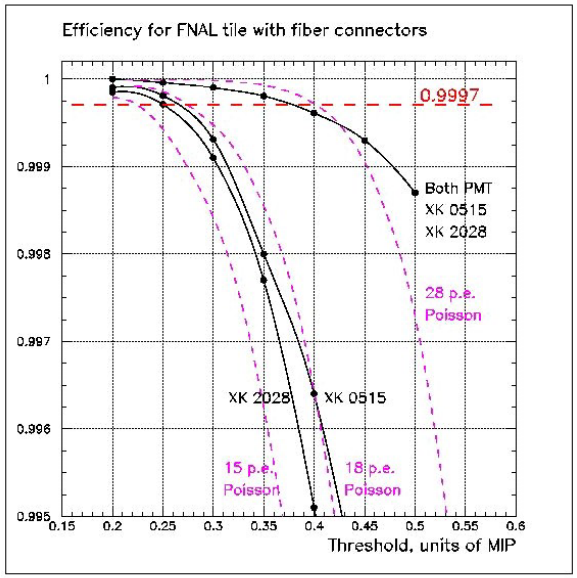
Identify the action requested

AI# 2.
Perform light yield tests and muon detection efficiency measurement of the final optical system (scintillator tiles; and fiber ribbons, connector, clear fibers, and photomultiplier tubes).

Complete – results are similar to those shown in January: with two phototubes, 0.9997 efficiency is met; with one phototube, efficiency is ~ 0.999

Light output of Fermilab tiles is good. Light losses in the optical connector and clear fibers were higher than expected. Design improvements were made to compensate for these losses.

LAT-TD-00843-D1, Design Qualification Tests for ACD TDA and Phototubes

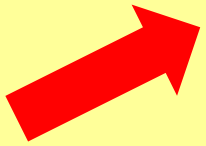


Show results

Design Specification

- Science/technical objectives and technical budgets
- Requirements & specifications metrics and flow down
  - All TBX (TBD, TBA, TBS, etc…) should be removed or addressed
- Drawing metrics
  - Number and percent complete of major assemblies and critical component drawings
  - Plans for completing the remaining drawings

Identify key requirements



Parameter	Requirement	Expected Performance	Verification Method
Detection of Charged Particles	**≥ 0.9997 average detection efficiency over entire area of ACD (less for bottom row of tiles)**	**≥0.9997** **≥0.99 (bottom tiles)**	**Test and Analysis**
Fast VETO signal	Logic signal 200-1600 nsec after passage of charged particle	200-1600 nsec	Test
PHA signal	For each phototube, pulse height measurement for each Trigger Acknowledge (TACK) Below 10 MIP, precision of <0.02 MIP or 5% (whichever larger) Above 10 MIP, precision of < 1 MIP or 2% (whichever larger)	 < 0.02 MIP or 5% < 1 MIP or 2%	Test and Analysis
False VETO rate - backsplash	**< 20% false VETO's due to calorimeter backsplash at 300 GeV**	**< 20%**	**Analysis**
False VETO rate - noise	< 1% gamma-ray rejection from false VETO's due to electrical noise	< 1%	Analysis
High Threshold (Heavy Nuclei) Detection	Detection of highly-ionized particles (C-N-O or heavier) for calorimeter calibration.	Yes	Analysis
Size	Outside: 1796 x1796 x 1015 mm Inside Grid: 1574 x 1574 x 204.7 mm Inside TKR: 1515.5 x 1515.5 x 650 mm	1796 x1796 x 1015 1574 x 1574 x 204.7 1515.5 x 1515.5 x 650	Demonstrate
Mass	< 228 kg	270	Demonstrate
Power	< 31 Watts (conditioned)	24	Demonstrate
Instrument Lifetime	Minimum 5 yrs	> 5 yr.	Analysis

Key Technical Budgets

- Identified technical budgets, it's allocation from LAT System, changes since PDR
- Show allocation flow down within the subsystem

Technical Resources

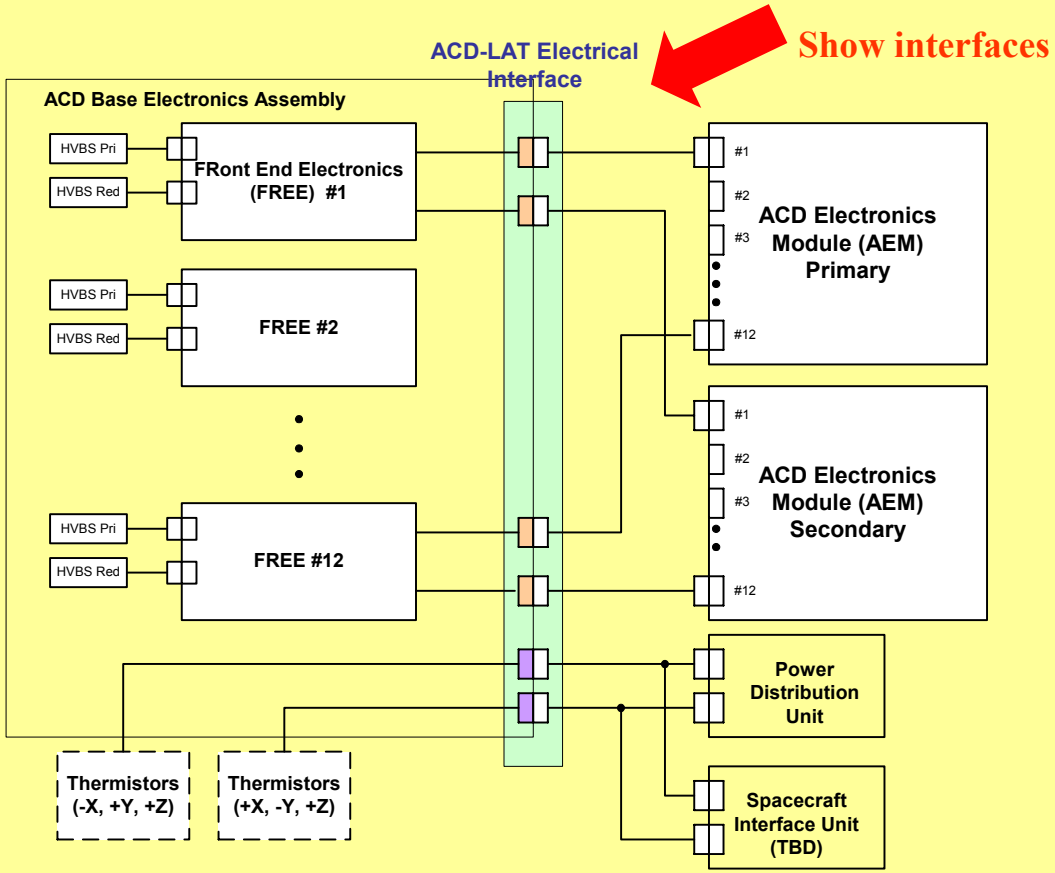
- **ACD Mass**
  - Allocation 235 kg
  - ACD detailed estimate 270 kg (15% over PDR allocation. LAT has been notified, CR is being submitted)
- **ACD Power**
  - Allocation 31 W (conditioned)
  - ACD detailed estimate 14 W max
- **Thermal Interface** (max dissipation across ASD-LAT interface)
  - Dissipation Allocation 16 W
  - Dissipation Estimate <14 W

Item	Estimated Mass (Kg)	Calculated Mass (Kg)	Actual Mass (Kg)	Total Mass without Margin (Kg)
Mechanical Hardware				
Tile Shell Assembly (TSA)		29.8004		29.8004
Shell/Base Middle & Corner Flexures	1.6000	5.9824		7.5824
Base Frame Assembly (BFA)		25.1535	0.1248	25.2783
Tile Flexures	4.3900		5.0320	9.4220
Clear Fiber Cable & Fiber Ribbon Tiedowns	1.1840	0.1984	1.6800	3.0624
Shield/Blanket Attachments	0.4000		2.5840	2.9840
ACD/LAT Interface Hardware			0.6000	0.6000
Uralane & Safety Cable	1.0000			1.0000
		Mechanical Hardware Total		79.7295
Tile Detector Assemblies				
Tiles		95.3650		95.3650
Tile Wrapping		7.7700		7.7700
Tile Pig Tails & Clear Fiber Cables		8.5026	3.7896	12.2922
Fiber Ribbons	0.0000	1.3928		1.3928
Fiber Ribbon Wrapping		0.3472		0.3472
Fiber Ribbon Pig Tails	0.1600	0.1200	0.1712	0.4512
		Tile Detector Assemblies Total		117.6184
Electronic Hardware				
PMT Assemblies	0.2910		11.8340	12.1250
Chassis Structure		13.8360		13.8360
FREE Board & PCB		6.0360	0.0000	6.0360
HVBS		2.2560		2.2560
Power Distribution Board		1.7280		1.7280
Bulkhead Connectors & Brackets		2.2352	1.3000	3.5352
Harnessing, Tiedowns & Fasteners	0.5000		0.3120	0.8120
		Electronic Hardware Total		40.3282
Thermal Hardware				
Thermistors, Wiring & Tiedowns	2.3800			2.3800
Micrometeoroid/Thermal Blanket		30.0800		30.0800
		Thermal Hardware Total		32.4600
		TOTAL ACD		270.1361

Show break down of allocation within subsystem

Interface Control Document

- ICD and IDD are completed and signed
  - Identify major trades to accommodate design
  - Remaining open issues should have closure plan



- 24 identical robust circular connectors (38999, series 2)
- 2 circular housekeeping connectors (38999, series 2)
- Parts, pin outs, signal def, grounding all defined in ICD

DATA Products

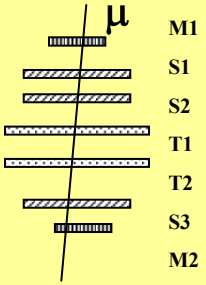
- Channel specific charged particle VETOs
- VETO hit maps
- PHAs
- Diagnostics
- Housekeeping (thermistor output, voltage monitor output, direct to AEM)

Analysis/Modeling/EM Reports

- Identify analysis and modeling performed since PDR
  - What are the impacts due to spacecraft/bus interface
- Highlight impact to analysis due to design change
- Highlight impact to design due to modeling change

- Provide example of EM testing
  - Identify objective and results

Example from ACD



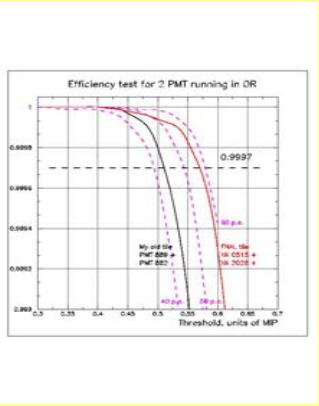
Efficiency measurement setup:

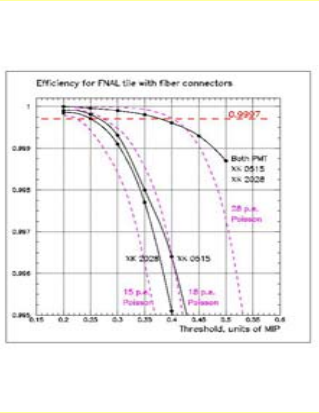
M1, M2 - hardware trigger scintillators

S1, S2, S3 - software trigger scintillators

T1, and T2 - tested TDA's

Subject of the test - Fermilab made TDA prototypes (T1 and T2) equipped with clear fiber extensions and fiber-to-fiber connectors (made by GSFC)

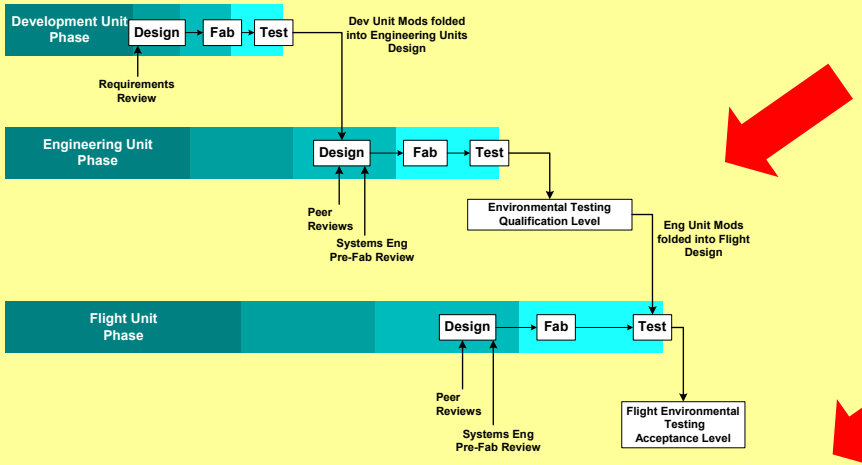




Up to 50% of the light created in the tile, is being lost during transportation to the PMT

Qualification/Environmental Test Plan

- **Identify qualification and environmental test to be performed in accordance to LAT Verification and Test Plan**



Show Flow

Traceability

Test & Verification Matrix

Links between Requirements

ACD Level III and IV Requirements Database

ACD-LAT ICD Requirements and Verification Database

ACD Allocation Tables

ACD Test Databases

Item	Level of Assembly	Unit Type	Supplier	Test Levels	Test Steps	Mech. Survey (low level sine survey)	Static Loads	Sine Burst	Sine Vibration	Random Vibration	Mechanical Function	Performance Testing (Optical)	Acoustics	Mass Properties	Interface Vent.	EMC/EMI	ESD Compatibility (Grounding)	Magnetics	Screening Process	Aliveness (A) / Functional (F) / Comprehensive (C)	Thermal-Vacuum Cycle	Thermal Cycle	Thermal Balance	Remarks
ACD Subsystem (Integrated A	**S**	**F**	**GSFC**	**Acpt**		**X**			**X ?**	**X?-r**		**X**	**X**	**X**	**X**	**X**	**X**			**C**	**4**		**X**	**Acceptance Levels**
Tile Shell Assembly	SA	F	GSFC	Acpt										X ?										
Tile Shell Assembly - partial	SA	D	GSFC	Qual			Xd	X	X	X	X			X							6			
ACD Mech S/S (no elect or Det)	S	F	GSFC	Qual		X-e		X-e	X-e	X-e	X			X							2			ACD Structure w/mass sims, no elect or det
Shell	C	F	TBD	Par Qual		X-e		X-e	X-e	X-e				X							2 ?			
Shell - partial	P	D	GSFC	Qual			Xd	h	h	h														
Tile Detector Assembly	SA	F	Fermilab	Acpt				X		X		X-d	h	X						A, F-h				117 Flt TDAs
Tile Detector Assembly	SA	S	Fermilab	Acpt						X		X-d									8			28 Flight Spares
Tile Detector Assembly	SA	EM	Fermilab	Qual				X	X	X		X-d		X						F	6			20 TDAs
Tile Detector Assembly	SA	D	Fermilab	Qual		X	X			X		X-d									6			Functional testing code660
TDA Tiedown (Flexure)	P	F	GSFC	TBD		X-c								X										Test bonded joint
TDA Tiedown (Flexure) ?	P	EM	GSFC	Par Qual		X-c	X	X	X	X				X							h			Test bonded joint
TDA Tiedown (Flexure)	P	D	GSFC	Qual		X-b															h			Characterize flexures
WSF/Clear Fiber Connector	C	F	GSFC	TBD										X						A, F-h				
WSF/Clear Fiber Connector	C	EM	GSFC	Par Qual					h	X	X-c			X						F	h			
WSF/Clear Fiber Connector	C	D	GSFC	Qual				X ?		h	X	X-d								A?	h	8-d		Several development models
Base Frame	C	F	GSFC	Acpt ?		X-e-c		X-e-c	X-e-c	X-e-c				X							4-c			
Partial BFA & Electronics Chassis	SA	EM	GSFC	Qual		X		X-?	X	X						X	X?	X?		F		2?		Corner or one side BFA, BEA assemb
Base Frame - partial	C	D	GSFC	Par Qual			X		X-e	X-e														
Shield & Thermal Blanket	C	F	GSFC											X							4-c			Similarity to dev. model
Shield & Thermal Blanket	C	EM	GSFC											X										Similarity to dev. model
Shield & Thermal Blanket	C	D	JSC, GS	Qual																	6			Characterize thermal perf., particle impact
Clear fiber cable assembly	SA	F	GSFC	Qual					X-c	X-c		X								A				
PMT/Fiber Connector	C	F	GSFC	TBD						X-c	X-c	X-c		X						A				
PMT/Fiber Connector	C	EM	GSFC	Par Qual							X	X-c		X						F	6-c			
PMT/Fiber Connector	C	D	GSFC	Qual						X	X	X-d								F		8-d		Several development models
Base Electronics Assembly	S	F	GSFC	Acpt					X-?	X-?										F				
Electronics Chassis	SA	F	GSFC	Acpt					X	X				X	X					F	2?			(FREE, HVBS, PMT)
Electronics Chassis	SA	EM	GSFC	Qual	X		X	X	X					X						F	10			(FREE, HVBS, PMT)
Electronics Chassis	SA	D	GSFC	Qual																F	2			(FREE, HVBS, PMT)
Electronics Chassis	SA	BB	GSFC																	F				mech BEA parts

Parts & FMEA/WCA

- Parts and qualification status
- FMEA/WCA/Fracture Control

Identify status of qualification test

Example - Results of Qualification PMT's acceptance test

	PMT	0882	0609	0610	0879	0883	0896	0885	1088	1085
1	Measured Sensitivity At 900 V At 1000 V At 1050 V	 209 480	 142 340 491	 264 609 879	 219 512	 249 569	 283 619 932	 148 330 490	 59 146 217	 247 578 810
2	Measured L.Y. at 900V-1050V	26-28.3	21.5-23.5	22.5-26	24-27	27-28	25-29	23-24	19-23	20-21.5
3	Measured L.Y. average, (place)	27.1 (2-3)	22.5 (7)	24.3 (5)	25.5 (4)	27.5 (1)	27 (2-3)	23.5 (6)	21 (8-9)	21 (8-9)
4	Measured L.Y. at sensitivity of 600 channels, (place)	28 (1)	24 (6)	24.5 (5)	25.5 (4)	27.5 (2)	27 (3)	23.5 (7)	21 (8-9)	21 (8-9)
5	Q.E., from Data sheet (hereafter D.S.), (place)	16.0 (5-6)	16.0 (5-6)	15.4 (7)	16.9 (2)	16.8 (3)	17.6 (1)	16.1 (4)	15.0 (9)	15.2 (8)
6	Measured Gain=sens (1000V)/L.Y. average, (place)	17.7 (6)	15.1 (7)	25.0 (2)	20.1 (5)	20.7 (4)	22.9 (3)	14.0 (8)	7.0 (9)	27.5 (1)
7	Gain, from Data sheet, (place)	7.91 (6)	6.19 (8)	10.40 (2)	8.66 (5)	9.11 (4)	10.10 (3)	6.42 (7)	3.00 (9)	11.44 (1)
8	L.Y. average / Q.E.(D.S.)	1.69	1.41	1.58	1.51	1.64	1.53	1.46	1.40	1.38
9	L.Y.(600) / Q.E.(D.S.)	1.75	1.50	1.59	1.54	1.64	1.53	1.52		1.38
10	Gain at 1000V/Gain D.S.	2.24	2.44	2.40	2.32	2.27	2.27	2.18	2.33	2.40

Peer Review Agenda

(Suggested)

Suggested Peer Review Agenda (1/3)

- **Subsystem introduction & overview**
  - Schedule summary
  - Critical path analysis
- **Subsystem engineering**
  - Overview - identify major subsystem and interface design changes since ΔPDR
    - CCB's (approved since ΔPDR and pending)
  - Requirements and budget allocation updates
  - Subsystem ICDs, drawings, and procedures status
  - Subsystem performance analysis
    - Simulation updates
    - Design trades analysis performed
    - Verification matrix
    - Reliability results
    - FMEA
    - Worst case analysis or part stress results
    - Fault tree analysis or single point failure analysis results
  - Subsystem technical risk assessment & mitigation plan
  - Engineering model assessment

Suggested Peer Review Agenda (2/3)

- **Major assemblies/elements within the subsystem**
  - Requirement/compliance matrix – update since ΔPDR
  - Allocated budgets (mass, power, c.g., etc..) – updates from EM or actual
  - Mechanical & electronic design changes since ΔPDR
    - Performance modeling updates (structural, thermal, electronics)
  - Major assemblies/component
    - Performance summaries
      - Performance prediction vs. requirement
  - Engineering model test results
    - Test data discussion
    - Test result as compared to expected performance/prediction
      - Design changes resulting from EM test
    - Qualification plan (including vibration, thermal, EMI/EMC, etc..)
  - Procurement plan & Status
    - Identify critical component need dates vs. delivery dates
    - Summarize procurement contract status
    - EEE parts and material approval status/readiness
    - Long lead part requirement/procurement

Suggested Peer Review Agenda (3/3)

- **Subsystem assemblies (fabrication plan)**
  - Assembly flow overview & facilities status
  - Production readiness reviews
    - Performed or planned
  - Test plan
  - Test Equipment (mechanical & electrical) preparation
    - MGSE and EGSE status
    - Rack elevation, cables, power, test adapter
    - Test software and scripts status
  - Processes & procedures
  - Transportation and handling plan/procedures
    - Transportation container design
- **Subsystem product assurance**
  - Non-conformance reporting tracking and readiness
  - Production travelers

Conclusion

Design Status

- ☑ Demonstrate evolution & heritage of "Final Design"
- ☑ Demonstrate compliance of system performance
- ☑ Closure of Actions from PDR & ΔPDR
- ☑ Complete ICDs
- ☑ Final implementation plans
  - EM
  - Prototype
  - Flight Units
  - Spares
- ☑ Complete design analysis

Fabrication Status

- ☑ Qualification/Environmental Test Plan and Flow
- ☑ Control methods for all safety hazards identified
- ☑ FMEA
- ☑ Worst case analysis
- ☑ Fracture control
- ☑ Shipping environment and mode of transportation

"We are ready to proceed to subsystem fabrication"