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GLAST LAT SUBSYSTEM SPECIFICATION	Prepared by(s) D. Thompson et al.	Supersedes Previous
	Subsystem/Office ACD Subsystem, Electrical System	
Document Title **LAT Electronics – ACD - Interface Document for Testing**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

LAT Electronics – ACD - Interface Document for Testing

Draft

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
1	12/23/02	Initial Draft
2	1/28/03	Many updates from Gunther Haller and Michael Huffer

Purpose

The purpose of this document is to establish testing interfaces between the ACD Front-end Electronics (i.e. Front-end event electronics (FREE) circuit card) and the LAT Electronics, including both the ACD Electronics Module (AEM) and the Global Trigger (GLT). It is intended to be used to delineate interfaces, so subsystems components can be designed and fabricated based on clear, understood values for their interfaces to the rest of the LAT. This Interface document will also serve as a requirements list against which interface tests are developed, and against which the ACD subsystem must be verified prior to integration on the LAT.

1 Scope

The scope of this Interface document includes descriptions of basic ACD testing requirements and the demands that those tests place on the LAT Electronics and the ACD electronics at various stages in the ACD development.

2 Acronyms

ACD – Anticoincidence Detector

ADC – Analog to Digital Converter

AEM – ACD Electronics Module

BEA – Base Electronics Assembly

BOL – Beginning of Life

DAQ – Data Acquisition System

DC – Direct Current

DFS – Data-Flow System

EGSE – Electrical Ground Support Equipment

EMI – Electromagnetic Interference

EOL – End of Life

FREE – Front-End Electronics

GAFE – GLAST ACD Front End

GARC – GLAST ACD Readout Controller

GASU - Global Trigger, ACD, DAQ and SIG Unit

GLAST – Gamma-ray Large Area Space Telescope

GLT – Global Trigger

GSFC – Goddard Space Flight Center

HLD – High Level Discriminator (previously called CNO)

HVBS – High Voltage Bias Supply

ICD – Interface Control Document

IRD – Interface Requirements Document

LAT – Large Area Telescope

LLD – Low Level Discriminator

LVDS – Low Voltage Differential Signal

MIP – Minimum Ionizing Particle

MSB – Most Significant Bit

PMT – Photo-Multiplier Tube

SIG – Signal Distribution

TACK – Trigger Acknowledge

TBR – To Be Resolved

TBD - To Be Determined

T&DF – Trigger and Dataflow System

TKR – Tracker

TRG – Trigger

TSA – Tile Shell Assembly

3 Definitions

μsec, μs – Microsecond, 10^{-6} second

Analysis – A quantitative evaluation of a complete system and /or subsystems by review/analysis of collected data.

Background Rejection – The ability of the instrument to distinguish gamma rays from charged particles.

cm – centimeter

Cosmic Ray Ionized atomic particles originating from space and ranging from a single electron or proton up to an iron nucleus and beyond.

Demonstration – To prove or show, usually without measurement of instrumentation, that the project/product complies with requirements by observation of results.

Event – an event results in that the instrument is triggered and the data associated to that event is read out.

Inspection – To examine visually or use simple physical measurement techniques to verify conformance to specified requirements.

Nominal MIP – 1 MIP produces a PMT anode signal of 0.64pC

MeV – Million Electron Volts, 10^6 eV

MHz – Megahertz, 10^6 hertz

s, sec – seconds

Simulation – To examine through model analysis or modeling techniques to verify conformance to specified requirements

TACK - Trigger Acknowledge signal distributed from the trigger system to the detector sub-systems. The sub-systems save the event data in an event buffer when receiving this signal.

Test Stand – All the LAT electronics required to carry out testing of the ACD (includes the AEM and GLT)

Testing – A measurement to prove or show, usually with precision measurements or instrumentation, that the project/product complies with requirements.

Trigger – generates a decision whether to readout the instrument and distributes a Trigger Acknowledge to acquire event data considering data received from the detector sub-systems.

V - Volts

Validation – Process used to assure the requirement set is complete and consistent, and that each requirement is achievable.

Verification – Process used to ensure that the selected solutions meet specified requirements and properly integrate with interfacing products.

4 Applicable Documents

1. LAT-SS-00458 LAT Electronics Subsystem Preliminary Design Report
2. LAT-SS-00289 Conceptual Design of the LAT ACD Electronics Module
3. LAT-SS-00291 Electrical Grounding and Shielding Plan
4. GSFC-433-RQMT GLAST EMI/EMC Requirements Document
5. Directive 561-PG-8700.2.1, Flight FPGA Design Guidelines
6. Directive 564-PG-8700.2.1, Microelectronics and Signal Processing Branch
7. LVDS Owner's Manual (A General Design Guide for National's LVDS and Bus LVDS Products), 2nd Edition
8. LAT-DS-00038 LAT Mechanical Systems Mechanical Integration LAT Instrument Layout
9. LAT-DS-00309 LAT Mechanical Systems Interface Definition Dwg
10. GEVS-SE General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
11. LAT-SS-00016 ACD level III requirements/specifications
12. LAT-SS-00352 ACD level IV requirements/specifications
13. LAT-SS-00010 LAT level IIb specifications
14. LAT-TD-00778 LAT Environmental Test Parameters
15. LAT-TD-TBD LAT Instrumentation Plan
16. LAT-DS-TBD ACD Outline Drawing
17. ANSI Y 14.5M
18. Interface Definition Drawing (IDD), LAT-DS-00309
19. ACD Interface Control Document, LAT-SS-00363.4
20. LAT-TD-00639-01 Draft THE ACD ELECTRONICS MODULE (AEM)
21. LAT-TD-01199-01 LAT Test Stand Communications Interface Software User's Guide
22. LAT-TD-00861-01 Test-stand architecture redux v1.1
23. ACD Test-stand Architecture, LAT-TD-xxx-01

5 Introduction

In the course of development, a need has been recognized for a document to supplement the full ACD Interface Control Document (LAT-SS-00363.4). Although nothing in the present document replaces contents of the ICD, that document is incomplete in the area of testing, particularly prior to integration of the ACD onto the LAT. In particular, the capabilities/requirements of the different generations of Test Stand (which we define to be all the electronics supplied by the LAT Electronics group to handle the commands and data between the ACD electronics and the EGSE supplied by the LAT I&T group) are outlined, along with brief descriptions of the tests that will be performed. In addition the EGSE electronics supplied by the ACD sub-system to enable development and testing of the DAQ electronics is described. This is needed to test the DAQ electronics at SLAC prior to delivery to GSFC, as well as to be able to develop hardware and flight-software for the LAT.

In all cases, the Test Stand is fully documented and supported by associated software on the EGSE computer, which is a Windows NT based system using XML, Python, QT, and Hippodraw software. Unless otherwise specified, all interfaces to the ACD are those defined by the ICD, ACD Interface Control Document, LAT-SS-00363.4

The test-stand versions are described in more detail in LAT-TD-xxxx (Michael Huffer's "ACD Test-Stand Architecture" document.)

Appendix A describes the ACD/LAT interfaces, both mechanical and electrical, for the Calibration Unit.

Appendix B is a summary chart of Test Stand capabilities needed for different phases of ACD testing.

6 Test-stands to be operated at GSFC

6.1 ACD Test Stand G0

Note: G0 of the test-stand consists of hardware and software as described in G1 of LAT-TD-xxxx with the exception of

a) G0 does not accept/process HLD and Veto trigger signals

b) G0 does not have external trigger mode

Status: Delivered in April 2002 to GSFC

Hardware: VME crate with pseudo-AEM and pseudo-GLT

Number of Test Stands: 1

Documentation: LAT-TD-00639-01 Draft THE ACD ELECTRONICS MODULE (AEM) + ACD Test-stand Architecture, LAT-TD-xxx-01

LAT-TD-01199-01 LAT Test Stand Communications Interface Software User's Guide

Capabilities:

Read and write GARC and GAFE registers per ICD

Send trigger commands per ICD

Send calibration strobe per ICD

Limitations:

No power to ACD

No self-trigger by ACD VETO signals

No external trigger input

No VETO rates

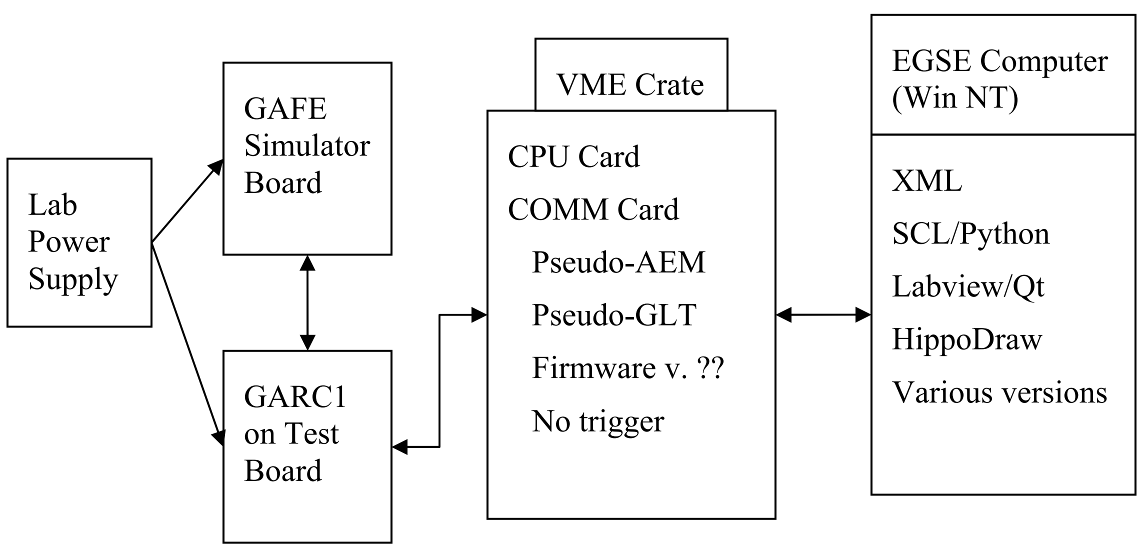
Interfaces to only one FREE card (non-flight-like connector)

Applications:

Verify interfaces to GARC and GAFE

Could do GAFE testing with calibration/charge injection if GAFE were working well

Typical configuration - G0



6.2 ACD Test Stand G1

Status: Upgrade of Test Stand 0 in December, 2002. This was accepted by the ACD as fulfilling a Level 3 milestone deliverable. ACD Electronics Module 1 (EM1).

Hardware: VME crate with pseudo-AEM and pseudo-GLT. Non-flight connectors.

Documentation: LAT-TD-00639-01 Draft THE ACD ELECTRONICS MODULE (AEM) + ACD Test-stand Architecture, LAT-TD-xxx-01

LAT-TD-01199-01 LAT Test Stand Communications Interface Software User's Guide

Number of test-stands: one: hardware/software was delivered to GSFC

Capabilities:

All G0 capabilities plus:

Handle external trigger (TTL input signal generates a TACK to read out ACD data).

Limitations:

No power to ACD

No self-trigger by ACD VETO signals

No VETO/HLD rates.

Interfaces to only one FREE card (non-flight-like connector)

Does not operate in vacuum

Applications:

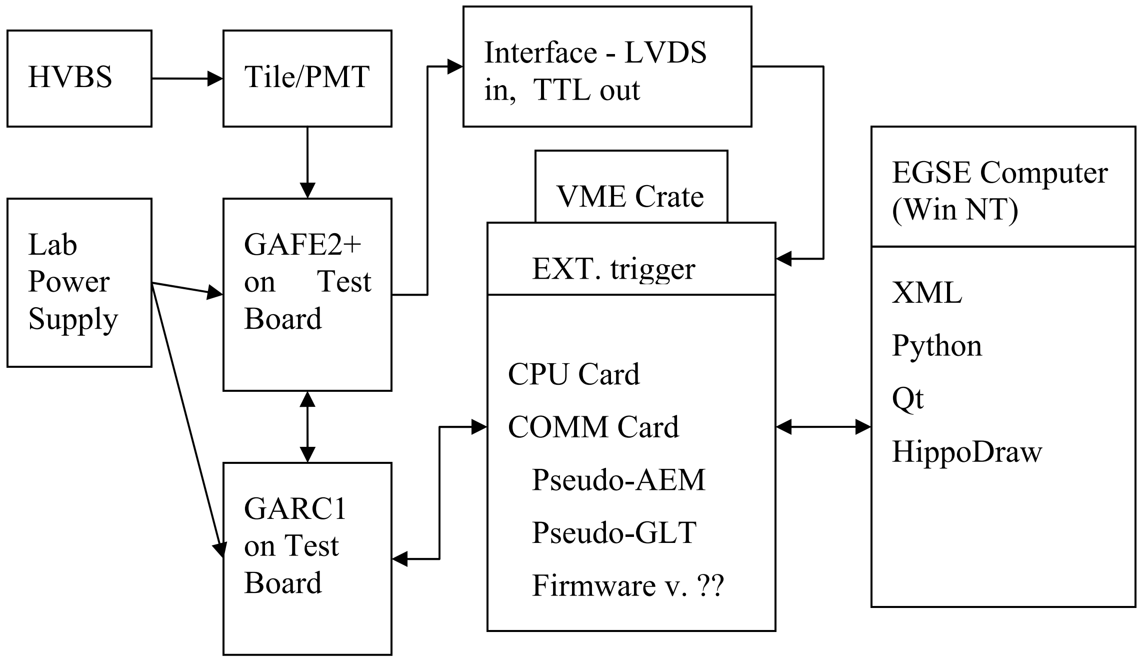
All capabilities of Test Stand G0, plus

GAFE/GARC testing (linearity, threshold, hit-map generation, etc.), defined by the GARC Test Plan (ACD-PROC-000062) and the GAFE Test Plan (ACD-PROC-000067) using test scripts written on the EGSE.

End-to-end testing: scintillator/phototube/GAFE/GARC/ADC to Test Stand to EGSE, using the VETO signal or a signal from an external hodoscope to generate an external trigger. Similar to PMT Acceptance Test (LAT–TD-1202) and TDA Acceptance Test (LAT-TD-001203).

Very limited version of Comprehensive Performance Test (LAT-TD-01112-D1) for up to 18 phototubes.

Typical Configuration - G1



6.3 ACD Test Stand G2

Status: Upgrade of Test Stand G1 in Spring, 2003. Exact date depends on testing of the interface at SLAC, which depends on producing FREE boards at Goddard, which depends at least somewhat on delivery of the GAFE4 ASICs.

Hardware: VME crate with pseudo-AEM and pseudo-GLT. **Flight-type connector, micro-D?**

Documentation: LAT-TD-00639-01 Draft THE ACD ELECTRONICS MODULE (AEM) + ACD Test-stand Architecture, LAT-TD-xxx-01

ACD Interface Control Document, LAT-SS-00363.4

Number of test-stands: three needed, one for each workstation already delivered to the ACD by I&T.

Capabilities:

All G1 capabilities plus:

Power to ACD (28 V and 3.3 V)

Redundant interfaces (one FREE card, both outputs), using flight-like connectors

Self-trigger by ACD VETO or HLD signals (VETO or HLD can be used to generate TACK. OR of 21 inputs – solicited trigger (software trigger?), external trigger, 18 VETO, 1 HLD - with any combination selectable.)

Monitor VETO rates (Trigger counter). Rate accumulation needs to handle expected rates on the ground, 5-10 Hz, for each tile.

Limitations:

No monitoring of temperatures, Vdd or High Voltage

Interfaces to only one FREE card

Does not operate in vacuum

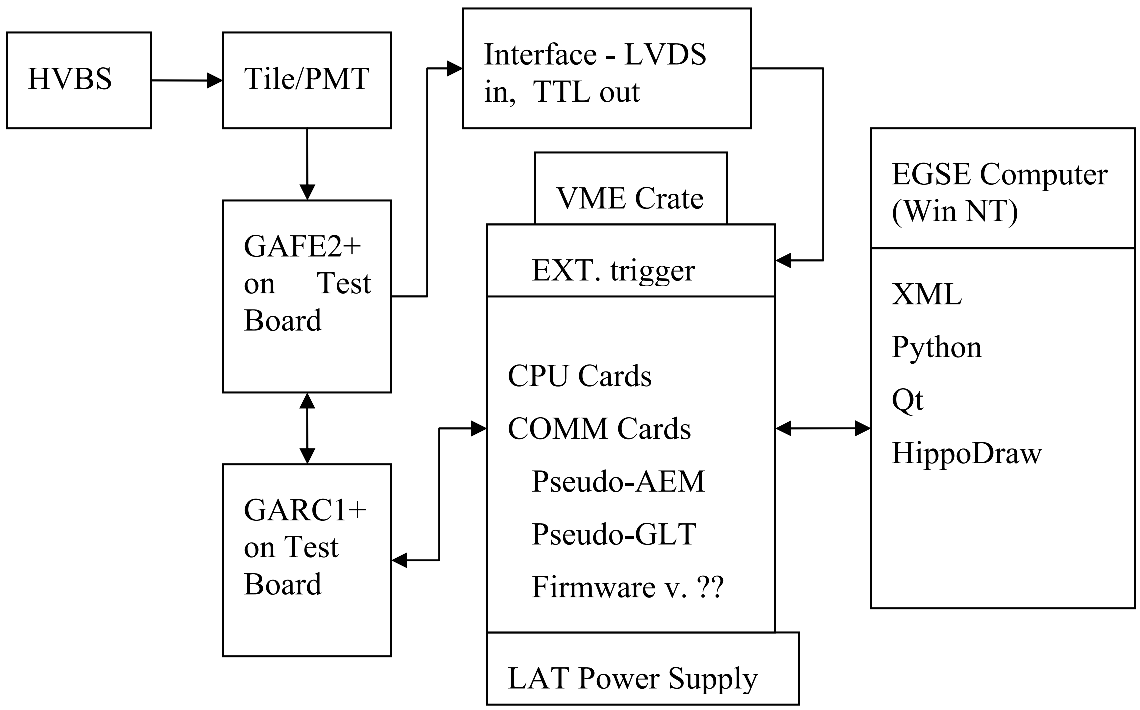
Applications:

All applications of G1, plus:

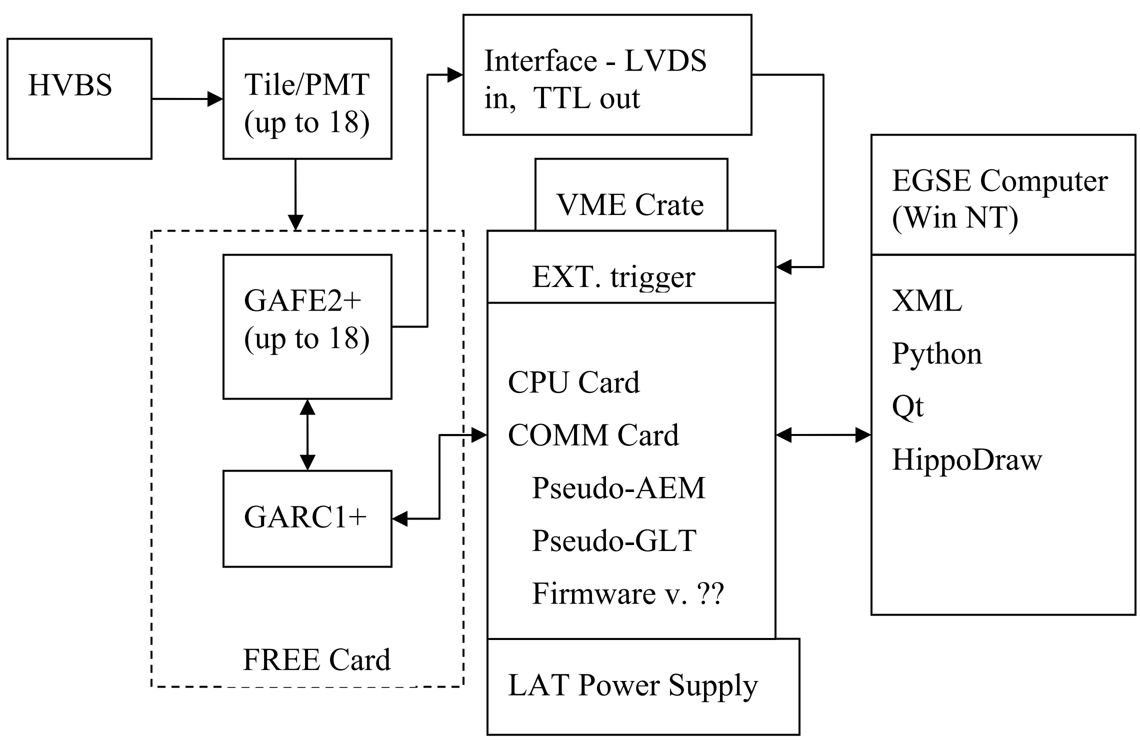
FREE Test Plan (ACD-PLAN-000050). Limited version of Comprehensive Performance Test (LAT-TD-01112-D1) for up to 18 phototubes, using test scripts written on the EGSE.

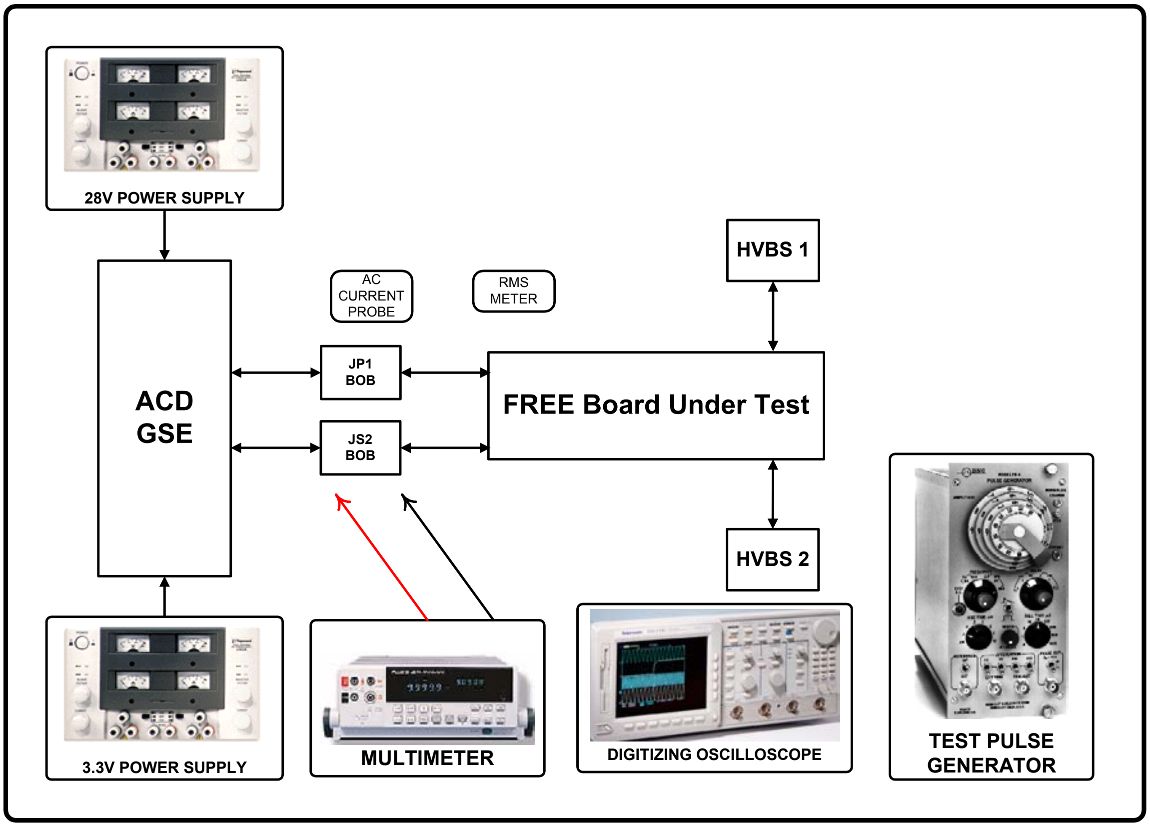
Operate Calibration Unit ACD? Or will we being using a G3?.

Electronics Test Configuration – G2



FREE Board Test Configuration – G2





Auxiliary equipment used during FREE card testing. Will any of the Test Stands have GPIB or similar hardware-control interfaces?

6.4 ACD Test Stand G3

Status: to be delivered Summer 03 (2-3 months after dataflow receives 1st FREE cards). Needed for full operation of the ACD. This is a Level 3 milestone deliverable.

Hardware: VME crate with processor, LAT Communications Board, and transition board, LAT Power supply, full GASU with redundant electronics. (**Note that although this is built by DAQ the funding for purchases comes from ACD. Note from ACD – not in our budget. We will have to take this up with the IPO.** Labor, etc are funded within DAQ).

Cables between GASU box and ACD: Non-flight cables (24) supplied by GSFC to connect full ACD to Test Stand using flight-like connectors. Note that the interface to test-stand is not like flight since there is no LAT shield. In other words the cables connect directly from the ACD to the GASU box (which has a different style connector, micro-D). LAT Electronics will produce 1 or 2 cable sets and deliver to ACD, where one set comprises a cable from the GASU to the LAT-shield bulk-head, a bulk-head, and a cable from the bulk-head to the ACD. This is to ensure compatibility. What is the LAT-shield connector? Like ACD?

Alternative is that LAT Electronics produces full set of 24-cables like flight configuration: 24 ACD-to-LAT-shield bulkhead cables, plate with 24 bulk-heads, 24 bulk-head to GASU cables. This is possible but is not part of the DAQ budget. This would only seem necessary if the LAT shield were necessary for operation of the ACD and the GASU. Is that expected? These sets of cables are expensive. We should minimize the number we make, consistent with adequate testing. How do we resolve the possible need for a shield?

Non-AEM monitoring interface, the two additional circular connectors.

Documentation: LAT-TD-00639-01 Draft THE ACD ELECTRONICS MODULE (AEM) + ACD Test-stand Architecture, LAT-TD-xxx-01

ACD Interface Control Document, LAT-SS-00363.4

Number of test-stands to be delivered to GSFC: One. **Note that this leaves us with no backup if something in the test stand fails. This is a risk.**

Capabilities:

All G2 capabilities plus:

Handle full set of 12 FREE cards (24 cables), i.e. entire ACD.

Capable of operating in vacuum over full temperature test range (-60 C to +45 C.). (regarding the test-stand, this applies to GASU. Note that the original plan was to not have the GASU in TV. The ACD-to-GASU cables penetrated the TV chamber. **However it may be possible to have the EM GASU operate in TV, tbd. TV operation of the GASU was agreed in March, 2002. If this is now a problem, we need to know about it.** The TV chamber for the ACD will be GSFC chamber 238, which has a diameter of 12 ft. There is ample space for the GASU and other support electronics.

Full GLT capabilities, including ACD self-trigger consisting of a global OR of all ACD VETO or HLD signals, with any set of inputs selectable by command.

Monitoring of all temperatures and voltages.

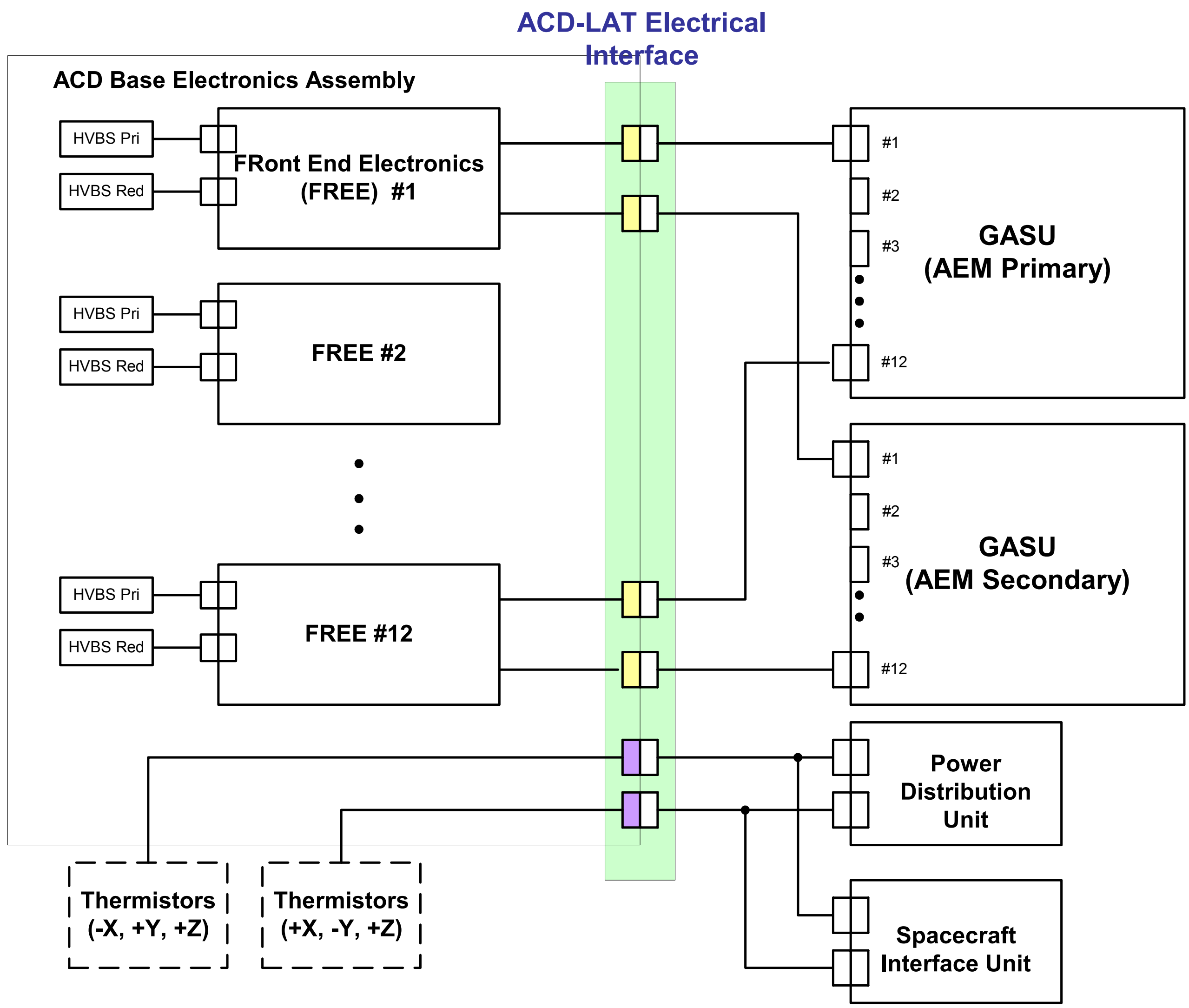
Limitations:

NONE. Completely flight-like interface.

Applications:

same as G2 plus:

Comprehensive Performance Test (LAT-TD-01112-D1), both in ambient conditions and during all phases of environmental testing. Note that this test includes the use of an external trigger at one point.



Test Stand G3 and Flight Electronics Interfaces

7 Test-Stands to be operated at SLAC

7.1 Bud-box

Delivered to LAT Electronics:

Box with ACD GARC code in FPGA, emulation of two GAFE's, registers only

Quantity: 1

Limitation:

no HLD/Veto signals

GAFE part emulation only of registers, only 2 of 18 GAFE's

No GAFE's, no HVBS

7.2 GAFE/GARC Test-Boards

Delivered to LAT Electronics:

CY02: One GAFE and one GARC test-board, both loaded. No cables

Jan 03: two GAFE and two GARC test-boards, unloaded, only GAFE-test-socket provided. No cables/connectors

Limitation:

GAFE-testboard holds 4 of 18 GAFE's

No HVBS

Use: ACD Test-stand HW and SW development; GAFE ASIC test station

7.3 FREE Cards, Part 1

Status: Expected early 02-03

Hardware: (1 Development Unit FREE board, unpopulated, plus parts – after ACD has verified basic operation of the card design.) (more boards ensure that R3 hardware/software to be delivered to ACD I&T will operate more reliably and will be delivered faster since SLAC groups can work in parallel, remember that there are at least three groups at at SLAC involved in the ACD part: the GASU designer needs one FREE, the VX-Works programmer needs one, and the I&T software people need one) **Note from ACD – despite the name, FREE boards are not free. They are fairly large and fairly expensive boards to produce. There is no extra money in the ACD budget for numerous FREE cards. Perhaps we (ACD and Electronics) should put in a CR?**

Cables? Flight-like ACD connector to flight-like GASU connector on a G2 test stand at the outset. **ACD may be able to supply one cable.**

Limitation:

No HVBS

7.4 FREE Cards, Part 2

Status: Expected late Spring, 2003. Delivery depends on development of the second-generation (Engineering model) FREE cards following the delivery of the GAFE4. Flight model FREE cards would only be available after delivery of the GARC2 and GAFE5 chips.

Hardware: (1 tested board, 11 unpopulated boards, plus parts,). Need to see whether GASU hardware as well as dataflow and filtering software is working correctly. Boards are used later as part of the test-bed. **Note from the ACD: this is a Level 3 milestone deliverable, now scheduled for May, 2003. Cost of producing these boards is not part of the ACD budget (and possibly not part of the Electronics budget, so we may have to go to the Instrument Project Office for help).**

Cables: Flight-like ACD connector to flight-like GASU connector on a G2 test stand at the outset. **ACD may be able to supply one cable.**

#? of HVBS boards Note: this is a Level 3 milestone deliverable.

Limitation:

No TV?

8 Flight Electronics at SLAC

Schedule: see PCMS

Hardware: Flight-DAQ with full GASU with redundant electronics.

Flight cables (24) supplied by LAT Electronics to connect full ACD to Flight Electronics

Documentation: LAT-TD-00639-01 Draft THE ACD ELECTRONICS MODULE (AEM)

Location: only at SLAC, there will be no DAQ flight-electronics delivered to GSFC

Capabilities:

same as G3 capabilities

Limitations:

NONE.

Applications:

same as G3

Appendix A – Calibration Unit Interfaces

Basic assumptions:

- We will use test scintillators and phototubes that are functionally equivalent to the flight designs, with test versions of electronics boards, coupled to an engineering model of a GASU supplied by the electronics group (the GASU incorporates the AEM but also includes the GLT trigger logic needed for the calibration). Scintillators will be approximately the size of flight scintillators.
- We will use no scintillating fiber ribbon. The volume and efficiency of a ribbon for backsplash detection is less than 10% that of a typical ACD tile. The ribbons are not used in the on-board processing. For these reasons, the backsplash effect of the ribbons is small enough that the test does not warrant their inclusion.
- Careful measurement (typically 1 mm with respect to the tracker) of the ACD tile positions is essential, for comparison with simulations. Provision for ACD mounting is the responsibility of the LAT I&T group. Because the waveshifting fibers and clear connecting fibers are fairly stiff, it would be helpful to mount the electronics chassis in a location similar to where they will be for the flight unit. The ACD group will be willing to help with design of the mounting.

  The mechanical interface is TBD.

Fig. 1 is a sketch of our Calibration Unit ACD configuration, consisting of 4 tiles - one top flat tile, one top curved tile, and two upper side tiles, forming a corner. Each tile has two sets of waveshifting fibers, so that eight phototubes will be needed for these tiles. In addition, we will add two phototubes with waveshifting fibers but no connection to tiles and two phototubes with no fibers, for the purpose of checking for showers that might trigger ACD signals without hitting scintillators. We will provide one electronics chassis (containing one FREE card populated with one GARCv2 and twelve GAFEv5 (TBR) chips, one HVBS, and twelve photomultiplier tubes). We assume that some version of the central LAT electronics will be available to supply power (+28 V and +3.3 V) as in the flight unit.

Our current assumption is that the electronics interface will be the same as that of Test Stand G2 as described above. **This interface is TBD**

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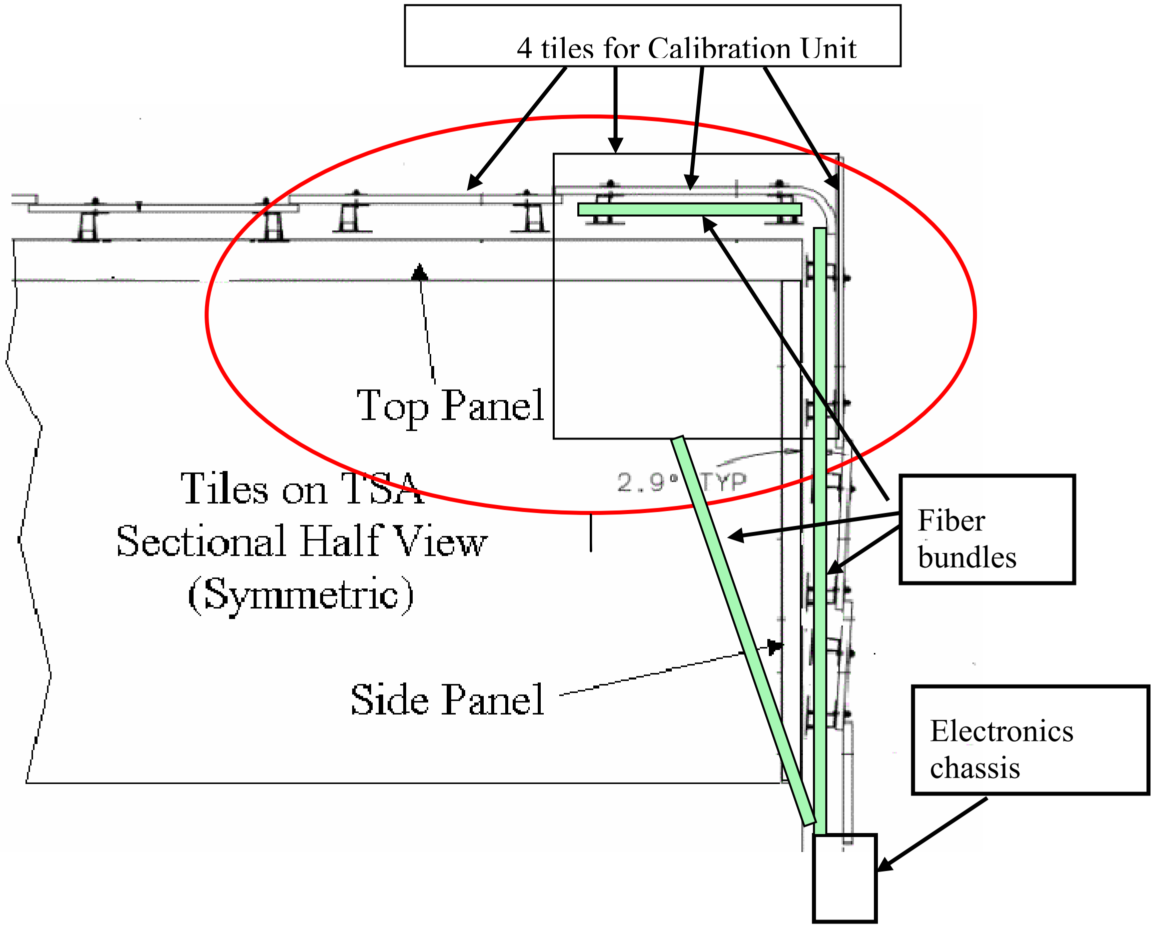

Fig. 1 – The ACD Calibration Unit consists of the four tiles shown within the red oval, plus ten fiber bundles (two from each tile, plus two not connected to tiles) and one electronics chassis mounted in a section of a Base Frame.

Table 1 – Dimensions of the ACD Calibration Unit Tiles

Tile Description	Length	Width	Thickness
Top flat	360 mm	340 mm	10 mm
Top curved	380 mm	340 mm	10 mm
Side	360 mm	380 mm	10 mm
Side	360 mm	340 mm	10 mm

Fig. 2 is a sketch of the ACD Base Frame. The section shown in the red oval is what will be delivered for the Calibration Unit Electronics Chassis. Because the chassis is built to handle up to 18 phototubes, it is longer than a tracker width. The dimensions of the unit to be delivered are 71 mm thick x 152 mm high x 686 mm long.

The Electronics Chassis will have a connector that is the same model as the flight connector, JTP02RE-20-35P(453) which is a MIL-DTL-38999 Series II bayonet coupling low profile metal shell connector with size 22 (high-density) contacts. The shell size is 20, and number of pins is 79. The arrangement of pins is shown below. Figure 3 shows the connector.

Depending on the distance from the ACD to the Test Stand, the ACD group may be able to supply a cable for this interface. The chassis will contain one GARC (digital ASIC) with a flight-like design, meeting the specifications of the Interface Control Document.

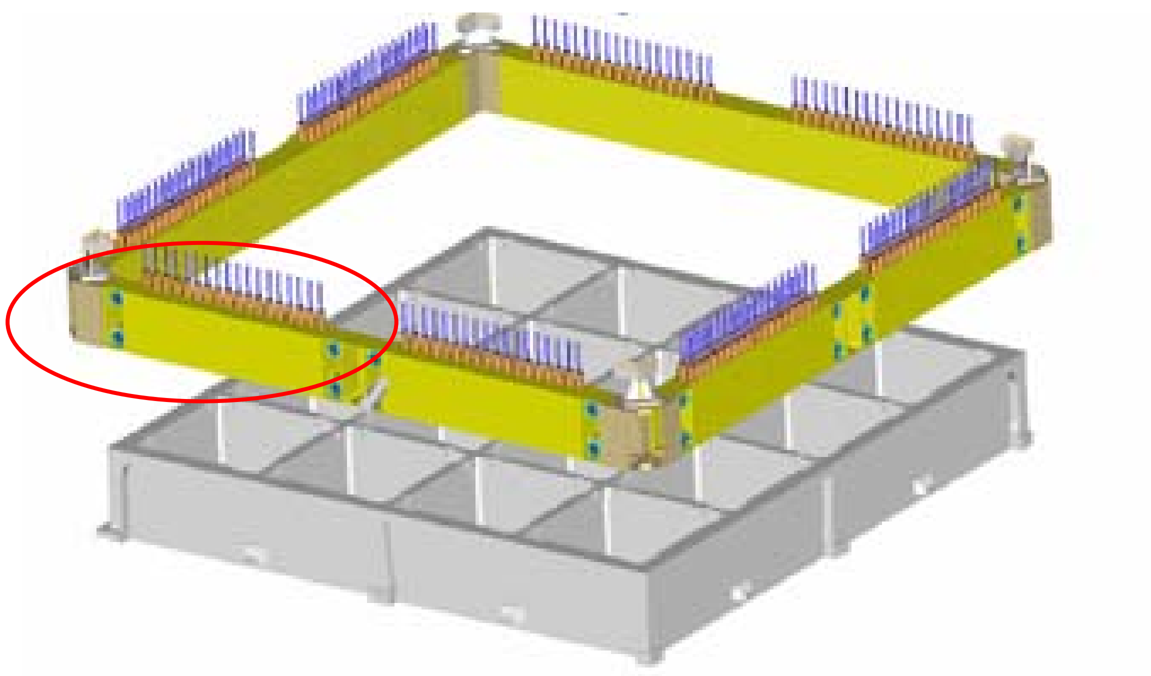

Fig. 2 – ACD Base Frame. The Electronics Chassis for the Calibration Unit will be one section of this assembly, shown in the red oval.

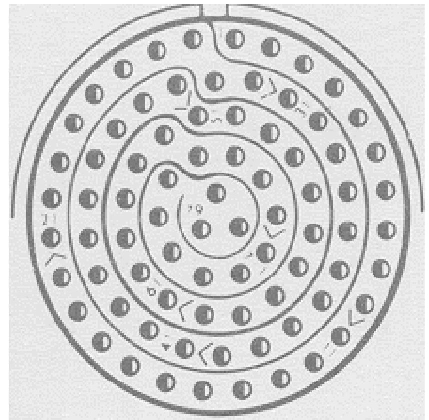

Figure 3. G35 Pin Arrangement

Appendix B - Summary Chart

	Test Stand G0	Test Stand G1	Test Stand G2	Test Stand G3	Flight
Date required (# of units)	4/02 (1)	12/02 (1)	4/03 (3)	07/03(1)	1
Number of (pseudo or) AEM units	1	1	1	2	2
# FREE cards supported	1	1	1	12	12
T-V compatible over –60 to +45 C	No	No	No	Yes	Yes
Interface connector(s)	Not flight-like	Not flight-like	Flight-like	Flight-like	Flight
Cable # and type	1 Non-flight	1 Non-flight	2 Non-flight	24 Flight-like	24 Flight
Write/Read GAFE & GARC registers	Yes	Yes	Yes	Yes	Yes
Send TACK from GSE cmd	Yes	Yes	Yes	Yes	Yes
Generate calibration strobe (TCI)	Yes	Yes	Yes	Yes	Yes
Send TACK from external signal	No	Yes	Yes	Yes	Yes
Send TACK from ACD VETO signal	No	No	Yes	Yes	Yes
Accumulate ACD rates and send to EGSE	No	No	Yes	Yes	Yes
Rate capability	Ground	Ground	Ground	Orbital	Orbital
ACD Trigger Primitives	No	No	??	As flight	Flight
Provide power to ACD	No	No	Yes	Yes	Yes
Read ACD flight temperature sensors	No	No	No	Yes	Yes
GPIB or other interface to test equipment	No	No	??	??	??