Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Dataflow Subsystem Specification

DRAFT 1.4
<table>
<thead>
<tr>
<th>Revision</th>
<th>Effective Date</th>
<th>Description of Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

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1 PURPOSE

This document defines level IV subsystem requirements for the GLAST Large Area Telescope (LAT) Dataflow System (DFS).

2 SCOPE

This specification captures the GLAST LAT requirements for the DF. This encompasses the subsystem level requirements and the design requirements for the DF. The verification methods of each requirement are identified.

This specification is identified in the specification tree of Figure 2-1.

FIG. 2-1 LAT SPECIFICATION TREE

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3 DEFINITIONS

3.1 Acronyms

ACD – Anticoincidence Detector
AGN – Active Galactic Nuclei
CAL – Calorimeter
CNO – Carbon-Nitrogen-Oxide
DFS – Data-Flow System
GLAST – Gamma-ray Large Area Space Telescope
GLT – Global Trigger
GRB – Gamma-Ray Burst
IRD – Interface Requirements Document
LAT – Large Area Telescope
TACK – Trigger Acknowledge
SRD – Science Requirements Document
TBR – To Be Resolved
T&DF – Trigger and Dataflow System
TRG - Trigger

3.2 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 proton up to an iron nucleus and beyond.

Dead Time – Time during which the instrument does not sense and/or record gamma ray events during normal operations. In this document additional dead-time is defined as the dead-time added in relation to a 100% instrument up-time and not as a percentage of the dead-time due to other systems.

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.

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.

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.

MeV – Million Electron Volts, $10^6$ eV

s, sec – seconds

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

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

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.

3.3 Purpose

The purpose of this document is to establish the level IV requirements for the dataflow part of the data acquisition system of the GLAST instrument.

3.4 Scope

The scope of this document is the event data flow, housekeeping, and commanding for the data acquisition system. The requirements for triggers, power supplies, electrical interfaces, and command interface to the spacecraft will be established in separate documents.

3.5 Applicable Documents

- Science Requirements Document (July 9, 1999)

- Spacecraft Performance Specifications Document GSFC-433-SPEC, Draft

- Space Instrument to Spacecraft Interface Requirements Document GSFC-433-IRD, Draft

- EMI/EMC Requirements Document GSFC-433-RQMT, Draft
  [http://glast.gsfc.nasa.gov/project/draft/textglast3d.doc](http://glast.gsfc.nasa.gov/project/draft/textglast3d.doc)

- LAT-SS-00019 Trigger and Dataflow Level III Subsystem Specifications
4 REQUIREMENTS

4.1 System Description

The LAT science instrument (SI) consists of an Anticoincidence Device (ACD), a silicon-strip detector tracker (TKR), a hodoscopic CsI calorimeter (CAL), a Trigger and Dataflow system (T&DF), and a Power Supply system. The principal purpose of the SI is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The T&DF system (or sometimes called DAQ system) provides the gamma-ray identification, readout of the detector measurements, assembly of gamma-ray source location and energy measurements, and the streaming of the data to the spacecraft. The spacecraft temporarily stores and then transmits the data to the IOC. The T&DF system also provides the functions for the instrument control and housekeeping operations. It also controls and monitors the LAT power system.

The trigger system decides whether the instrument should be triggered in response to trigger input information from the detector system. If the instrument is triggered, the detector systems are notified to acquire the data of that event. The trigger system is described in a separate Level IV requirements document. The dataflow system transports the data to the processor system, which filters the events to pick out interesting events. Those events are then forwarded to the spacecraft.

In this document the dataflow system is specified. It includes event data flow, commanding, and housekeeping.

Throughout this document, reference is made to the instrument or to a detector module. The Instrument refers to the sum of all detector modules where there are 16 CAL modules, 16 TKR modules and one ACD. Average event sizes are computed by summing all events over an orbit and dividing by the number of events. Average rates refer to orbit averages, and orbit maximum refers to the peak trigger rate, which occurs when the observatory is at the orbit location corresponding to maximum cosmic ray flux.

5 Trigger Requirements

Trigger requirements are specified in the Level IV Trigger Requirements Document.

6 Event Data Flow Requirements

The DFS shall read out the ACD, CAL, and TKR detector and Trigger event data.

6.1 Event Flow Rate

The DFS shall read out the event data at a rate determined by the Trigger Acknowledge (TACK) signal.
6.2 DFS Contribution to Dead Time

The DFS readout shall not increase the dead time of the instrument more than 5% when the TACK rate is at maximum TACK rate and nor more than 1% when the TACK rate is 60% of maximum.

6.3 Anti-Coincidence Detector (ACD) Event Data

The DFS shall read out the ACD event data assuming the ACD configuration consists of 2 sets of 105 PMTs reading out 105 tiles, where each tile is read out by a redundant pair of PMTs. The PMT outputs are fed to low (Veto) threshold discriminators, and a subset of 65 (TBR) PMT outputs from the top tiles and first row of side tiles are also fed to high-level discriminators to detect high ionizing cosmic rays (CNO). Note that the generation of trigger primitives on the towers are part of the trigger requirement document.

The model is here that the event data is provided to the dataflow system from six 18-channel primary and six secondary (redundant) front-end boards. Each provides 18 ACD Low (Veto) signals, one ACD Hi (CNO) signal. In addition, depending on the trigger type, PHA data is provided either only from channels which are above threshold, or from all. Note that the number of bits to be read out for each hit is defined in the ACD interface document.

6.3.1 ACD Readout Data

The DFS shall readout event data from 6 primary and 6 secondary 18-channel front-end boards.

6.3.2 ACD Veto Word Readout

The DFS shall read out 105 primary and 105 secondary 105 ACD Low (Veto) bits for a total of 210 bits for each event.

6.3.3 ACD CNO Word Readout

The DFS shall read out 6 primary and 6 secondary ACD High (CNO) bits for a total of 12 bits for each event. (One bit from each front-end board).

6.3.4 ACD PHA Readout

The DFS shall be able to read out an instrument total of 105 primary and 105 secondary 12-bit PHA values (with a 5-bit address from each of the front-end board).

6.3.5 ACD Readout Data Content

The DFS shall readout ACD event data as defined in the ACD Electronics Interface Document. It contains the 18-bit ACD Veto word, followed by a variable number of PHA values, up to the maximum of 18 PHA values from each front-end board.

6.3.6 ACD Average LAT Event Size

The DFS shall assume an average of 10 (TBR) tiles PHA information per event.
6.3.7 **ACD Zero-Suppressed Readout Dead-Time**

The DFS shall be able to readout the instrument average, zero-suppressed PHA data at 10 KHz without adding to the average instrument dead-time, assumed to be 20 µsec after a trigger.

6.3.8 **ACD Not Zero-Suppressed Readout Dead-Time**

The DFS shall be able to readout the instrument average, not zero-suppressed PHA data at 50 Hz (TBR) without adding to the average instrument dead-time, assumed to be 20 µsec after a trigger.

6.4 **Calorimeter (CAL) Event Data**

The DFS shall assume 16 CAL modules composed of 96 logs with 2 ends for a total of 192 log ends per module and 3,072 log ends for the instrument. Each log end has 4 gain channels for a total of 768 gain channels per module and 12,288 for the instrument. The logs-ends are read out as 16 layers of 12 channels for each module, via one controller ASIC per layer. Each signal channel has one analog ASIC and one COTS ADC and provides 12-bit ADC data, 2 Signal-Range Bits, and 1 Log-Accept bit. The Log-accept bit is used for zero-suppression. Note that the exact number of bits to be read out for each hit is defined in the CAL interface document.

6.4.1 **CAL Readout Path**

The DFS shall readout event data from 4 Analog Front-End Electronics Boards (AFEE) for each CAL module.

6.4.2 **CAL Readout Data**

The DFS shall readout data patterns as defined in the CAL Electronics Interface Document. It consists of 12 sets of 12-bit ADC data, 2-bit Range Data, and 1-bit Log-Accept bit from each layer of each AFEE board.

6.4.3 **CAL Data Merging**

The DFS shall correlate and merge the measurements from each end of all CsI logs. This requires coordinated merging of data from pairs of AFEE boards.

6.4.4 **Single Range and Four Range Readout**

The DFS shall read out the data from a single gain range or four gain ranges per log-end determined by the trigger type received from the trigger system.

6.4.5 **Zero-Suppression**

6.4.5.1 **Zero Suppression Mode**

The DFS shall zero-suppress the event data depending on the state of the log-accept bit and the trigger type.
6.4.5.2 Zero Suppression Criteria

The DFS shall keep the data of both sides of a log when at least one of the log-end log-accept bits is set or when the trigger type disables zero-suppression.

6.4.5.3 Zero Suppression Log-End Disable

The DFS shall zero-suppress the data based on the state of only one of the two log-accept bits. (Note: needed to disable a channel which threshold comparison is malfunctioning).

6.4.6 CAL Number of Logs Hits

The DFS shall expect instrument average, zero-suppressed CAL event data from 38 logs per event.

6.4.7 CAL Zero-Suppressed Single-Range Readout Dead-Time

The DFS shall be able to readout the instrument average, zero-suppressed single-gain range data at 10 KHz without adding to the average instrument dead-time, assumed to be 20 µsec after a trigger.

6.4.8 CAL Zero-Suppressed Four-Range Readout Dead-Time

The DFS shall be able to readout the instrument average, zero-suppressed four-gain range data at 50 Hz (TBR) without adding to the average instrument dead-time, assumed to be 20 µsec after a trigger.

6.4.9 CAL Not Zero-Suppressed Single-Range or Four-Range Readout Dead-Time

The DFS shall be able to readout the instrument average, not zero-suppressed single or four-gain range data at 1 Hz (TBR) without adding to the average instrument dead-time, assumed to be 20 µsec per trigger.

6.5 Tracker (TKR) Event Data

The DFS shall assume a TKR layout as follows: 16 tracker modules, each with 18 x,y planes, or 36 layers, and each layer with 1536 channels. There are a total of 884,736 channels. Each module is divided into 4 sides, with each side having two independent readout paths (cables). Each layer has 24 front-end ASICs (GTFE) with 64 channels per ASIC. Controllers on each end are limited to 127 (programmable) hit addresses per layer in any given event.

Therefore, each TKR module would in principle have to handle 36 layers*2 controllers *127 hits = 9,144 hits per event per module or 146,304 hits for the instrument total. However the number of hits for each TKR module will be limited for implementation reasons (memory buffer size). The TKR readout word sizes and bit rates are referred to the 4 sides*2cables/side = 8cables which interface the TKR-hybrid mounted electronics to the DFS. Note that the number of bits to be read out for each hit is defined in the TKR interface document.

6.5.1 TKR Dual Readout

The DFS shall readout each layer of the TKR from a dual cable interface with the split between GTFE ASICs within any layer determined by command.
6.5.2 **TKR Single Cable Readout**

Upon command, the DFS shall be able to readout an entire layer through either one of the dual readout cables.

6.5.3 **TKR Readout Event Data Content for Each Layer**

The DFS shall readout TKR event data as defined in the TKR Electronics Interface Document. It contains a header word which identifies the layer and number of hits in the layer, a Time-Over-Threshold (TOT) word, followed by hit addresses of up to the maximum of 127 hits per layer controller.

6.5.4 **TKR Readout Event Data Content for each TKR Module**

The DFS shall readout a total number of 64 hits (32 hits per layer controller) for 30 (tbr) layers and 128 hits (64 per layer controller) for 6 (tbr) layers for a total of 2,688 hits, for each TKR module.

6.5.5 **TKR Readout Calibration Data Content**

The DFS shall readout a total number of 128 hits (64 hits per controller) for a maximum of 10 (tbr) layers for a total of 2,652 hits, for each TKR module.

6.5.6 **TKR Dead-Time**

The DFS readout of the tracker shall have sufficient event buffering that dead time due to readout becomes significant (>1%) only when the readout bandwidth is saturated. This implies that it must be possible to keep the tracker trigger live during readout.

6.5.7 **TKR Hit Number**

The DFS shall readout the TKR assuming a number of hits of 196 hits orbit average and 226 hits orbit maximum. (Info: According to the TKR interface document there are approximately 65 bits per hit on a cable).

6.5.8 **TKR Readout Dead-Time**

The DFS shall be able to readout the instrument average TKR data at 10 KHz without adding to the average instrument dead-time, assumed to be 20 μsec after a trigger.

6.6 **Trigger Event Data**

The DFS shall assume that trigger data is generated on each of the 16 towers as well as on the ACD module and the global trigger module. Note that the number of bits to be read out for each hit is defined in the TRG interface document.

6.6.1 **Time and Event Number Event Data**

The DFS shall read out the trigger time and trigger number for each event.
6.6.2 **ACD Trigger Event Data**

There shall be no contribution from the ACD to the tower trigger event data.

6.6.3 **CAL Trigger Event Data**

The DFS shall read out trigger event data generated by the trigger CAL primitive logic. The data consists of the trigger inputs from the CAL layers, consisting of 8 Cal Lo and 8 Cal High signals (each generated by a logical OR operation of the two log-end signals in the trigger system).

6.6.4 **TKR Trigger Event Data**

The DFS shall read out trigger event data generated by the trigger TKR primitive logic. The data consists of the trigger inputs from the TKR layers, consisting of 36 Layer-Or signals (each generated by a logical OR operation of the two redundant cable signals).

6.6.5 **Global Trigger Event Data**

The DFS shall read out trigger event data generated by the Global trigger logic. The data consists of live and dead-time counters, state of ACD, TKR, and CAL trigger primitive inputs, and the type of trigger requested. (Details see trigger document).

6.6.6 **Trigger Event Readout Dead-Time**

The DFS shall be able to readout the instrument trigger data at 10 KHz without adding to the average instrument dead-time, assumed to be 20 µsec after a trigger.

6.7 **Event Data Bit Rates**

The DFS shall readout events at a rate determined by the average and maximum trigger rates and the readout mode of each element.

6.7.1 **ACD Maximum Discriminator Data Rate Output**

The DFS shall readout the ACD discriminator data at a rate of at least 2.2 Mbps assuming 222 bits per event total for Veto (210 bits) and CNO (12 bits) discriminator output at the maximum trigger rate of 10 kHz.

6.7.2 **ACD Average PHA Data Rate Output**

The DFS shall readout the ACD PHA at an orbit averaged bit rate of at least 5.5kHz * (8address+12ADC+1 Range-bit)*10 tiles/event = 1.2 Mbps.

6.7.3 **ACD Maximum PHA Data Rate Output**

The DFS shall readout the ACD PHA at an orbit maximum bit rate of at least 10kHz*(8address+12ADC+1Range-bit)*10tiles/event=2.1 Mbps.

6.7.4 **CAL Average Data Rate Output**

The DFS shall readout the CAL at an orbit averaged bit rate of at least 5.5KHz*32bits*38 logs/event= 6 Mbps.
6.7.5 **CAL Maximum Data Rate Output**

The DFS shall readout the CAL at least up to a sustained bit rate of 10KHz*32bits*38 logs/event = 12 Mbps.

6.7.6 **TKR Average Data Rate Output**

The DFS shall readout the total instrument TKR at an orbit average rate of 70 Mbps (70Mbps/16modules=4.3 Mbps/module) assuming a noise occupancy of 1e(-4), an average of 196 hits, 65 bits per hit, and an average trigger rate of 5.5 kHz

6.7.7 **TKR Maximum Data Rate Output**

The DFS shall provide a minimum sustained readout of each TKR module at a rate of 9.1 Mbps or 147 Mbps instrument total assuming an average number of hits per event of 226 and 65 bits per hit at maximum trigger rate of 10 kHz.

6.7.8 **Trigger Data Rate Output**

The DFS shall readout the trigger event data at a rate of at least 300bytes*10kHz*8bits = 24(TBR) Mbps. (300 bytes is a first estimate)

7 **Science Housekeeping Requirements**

The DFS shall readout and reset to zero rate counters for monitoring the singles rates of each of the detector modules.

7.1 **ACD Rate Counters**

The DFS shall readout 4 rate counter types from the ACD.

7.1.1 **ACD Rate Counter Word**

The DFS shall readout 16-bit ACD rate counters.

7.1.2 **ACD CNO Discriminator Rate Counters**

The DFS shall count and read the rates of the 6 primary and 6 secondary veto signals from the front-end board via two input-maskable rate-counters (logical OR of enabled inputs)

7.1.3 **ACD Veto Discriminator Rate Counters**

The DFS shall count and read the rates of the 105 primary and 105 secondary veto signals via six input-maskable rate-counters (logical OR of enabled inputs).

7.1.4 **ACD Supertile Rate Counters**

The DFS shall read out an ACD rate counter for each of the 16 Supertiles.

7.1.5 **ACD Zone Rate Counters**

The DFS shall readout an ACD rate counter for each of the 5 zones of the ACD. The counter is input-maskable to select between 1, 2 or 3 hits per zone.
7.2 **CAL Rate Counters**

The DFS shall readout rate counters from each of the 16 CAL modules.

7.2.1 **CAL Rate Counter Word**

The DFS shall readout the CAL rate counters as 16 bit words.

7.2.2 **CAL CAL LO Discriminator Rate Counters**

The DFS shall count and readout the 16 CAL LO signal of each module via two input-maskable counters (logical OR of enabled inputs).

7.2.3 **CAL CAL HI Discriminator Rate Counters**

The DFS shall count and readout the 16 CAL HI signal of each module via two input-maskable counters (logical OR of enabled inputs).

7.3 **TKR Rate Counters**

For each Tracker module, the DFS shall count and read out the 72 layer-OR rate counters via two input maskable counters.

7.4 **Science Housekeeping Readout**

The readout of the science housekeeping rate counters shall be initiated by a command signal. The counters are reset via a Reset command and latched in a buffer on a Latch command. Readout is initiated via a Readback command. Since these are broadcast commands, the instrument counters can be reset and latched synchronously.

7.5 **Science Housekeeping Bit Rate**

The DFS shall have the capability to readout the science rate counters up to maximum rate of 100 Hz.

7.5.1 **ACD Rate Counter Maximum Bit Rate**

The DFS shall have the capability to read out the ACD discriminator and supertile rate counters at a bit rate of \((\text{number of counters, tbr}) \times 16 \text{ bits/second} = y \text{ kbps}\).

7.5.2 **ACD Rate Counter Average Bit Rate**

The DFS shall have the capability to read out the ACD discriminator and supertile rate counters at a bit rate of \((\text{number of counters, tbr}) \times 16 \text{ bits/second} = y \text{ kbps}\).

7.5.3 **CAL Rate Counter Maximum Bit Rate**

The DFS shall have the capability to read out the CAL diagnostic rate counters at a bit rate of 16 modules\(*16\text{bits}*(\text{number of counters, tbr})/\text{sec} = y \text{ kbps}(TBR) \text{ instrument maximum}.}
7.5.4 **CAL Rate Counter Average Bit Rate**

The DFS shall readout the CAL rate counters at an average bit rate of 16 modules*16 bits*7 counters*1/64seconds=y kbps assuming one sample every 64 seconds.

7.5.5 **TKR Rate Counter Maximum Bit Rate**

The DFS shall have the capability to read out the TKR rate counters at a maximum bit rate of 16towers*16bits*2 counters*16/sec=8 k (TBR) bits per second instrument average.

7.5.6 **TKR Rate Counter Average Bit Rate**

The DFS shall readout the TKR rate counters at an instrument average bit rate of 16towers*16bits*2 counters*1seconds= 512 bits per second assuming one sample per second.

8 **Command and Messaging Requirements**

8.1 **Command and Messaging to/from Spacecraft**

The LAT shall interface to the spacecraft as specified in GSFC-433-IRD-0001.

8.2 **CCSDS Data Format**

Telemetry data that are transferred over the command/data bus shall be formatted as CCSDS source packets.

8.3 **Command Data Format**

Command data that are transferred over the command/data bus shall be formatted as MIL1553 packets.

8.4 **1553B Command Services Supported**

The DFS shall not require segmentation or grouping services.

8.5 **SI Command/Response Data**

This section addresses the specific transactions that coordinate DFS-SC operations.

8.5.1 **Housekeeping Data from the DFS**

The DFS shall transfer the housekeeping data packet (which will be down-linked in the S-band telemetry stream by the SC) containing parameters and monitor values necessary for SC monitoring of operation and safety. (Probably not since there is no HSK data required by the SC on the 1553, see SC IRD)

8.5.2 **Time Distribution to DFS**

The DFS shall receive a time message that gives GPS time at the 1 PPS signal. This message will be issued 50 to 100 ms (TBR) after the transition of the 1 PPS signal.
8.5.3 **Ancillary Data To DFS**

The DFS shall receive ancillary data from the SC.

8.5.3.1 **Attitude**

The DFS shall receive from the SC a time tagged attitude vector from the SC Attitude Control Subsystem (ACS) at the attitude control loop rate of 5 Hz (TBR).

8.5.3.2 **Orbit Position Vector**

The DFS shall receive the SC determined orbit position data.

8.5.3.3 **Observation ID**

Other ancillary data, such as observation ids that are generated on the ground, shall be received by the DFS in the data field of commands sent by the SC.

8.5.4 **Ancillary Data Downlink**

The DFS shall include the SC ancillary data received via the command/data bus in the telemetry data stream.

8.6 **Observatory Pointing Commands**

8.6.1 **Transient Event Control**

When enabled, the DFS shall transmit a pointing command to the SC.

8.7 **Transient Alert Message**

The DFS shall be able to generate a Transient Alert Message to the SC for real-time transmission to the ground.

8.7.1 **Transient Message Type**

The Transient message shall contain information indicating the type of event detected.

8.7.2 **Transient Message Coordinates**

The Transient message shall use the J2000 coordinate system to indicate the direction of the Transient.

8.7.3 **Transient Message Timestamp**

The Transient message shall contain the GPS time of the start of the Transient in units of 1 microsecond.

8.7.4 **Transient Message Quality Factor**

The Transient message shall contain a Transient Quality Factor, which is a measure of the confidence that a Transient has been detected.
8.7.5 **Transient Message Sequence Number**

The Transient message shall contain an incrementing sequence number, which uniquely identifies each event.

8.7.6 **Transient Message Revision Number**

The Transient message shall contain an incrementing revision number which permits changes to be issued in the pointing direction and Quality Factor for the same Sequence Number.

8.7.7 **Transient Message Variable Text**

The Transient message shall provide for a variable length text of up to 800(TBR) bytes.

8.7.8 **Transient Message Latency**

The DFS shall compute and transmit the Transient message in less than 5 seconds after the detection of the start of an event.

8.8 **Hardware Commands**

The DFS shall provide hardware commands for the instrument.

8.8.1 **ACD Hardware Commands**

The DFS shall provide for hardware commanding of the ACD as specified in the ACD Interface Document.

8.8.2 **CAL Hardware Commands**

The DFS shall provide for hardware commanding of the CAL as specified in the CAL GCRC Readout Controller Document.

8.8.3 **TKR Hardware Commands**

The DFS shall provide for hardware commanding of the TKR as specified in the TKR GTRC Readout Controller Document.

8.8.4 **Trigger Hardware Commands**

The DFS shall provide for hardware commanding of the Trigger system as specified in the TKR-CAL TEM, ACD EM, and GLT Documents.

8.8.5 **DFS Hardware Commands**

The DFS shall provide for hardware commanding of the DFS.

8.8.6 **Power System Hardware Commands**

The DFS shall provide for hardware commanding of the LAT power system.
8.9  Electronics Calibration

8.9.1  ACD Electronic Calibration
The DFS shall generate and supply a calibration strobe signal, used to inject a signal at the front-end input.

8.9.1.1  ACD Calibration Strobe Minimum Spacing
The DFS shall generate a calibration strobe with minimum spacing of 100 µsec (TBR).

8.9.1.2  ACD Calibration Strobe Timing Accuracy
The DFS shall generate a calibration strobe with a minimum inter-strobe timing precision of 30 µsec (TBR).

8.9.2  CAL Electronic Calibration
The DFS shall generate and supply a calibration strobe signal, used to inject a signal at the front-end input.

8.9.2.1  CAL Calibration Strobe Minimum Spacing
The DFS shall generate a calibration strobe with minimum spacing of 100 µsec (TBR).

8.9.2.2  CAL Calibration Strobe Timing Accuracy
The DFS shall generate a calibration strobe with a minimum inter-strobe timing precision of 30 µsec (TBR).

8.9.3  TKR Electronic Calibration
The DFS shall generate and supply a calibration strobe command, used to inject a signal at the front-end input.

8.9.3.1  TKR Calibration Strobe Command Minimum Spacing
The DFS shall generate a calibration strobe command with minimum spacing of 100 µsec (TBR).

8.9.3.2  TKR Calibration Strobe Command Timing Accuracy
The DFS shall generate a calibration strobe command with a minimum inter-strobe timing precision of 30 µsec (TBR).

8.9.4  GLT Electronic Calibration
The DFS shall supply all instrument calibration strobe commands to the Global Trigger system. (Needed to generate TACK).

8.10 DFS Software Loads Command
The DFS software shall be re-programmable via software load commands.
8.11 DFS Memory Dump Command
The DFS shall be able to dump program memory as well as data memory on command.

8.12 Command Verification
The DFS shall provide for non-destructive, hardware command verification for all hardware commands.

8.13 Configuration State Commands
The DFS shall command the configuration state of each sub-system i.e. detector module, the trigger and dataflow system, and the power system.

8.13.1 Configuration State Table
The DFS shall maintain one or more command configuration tables for each sub-system.

8.13.2 Configuration State Table Updates
The DFS shall maintain a current command configuration table for each sub-system.

8.13.3 Configuration State Initialization
The DFS shall be capable of commanding the state of each sub-system. using a command configuration table.

8.13.4 Command Configuration Verification
The DFS shall be capable of non-destructive readout of the current command state of each sub-system. for comparison with the current command configuration table.

8.13.5 Configuration State Reporting
The DFS shall communicated the configuration state back to the SC at least once per orbit and up to once per second (for ground-testing).

8.13.6 Configuration State Anomilies
The DFS shall detect configuration state anomalies and take corrective action.

8.14 Command Acknowledgement
The DFS shall acknowledge the receipt of each command (to whom, tbr).

8.14.1 Command Counter
The DFS shall increment separate, non-resetable command counters for each processor.

8.14.1.1 Receive Command Counter
The DFS shall increment a non-resetable, non-volatile (tbr) command counter for each command received with one counter for each processor.
8.14.1.2 Execute Command Counter
The DFS shall increment a non-resetable command counter for each command executed
with one counter for each processor.

8.14.1.3 Reject Command Counter
The DFS shall increment a non-resetable command counter for each command rejected with
one counter for each processor.

8.14.2 Command Copy
The DFS shall save a copy of the received command for 100 msec (tbr).

8.14.3 Command Timestamp
The DFS shall generate a timestamp upon the receipt of a command.

8.14.4 Command Verification
The DFS shall verify the execution of each command.

8.14.5 Command Acknowledgement Packet (CAP)
The DFS shall generate a command acknowledgement packet for each command received.

8.14.5.1 CAP Command Counter
The command acknowledgement packet shall include the command counter.

8.14.5.2 CAP Timestamp
The CAP shall include the command timestamp.

8.14.5.3 CAP Command Echo
The command acknowledgement packet shall include a copy of the command as received.

8.14.5.4 CAP Command Verification
The CAP shall include the verification status of each command.

8.14.5.5 CAP Checksum
The CAP shall include a packet checksum.

8.14.6 CAP Transmission
The CAP shall be transmitted after generation to whom (tbr).

8.15 Operating Modes
The DFS shall provide operating modes of the instrument.
8.15.1 **Initialization Mode**

The DFS shall provide a mode to support the initialization of the instrument after power on or anytime by command.

8.15.2 **Checkout Mode**

The DFS shall provide a checkout mode used to determine the functional status of the instrument.

8.15.3 **Calibration Mode**

The DFS shall provide a calibration mode used to calibrate the detector performance, gain, and position.

8.15.4 **Test Mode**

The DFS shall provide for multiple test modes dedicated to specific tests.

8.15.5 **Pointed Mode**

The DFS shall provide for a pointed mode in which the instrument is pointed at a fixed direction in inertial space.

8.15.6 **Data Filtering Modes**

The DFS shall provide commands to configure the higher level software filters (former Level 2 Trigger and Level 3 Trigger.)

8.15.7 **Time Dependent Event Mode**

The DFS shall provide modes which support the detection and acquisition of time dependent events.

8.15.7.1 **Gamma-Ray Bursts (GRB)**

The DFS shall provide for the detection and response to a GRB.

8.15.7.1.1 **Peak GRB trigger rate**

The DFS shall accept a 20 kHz (TBR) additional trigger rate for up to 100 (TBR) milliseconds at any time during nominal operation.

8.15.7.1.2 **GRB detection**

The DFS shall accept a GRB in progress message from the SC or the instrument and initiate a special (TBR) GRB operating mode.

8.15.7.1.3 **GRB alert message**

Open detection by the instrument of a GRB, the DFS shall generate a Transient Alert Message.

8.15.7.1.4 **GRB Dead Time**

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At the peak L1T Trigger Rate, the DFS shall accept up to 2000 additional photon induced L1T triggers during a transient event within 100 (TBR) milliseconds without increasing the dead time by more than 10% (TBR) of the Level 1 Trigger contribution.

8.15.7.2 Active Galactic Nuclei
The DFS shall provide a mode to detect, acquire data from, and send a Transient Alert Message for Active Galactic Nuclei events.

8.15.7.3 Solar flares
The DFS shall provide a mode to detect, acquire data from, and send a Transient Alert Message for Solar Flares which produce gamma-rays within the GLAST energy range.

8.15.8 South Atlantic Anomaly Environment
The DFS shall provide a mode to support instrument operation in the SAA environment.

8.15.8.1 SAA Detection
The DFS shall provide a means of detecting the entry and exit of the SAA (tbr).

8.15.8.2 SAA Response
The DFS shall respond to the SAA entry and exit information supplied by the spacecraft and issue LAT commands to protect the instrument (e.g. lower high-voltage on PMT’s).

8.15.8.3 SAA Mode
When commanded, the DFS shall place the instrument in a safe and stable configuration during the SAA passage and return the instrument to its previous operating configuration upon exit from the SAA.

9 Power Supply
The power system is specified in LAT-SS-00301.

9.1 Configuration
The DFS shall configure and control the on-off state of the power system of the LAT with the exception of the primary and secondary Spacecraft Interface Unit (SIU) power which is controlled directly by the SC.

9.2 Module Control
The DFS shall control the on-off state of the power for each of the 16 TKR-CAL TEM DAQ modules, the 2 ACD DAQ modules, and the 2 Global Trigger DAQ modules independently.

9.3 Redundancy Control
The DFS shall control whether the primary or secondary power supply is used for the electronics modules with the exception of the SIU.
9.4 Sub-System Electronics

The DFS shall control the on-off state of the sub-system electronics, i.e. the 16 CAL, 16 TKR, 12 ACD front-end electronics, independently.

9.5 Sub-System Electronics

The DFS shall operate the rest of the system while part of the front-end electronics are powered off.

10 Instrument Health Housekeeping Requirements

The DFS shall provide housekeeping monitors for the instrument.

10.1 Temperature monitors

The DFS shall provide temperature monitors for the instrument.

10.1.1 ACD Temperature Monitors

The DFS shall monitor the temperature of the ACD at 12 (TBR) places, one for each front-end board.

10.1.2 CAL Temperature Monitors

The DFS shall monitor the temperature of each CAL module at 4 (TBR) places (one for each front-end board).

10.1.3 TKR Temperature Monitors

The DFS shall monitor the temperature of each TKR at 8 (TBR) places (one from each cable).

10.1.4 DFS Temperature Monitors

The DFS shall monitor the temperature at 16 (TBR) locations within the DFS and Grid.

10.1.4.1 Power Supply Temperature Monitors

The DFS shall monitor the temperature of each power supply.

10.1.4.2 Electronics Board Temperature Monitors

The DFS shall monitor the temperature of each electronics board within the DFS.

10.1.4.3 Grid Temperature Monitors

The DFS shall monitor the temperature at 16(TBR) places on the Grid and other structural elements of the instrument external to the DFS housing.

10.2 Input Voltage Monitors

The DFS shall monitor the input voltage for all power supplies.
10.3 Output Voltage Monitors
   The DFS shall monitor the output voltage of all power supplies.

10.4 Input Current Monitor
   The DFS shall monitor the input current to the instrument at the SC power bus interface (tbr).

10.5 Power Supply Current Monitors
   The DFS shall monitor the output current of each power supply (tbr).

10.6 Discrete IO to/from Spacecraft
   The DFS shall interface to the spacecraft as specified in GSFC-433-IRD-0001. (64 Analog and 16 digital inputs/outputs from DFS)

11 Verification Matrix
   To follow