

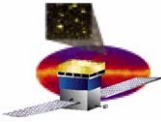
GLAST Large Area Telescope

**Instrument Flight Software
Flight Unit Design Review
16 September 2004**

GRB Detection and Response

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GRB Requirements

- **FSW General Requirements:**
 - **GRB External Detection (5.3.10.1, 5.3.10.1.2, 5.3.10.1.3)**
 - **The SIU FSW shall be able to reconfigure and direct the operation of the LAT instrument within 15 seconds in response to:**
 - **GRB notification message from the GBM via the CTDB**
 - **The SIU FSW shall be able to accept a GRB interrupt from the GBM instrument on a discrete line, for inclusion in the telemetry stream.**
 - **No other response to this signal currently required of FSW**
 - **LAT GRB Detection (5.3.10.2, 5.3.10.2.1, 5.3.10.2.2)**
 - **In any science observation mode, FSW shall monitor the science data to identify GRBs**
 - **For a GRB with default criteria of > 100 reconstructed photons above 1 GeV in less than 20 seconds, the SIU FSW shall execute the algorithm that will locate the source of the GRB to within 10 arcmin (1 sigma radius).**
 - **The default GRB criteria shall be adjustable by command.**

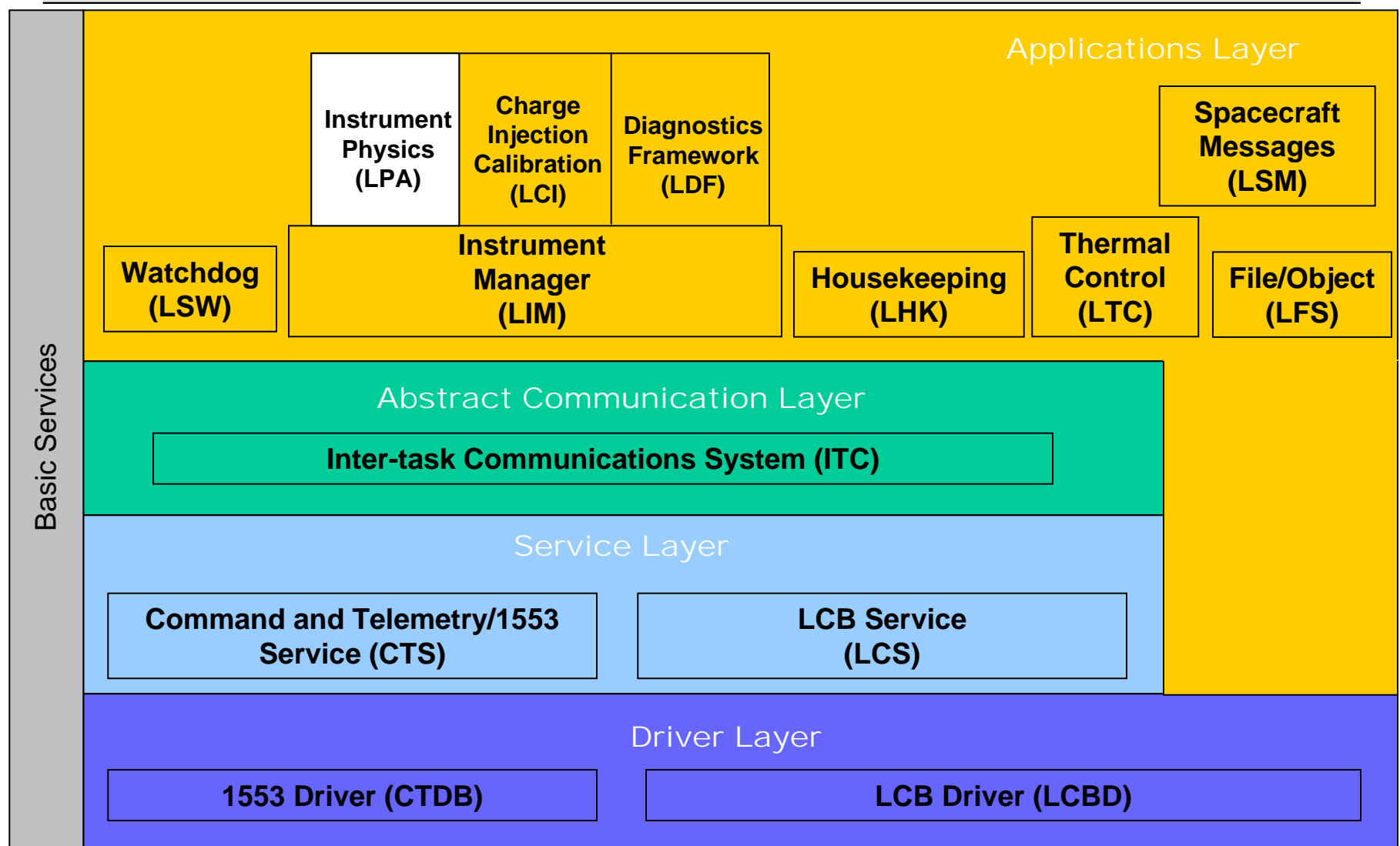


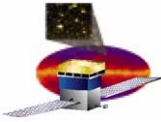
GRB Requirements (cont'd)

- **GRB Response (5.3.11, 5.3.11.1 through 5.3.11.8)**
 - **The LAT FSW shall respond to GRB alert messages from all sources (a GRB alert message/interrupt from the GBM or an internally generated GRB alert) when in Sky Survey or Pointed Observation modes.**
 - **In response to these alert messages, FSW shall:**
 - **Loosen the event filter, allowing more events to be collected for a limited period of time**
 - **Provide buffering for a minimum of 10,000 photon events from a burst**
 - **For LAT-generated alerts**
 - » **Send alert message to Spacecraft over CTDB (within 5 seconds, goal is 2 seconds)**
 - » **Receive and process attitude data from the Spacecraft in order to include GRB location information in its alert message to the Spacecraft**
 - » **Send a command indicating the time of detection for GRBs detected by the LAT**
 - » **Send a message to the GBM after a configurable time period of below-threshold detection of at least one minute (or non-detection)**
 - » **Send a repoint message to the Spacecraft (for GRBs that meet ground-configurable repoint criteria) and handle the Spacecraft's response to that message**



FSW Layer Architecture





Functional Inputs

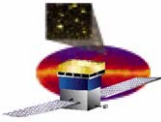
- **5.3.10.1.x Requirements – GRB External Source Notification**
 - **GBM Interrupt/discrete via Spacecraft**
 - **An interrupt into the SIU received via a PID**
 - **Carries no information**

 - **GRB Alert message from GBM**
 - **Follow-on to GBM interrupt**
 - **Localizes and quantifies the alert**



Functional Inputs

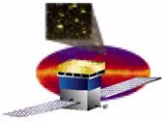
- **5.3.10.2.x – Define a LAT initiated alert**
 - **Attitude data for location of event**
 - Usual 5 Hz messages from the Spacecraft
 - Used to transform local coordinates to RA and DEC
 - **Telecommand to adjust GRB detection criteria**
 - Parameterize the criteria
 - **Response from Spacecraft to repoint request from LAT**
 - Used to evaluate what to do after initiating a repoint request



Functional Processing

- **Functional Processing**
 - Respond to external GRB alerts
 - Collect and buffer event data up to 10,000 photons
 - Locate GRB source to within requirements
 - Generate internal GRB Alert message if GRB detected

- **Functional Outputs**
 - GRB Alert message if LAT-detected
 - GRB repoint request to S/C
 - GRB message with time data to GBM
 - Closeout message for LAT-detected



GRB Detection and Response: Overview

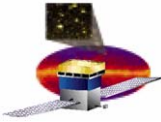
- **What are GRBs**
 - While the science is interesting, for FSW a GRB is simply:
 - A higher than normal photon rate in a localized region

- **What the FSW must do to respond**
 - Loosen trigger
 - Loosen filter
 - Accomplished by switching in pre-defined alternate configurations
 - The form of these configurations is a physics decision
 - Selecting and switching is a FSW process
 - Generate and handle signals and messages to
 - Detect and indicate the location
 - Capture (potentially) large burst of data
 - Filter runs slower on photons



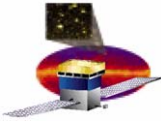
Algorithm for LAT GRB Detection

- **EPU**s identify GRB photons
 - Need criteria for what a GRB photon is
- **EPU**s produce a list of such photons, giving
 - Absolute pointing information + timestamp
 - Energy
 - Confidence level
- **EPU**s forward a list to the **SIU** at ~10Hz
 - **SIU** maintains a time windowed histogram of the last 10 seconds
 - Removes stale entries
 - Adds new entries from the **EPU** lists
- After the update procedure
 - **SIU** scans for the histogram bins that are above detection threshold



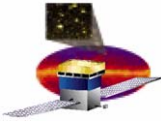
GRB Notification

- Once detected, LAT issues appropriate messages
 - May include a repoint request if confidence level is high
- After GRB is detected:
 - Update messages are periodically issued.
 - Once it dips below the confidence level for 1 minute, a close-out message is issued



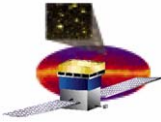
Detection Accuracy and Latency

- The SIU FSW shall execute the algorithm that will locate the source of the GRB to within 10 arcmin (1 sigma radius).
 - **Function of**
 - Onboard reconstruction accuracy
 - Knowledge of the LAT's TKR geometry
 - **Crudely (ignoring improvements for fitting) this is**
 - Strip Spacing / Level Arm / $N^{1/2}$
 - **With**
 - Strip Spacing ~ 200 μm
 - Level Arm ~ 30 cm
 - N ~ 100
 - **Theoretically gives ~2 arcmin**
 - **Not yet demonstrated and there is some worry here**
- The goal is to provide the notification within 2 seconds.
 - **Don't see this as a problem**



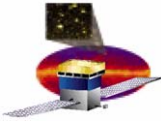
Burst Buffering

- **Is 10,000 events the right metric?**
 - **Has always been an ill-defined requirement**
 - **What is the spirit of this requirement?**
 - **Don't lose photons during a GRB**
 - **Don't cause excessive deadtime during a GRB**
 - **Things to keep in mind**
 - **Photons used to identify a GRB are quick & easy to find**
 - **Photons to be preserved during a GRB are harder**
 - **Second is made more difficult by the tacit assumption that the trigger will be 'opened up', i.e. more junk to paw through**
 - **Second is (perhaps) made easier by loosening the filtering**
 - **This is a work not yet in progress**
 - **Possibly, switch to a buffering mode upon GRB detection rather than completely processing on-the-fly**
 - **Costs about 5-10 μ secs to copy events that pass the initial filter stages to a holding buffer**



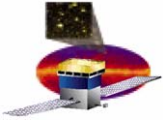
Loosening the Event Trigger/Filter

- The mechanism for adjusting the trigger is
 - Store a number of named trigger configurations
 - When GRB is active (internal or external)
 - Select new configuration based on GRB information
 - Pause the triggering
 - Emit record noting the change
 - Reconfigure the trigger
 - Restart the trigger
- The mechanism for adjusting the filter is the similar



GRB Detection Architecture

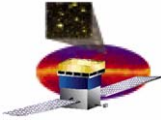
- The GRB Detection function executes as a set of separate tasks running on multiple CPUs.
 - Works in conjunction with the Event Filter and Attitude/Time distribution tasks
- The GRB Detection master task performs the following duties:
 - Responds to alert messages from the ground or from the Spacecraft
 - Creates its own alert messages by
 - Accepting lists of photons from the EPUs
 - Updating a time windowed histogram
 - Issuing alert message when above threshold
- The EPU slave tasks perform the following duties:
 - Identifies photon candidates
 - Attaches absolute direction to the candidates
 - Collects lists of such photons
 - Forwards them to SIU at 10 Hz
 - Responds to requests to reconfigure the filter



GRB-Related Telecommands and Telemetry

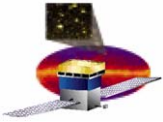
- **Telecommands**
 - Define trigger and filter configurations
 - Define parameters setting GRB photon criteria
 - Energy threshold, quality criteria, etc
 - Define parameters setting GRB detection thresholds
 - Time scales, resolution bins, etc
 - Match a GRB threshold with an action
 - Which trigger/filter configuration to use

- **Telemetry**
 - All actions recorded in telemetry
 - Plus the elaborate LAT – S/C – GBM sequencing



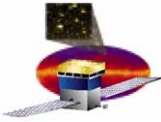
Forward Work

- **Code 50% complete**
- **GRB detection will be demonstrated in January 2005**
- **Code and unit testing complete 1/05/05**



GLAST Large Area Telescope

Backup



LPA Configuration Management

- LPA directly uses the following packages/constituents
 - GRB
 - Filter
 - LEM
 - LATC
 - ITC