GLAST Large Area Telescope

Instrument Flight Software
Flight Unit Design Review
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Charge Injection Calibration

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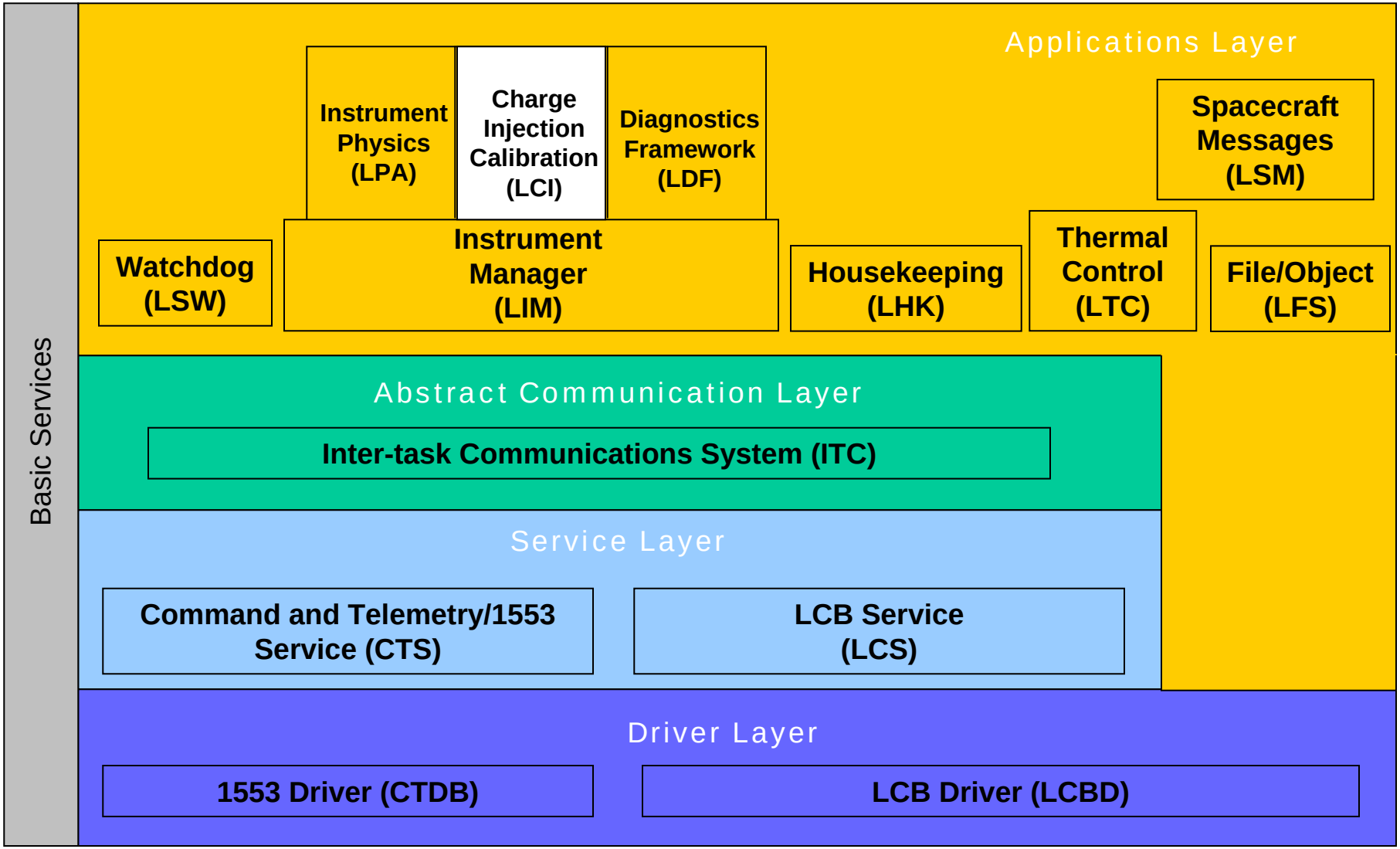
Calibration Requirements

- **Flight Software General Requirements:**
  - **The Calibration FSW support collection of calibration data for each of the major LAT subsystem:**
    - **TKR**
      - **5.3.12.1, 5.3.12.1.1, 5.3.12.1.2, 5.3.12.1.3: Collect data for TKR TOT gain calibration. Parameters for this data collection are stored in an updatable configuration file.**
      - **5.3.12.2, 5.3.12.2.1, 5.3.12.2.2: Perform a TKR threshold scan to collect calibration data to support analysis by the ground to determine the best threshold for each GTFE chip and provide a noise value for each channel.**
      - **5.3.12.3 On command from the ground, perform a TKR trigger check**
    - **ACD**
      - **5.3.12.4, 5.3.12.4.2 , 5.3.12.4.3: Puts the ACD into Charge Injection Calibration Mode, initiates triggers in a required sequence, and returns pulse height data in telemetry**

Calibration Requirements (cont'd)

- **Flight Software General Requirements (cont'd):**
  - **CAL**
    - **5.3.12.5.1, 5.3.12.5.2, 5.3.12.5.2.1, 5.3.12.5.2.2: Put CAL in Charge Injection Calibration Mode ("abbreviated or "detailed" configuration), then initiate a programmable number of triggers for each of a programmable number of amplitude steps**
      - » **Charges must be injected simultaneously**
    - **5.3.12.5.3, 5.3.12.5.3.1, 5.3.12.5.3.2, 5.3.12.5.3.3, 5.3.12.5.3.4 Return the CAL calibration information as a set of histograms of triggered event data.**
      - » **Apply a commanded prescaling factor, forming a multi-peaked**
      - » **For limited, abbreviated calibrations, telemeter raw event data from charge injection**

FSW Layer Architecture



Functional Components

- **Functional Inputs**
  - **LCI reads calibration mode configuration data from files chosen or uploaded by the ground.**
  - **FSW responds to commands to configure the ACD for ACD Charge Injection Calibration Mode or the CAL for CAL Charge Injection Calibration Mode.**
- **Functional Processing**
  - **LCI reads configuration data and initializes calibration of the ACD, TKR, or CAL**
  - **LCI controls injection of a known quantity of charge into the data acquisition electronics**
  - **LCI acquires the resulting event data from the electronics**
  - **LCI reduces the resulting raw data acquired from the electronics**
- **Functional Outputs**
  - **LCI produces reduced calibration data sets applicable to each subsystem (TKR, ACD, CAL)**
  - **LCI sends these data sets to the ground in telemetry**

Calibration: The General Problem

- The goal of calibration is to provide ground software with information characterizing electronics behavior and response. This information enables ground software to:
  - Find dead/noisy channels
  - Characterize channel response and compute calibration curves/constants
    - Linearity
    - Continuity
    - Response range
    - Overlap
- Ultimately, these data are used to establish and adjust tables of calibration constants which are sent back to the instrument and applied in subsequent real-world data acquisition.

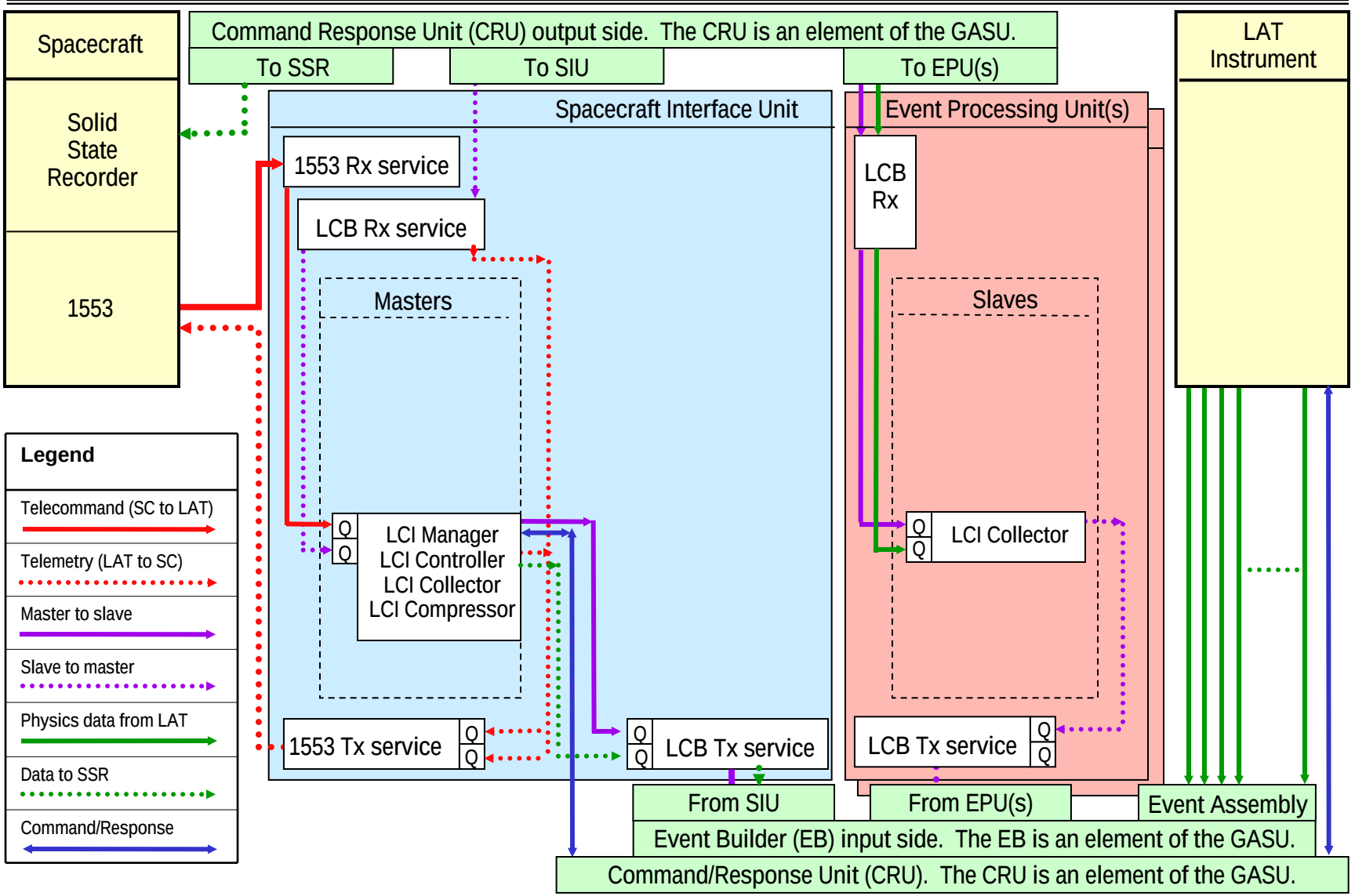
Calibrating the LAT

- **Naturally, under normal operations, real event data is collected on the TKR, ACD, and CAL subsystems.**
  - **Based on the qualities of the raw data, a trigger decision is made in the hardware. If a trigger is issued, front-end electronics throughout the LAT are read out**

- **For calibration, the Calibration FSW triggers the instrument, and controls injection of charge into the electronics front-ends**
  - **The subsystem front-end electronics and the data acquisition system are put into special calibration modes, depending on which subsystem is being calibrated**
    - **The instrument configurations that define these modes are defined by the engineering teams developing each subsystem, not by FSW.**
    - **The Calibration FSW reads these configurations, configures the LAT accordingly, fires the triggers, injects charge, and collects the resulting event data**
  - **Calibration constants are not applied when calibration data is acquired**

- **Calibration data should be collected and reduced in the shortest time possible.**
  - **The instrument is in a dedicated Calibration mode during the process, thus FSW can use whatever processing resources and bandwidth are available to complete the calibration**

LAT FSW Architecture (Calibration Specific)



LCI Processing Overview

- An LCI procedure comprises two active states – acquisition and reduction.
  - Naturally, separate LCI procedures for ACD, TKR, and CAL
    - e.g., TKR trigger check, ACD charge injection calibration procedure
  - Acquisition is the state wherein LCI coordinates configuration, triggering and event collection
  - Reduction comprises statistical processing and construction of a dataset meaningful to ground software.
- In order to minimize the interruption caused by an LCI procedure, acquisition must be done post-haste while reduction (and subsequent telemetry) can be done afterwards and/or in the background.
- Thus, at least initially, these states will be executed serially. That is, the coarse steps of a given LCI procedure are:
  - Acquire raw data for a given LCI procedure
  - Reduce and package results for ground

LCI Software Architecture

- **Manager**
  - Handles constituent initialization, configuration and startup
  - Prepares constituents for subsequent LCI execution
  - Single instance running on SIU
  - Handles setup, control and monitoring of LCI procedure
  - Exports user-level API
- **Controller**
  - Single instance running on SIU.
  - Handles register setup, instrument configuration and trigger synchronization
- **Collector**
  - N instances running on SIU and EPUs (max 3)
  - Event data is processed round-robin fashion among collectors
  - Gathers and stores event data during LCI procedure
  - Minimal event processing/parsing
- **Compressor**
  - Single instance running on SIU
  - Solicits data from collectors
  - Reduces and compresses data
  - Sends results to SSR via science data interface

The Acquisition Step

- Data will be acquired without application of calibration constants.
  - In other words, since the data collected during LCI is used to derive runtime calibration constants on the ground, it must not be otherwise modified by calibration tables used in 'normal' event collection.
- It is likely that standard acquisition settings for each type of LCI procedures will be developed
  - Once the FSW Testbed has matured, and empirical data on throughput, processor load, DAC settling and recovery time, useful DAC ranges, etc, are available
- However, flexibility will be maximized by allowing configuration of parameters, like these example parameters for the CAL:
  - # of towers
  - channels/sample
  - zero suppression
  - sample count
  - theoretical duration/tower
  - four-range/force range
  - charge levels (major cycle)
  - samples/level (minor cycle)
  - event rate

The Data Reduction Step

- One might consider supplying all sample data to ground. However, communication bandwidth constraints prohibit such a plan. The data is reduced:
  - At the cost of a bit of onboard background computation, the LCI reduction pass will construct a dataset less than 2% of the raw data size while providing ground software with enough information to satisfy its requirements.
  - At a minimum it consists of a header and reduced data payload.
    - The header contains a description of the procedure including its parameters, start time, duration, etc.
    - The payload contains statistics reduced from each channel/minor cycle (e.g., capture efficiency for TKR threshold scan, failed channel information for TKR trigger check)
  - The resulting dataset is packed further to minimize telemetry time.

Data Reduction Example

- Again, assuming we're dealing with the CAL, the dataset is structured as follows:
  - Header
    - Test parameters and identification
  - Payload
  - For each of 3072 channels (16 towers * 192 channels)
    - Channel identifier
      - For each charge level (128)
        - » Samples observed (usually = number of minor cycles)
        - » For each of 4 gain ranges (four-range configured)
        - » * High value
        - » * High sample number
        - » * Low value
        - » * Low sample number
        - » * Mean
        - » * StDev
- The uncompressed dataset reflected here is upwards of 6.3MB.
  - Simple compression will reduce it to at most 3MB and likely closer to 1.6MB.
  - If additional compression is necessary, the issue can be revisited

Calibration Telecommands and Telemetry

- **Telecommands**
  - Use file upload command to upload new:
    - TKR TOT parameter file
    - TKR threshold scan parameter file
  - On telecommand, LCI performs a TKR trigger check
  - One telecommand, LCI puts the instrument into calibration modes:
    - ACD Charge Injection Calibration Mode
    - CAL Charge Injection Calibration Mode (abbreviated or detailed)
  - LCI can be commands to return raw CAL charge injection data

- **Telemetry**
  - LCI returns reduced (or raw) calibration data in telemetry

Forward Work

- Coding on Calibration will begin in October 2004
- A demonstration will be held in December 2004
- Coding and unit testing complete on 12/15/04

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Backup

LCI Configuration Management

- **LCI directly uses the following packages/constituents:**
  - **LEM**
  - **ITC**
  - **ZLIB**
  - **FILE**

- **The dependency tree, constituent list, command and telemetry list, and other configuration management information related to LCI are published dynamically on the FSW Web site at http://www.slac.stanford.edu/exp/glast/flight/web/a_pnp/Pack_LCI.shtml**