GLAST Large Area Telescope

Instrument Flight Software
Flight Unit Design Review
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Mode Control, Instrument Safety and Diagnostics

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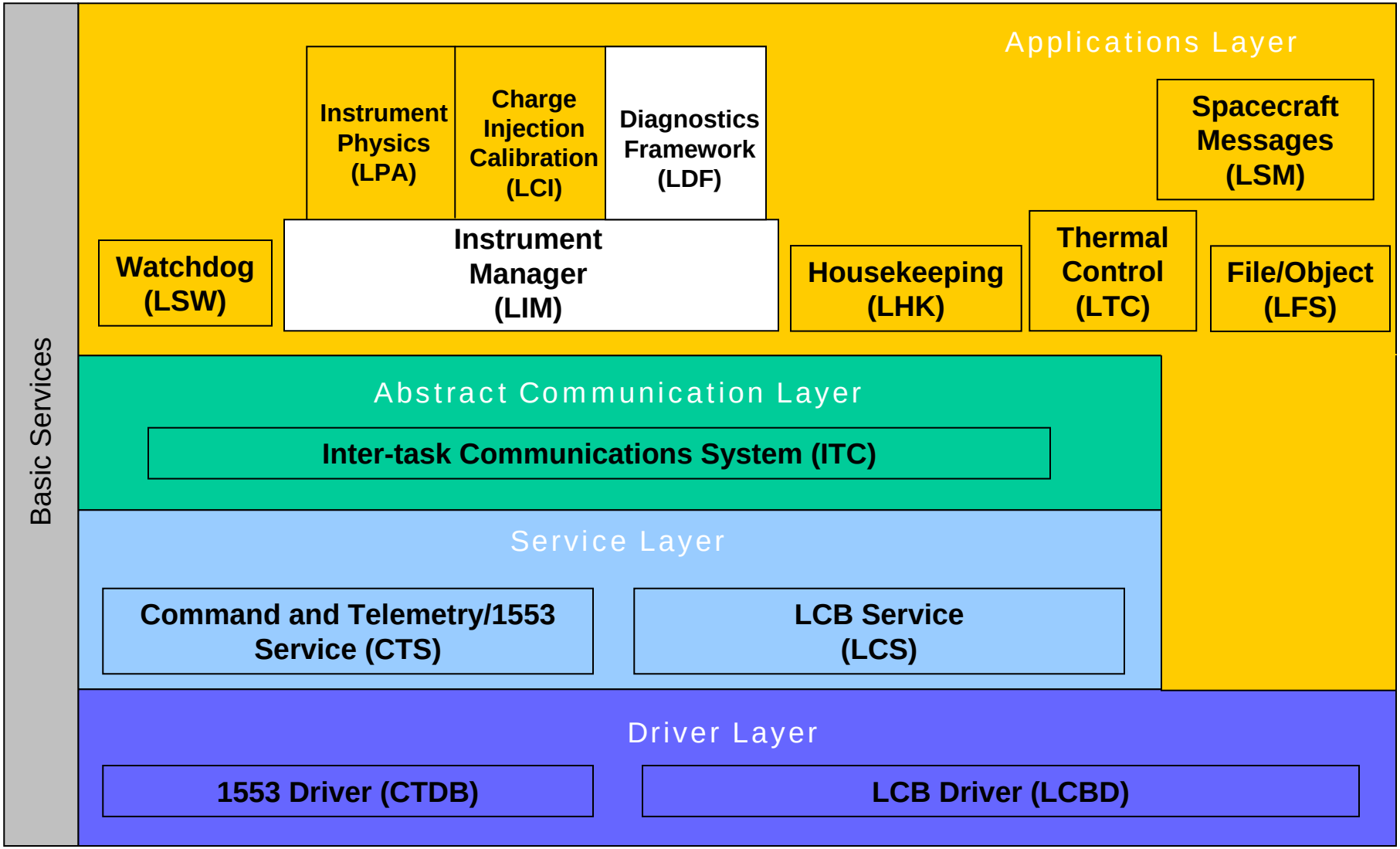
Mode Control and Instrument Safety Requirements

- **Flight Software General Requirements:**
  - **Mode Control (5.3.15)**
    - **The SIU FSW shall support the observatory modes of (1) sky survey, (2) pointed observation, (3) repointed observation, and (4) engineering, in addition to Safe Mode and any required special modes for in-orbit checkout.**
  - **Safe Mode and Load Shedding (5.3.16, 5.3.16.1, 5.3.16.1.1, 5.3.16.1.2, 5.3.16.2, 5.2.16.2.1, 5.3.16.2.2)**
    - **FSW shall process safe-mode and load shedding notification messages from the ground, and put the LAT in safe mode configuration or power off all SIU-controlled LAT components within 15 seconds.**
    - **Assuming that power is maintained during the 15 seconds, the SIU FSW shall put messages into the telemetry stream reporting either entry into Safe Mode or power down due to load shedding.**
  - **SAA Transit (5.3.18, 5.3.18.1, 5.3.18.2, 5.3.18.3)**
    - **Prior to entry into the South Atlantic Anomaly, the FSW shall configure the ACD and CAL for safe transit**
    - **After SAA transit, the FSW shall verify the configuration of the ACD, TKR, and CAL subsystems against their expected configuration and reconfigure if necessary.**

FSW Architecture



Functional Components

- **Functional Inputs**
  - Telecommands and autonomous messages from the Spacecraft to put the LAT in specific operational modes
- **Functional Processing**
  - FSW sets hardware registers to put the LAT in the desired modes:
    - Observatory modes: sky survey, pointed observation, repointed observation, engineering
    - SAA Transit mode
    - Safe Mode
    - Diagnostics mode
  - FSW controls power up and power down of the LAT to respond to load shedding messages
- **Functional Outputs**
  - After load shedding occurs, if power is available, FSW sends notification of load shedding in telemetry
  - After transitions to Safe Mode, if power is available, FSW sends safe mode notification in telemetry

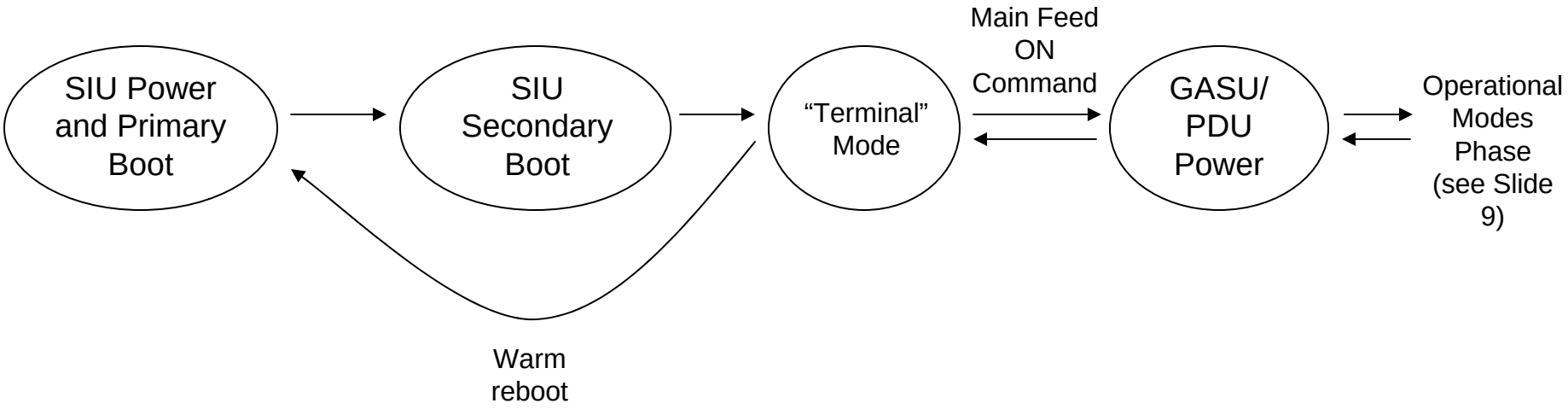
Mode Control Overview

- **The Software Requirements Specification defines the following set of operational modes (launch and early mission modes before FSW is operational are not addressed here):**
  - **Sky Survey Mode**
    - **In Sky Survey mode the observatory can be pointed in the Zenith direction or it can be commanded to change orientation to obtain a full sky survey in two orbits.**
    - **Physics Acquisition mode in FSW mode control model**
    - **FSW does not distinguish between Sky Survey and Pointed Observation modes**
  - **Pointed Observation Mode**
    - **The observatory can be commanded to perform a "point anywhere at anytime" to gather data on a specific celestial object. Earth avoidance is autonomously performed to maximize science data collection.**
    - **Physics Acquisition mode in FSW mode control model**
    - **FSW does not distinguish between Sky Survey and Pointed Observation modes**
  - **Repointed Observation Mode**
    - **The repoint observation mode is the interrupt of the sky survey or pointed observations for ground commanded Target of Opportunity (ToO) or autonomous repoint request. The observatory shall repoint to the target for a set time and return to the original mode. ToOs are ground commanded changes to the scheduled pointing timeline. Repointed mode is also a response to an autonomous repoint request to investigate a Gamma Ray Burst.**
    - **Physics Acquisition: ToO and Physics Acquisition:ARR modes in FSW model**

Mode Control Overview (cont'd)

- **Safe Mode**
  - **Safe mode is used when the LAT instrument has sustained a hardware failure where transition to a redundant unit is required.**
  - **LAT Safe Mode in FSW model**
- **Engineering Mode**
  - **The Engineering mode is used for more extensive troubleshooting and diagnostics than can be performed in safe mode. During Engineering Sub-Mode, TDRSS provides high rate housekeeping. Also used when initiating new software uploads and performing raw data downlinks. The default control mode for the observatory will be continuous zenith-pointed scanning.**
  - **Quiescent, Calibration and Diagnostics modes in FSW mode model**
- **SAA Transit Mode**
  - **The Spacecraft provides an SAA message to the LAT. The LAT then safes the High-Voltage power supplies for the ACD photo multiplier tubes. No other instrument state changes are required.**
  - **This mode is available from all other modes.**

Mode Control State Machine: Boot and Power Phase



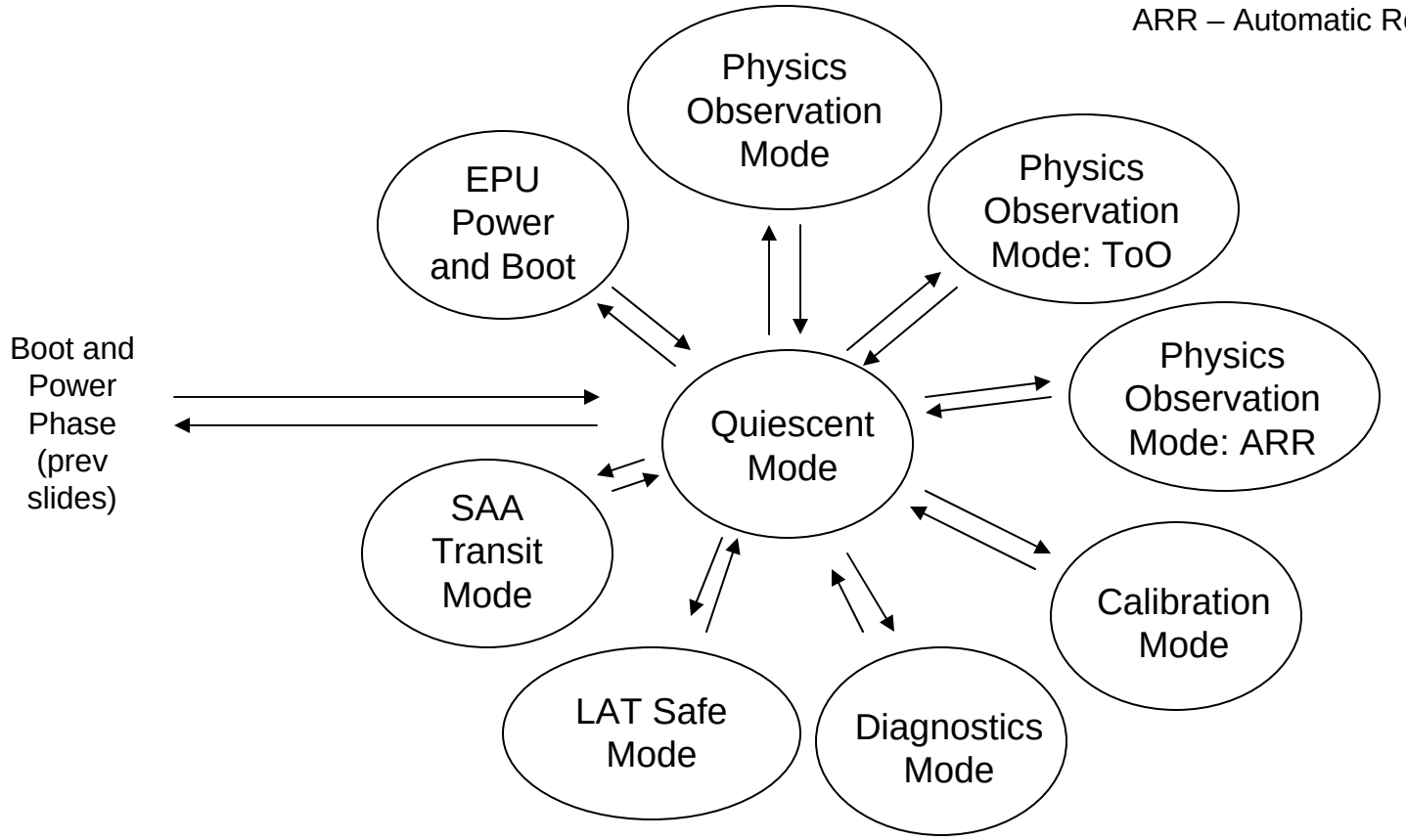
Boot and Power Phase and LAT State

Mode	SIU state	EPU state	GASU/PDU/DAQ state	FSW states
SIU Power/Boot Mode	Power On	Power Off	Power Off	•Boot code operational •Polled mode 1553 and LCB drivers available
Terminal Mode	Power On	Power Off	Power Off	•Command and Telemetry Service operational •1 PPS Interrupt enabled •Attitude/Time task operational •File/Object task operational •Housekeeping operational •Watchdog operational •Thermal Control System operational
GASU/PDU Power Mode	Power On	Power Off	•PDU Power On •GASU/DAQ Power On •Front-end electronics power on	•LCB Service operational

Mode Control State Machine: Operational Modes Phase

Legend

ToO – Target of Opportunity
ARR – Automatic Repoint Request



Commanding Mode Transitions

- Quiescent mode accepts a large number of commands
  - Start command for any of the downstream operational modes
- Once a mode transition has been accomplished, only mode-specific commands are accepted:
  - In the Physics Acquisition modes, Calibration mode, and Diagnostics mode, no power up/down commands accepted
    - The exceptions:
      - A Load Shed command is honored, sending the LAT back to Quiescent, then to LAT Safe Mode
      - LAT Safe Mode and SAA Transit commands are accepted, also sending the LAT back to Quiescent, then on to the appropriate mode
  - Each mode accepts a Stop command, after which the system returns to Quiescent.
- Thus, Quiescent mode serves as the synchronization point between the Spacecraft and the LAT, mediated by FSW:
  - Out-of-mode commands received from the Spacecraft are rejected
  - Once back in Quiescent, all commands are accepted and Spacecraft and instrument states can be reconciled

Operational Modes and LAT State

Mode	SIU state	EPU state	GASU/PDU/DAQ state	Other FSW states
Quiescent Mode	Power On	Power On	Power On	* Instrument Physics master and slave tasks operational on SIU and EPU
EPU Power/Boot Mode	Power On	Power On	Power On	•Master/slave inter-task communications initialized •GBM interrupt enabled
Physics Acquisition Mode	Power On	Power On	Power On	NA
LAT Safe Mode	Power On	Power On	Power On	NA
Diagnostics Mode	Power On	Power On	Power On	NA
Calibration Mode	Power On	Power On	Power On	* Calibration FSW master and slave tasks operational on SIU and EPU

Safe Mode and Load Shedding

- Upon receipt of a load shed command
  - The current operation is given 5 seconds to stop
  - The LAT is powered down in the reverse order of power on
    - 100 millisecond delay between each switch
    - Total time to power off 6.2 seconds
  - Load shed completes in 11.2 seconds
- Load shedding command cannot be canceled.
  - Once load shedding begins, the process cannot be reversed.
- Load shedding is complete when the LAT is in the “Terminal” mode.
  - Transition back to Quiescent by “Main Feed On” command.
- LAT Safe Mode stops short of powering off the GASU/PDU(s).
  - Safe mode to Quiescent transition by single command.

Diagnostics Framework

Diagnostics: Requirements

- **Flight Software General Requirements:**
  - **Diagnostics During Special Modes (5.3.13.2, 5.3.13.2.1, 5.3.13.2.2, 5.3.13.2.3, 5.3.13.2.4, 5.3.13.2.5)**
    - **The FSW provides the means to perform on-orbit diagnostics of the ACD, TKR, CAL, and T&DF subsystems through monitoring activities by establishing special configurations and executing algorithms provided by the subsystem designers. FSW shall be able to conduct special diagnostics and return data on:**
      - **ACD Trigger Mode**
      - **ACD Pedestal Data**
      - **CAL Pedestal Value Data**
      - **CAL Pedestal Histogram Data**
      - **TKR GTRC Rates**

Diagnostics Framework

- FSW provides a diagnostics capability in two ways:
  - FSW can execute special-purpose diagnostic algorithms when in Diagnostics Mode
  - FSW issues a regular diagnostic data stream in telemetry
- FSW provides a framework or infrastructure for running special-purpose diagnostics
  - It is not possible to anticipate every type of diagnostic procedure that may have to be performed
  - The bulk of the configuration data and diagnostic algorithms will be provided by the ground and executed within the FSW diagnostic framework
- This framework is scheduled to be implemented as the LDF (LAT Diagnostics Framework) software package
  - Only those diagnostic algorithms formally specified in the SRS will be implemented in LDF
  - Additional diagnostic configurations and algorithms must be provided by the ground
- Charge Injection Calibration is an essentially a single extensive diagnostic procedure, and a good example of the kinds of diagnostics the general framework can support
  - Calibration will be covered later in the review session

Mode Control, Safety, and Diagnostics: Telecommands and Telemetry

- **Telecommands**
  - Commands to change LAT operational modes (e.g. Diagnostics Mode)
  - File upload commands to change configuration data for diagnostic runs
  - File upload commands to change diagnostic algorithms

- **Telemetry**
  - Critical housekeeping telemetry fields:
    - Current operational mode
    - Time of last mode transition
    - Confirmation of load shedding operation or transitions to LAT Safe Mode
  - Regular diagnostic telemetry messages issued by FSW tasks
  - In Diagnostics Mode:
    - ACD pedestal data histograms
    - CAL pedestal data
    - CAL pedestal data histograms
    - TKR GRTC
    - Other diagnostic results, depending on the goals of ground-defined diagnostic algorithms

Forward Work

- **Coding progress:**
  - **Coding on mode control via the Instrument Manager to begin in October**
  - **Coding on the power control package is 50% complete**
  - **The Diagnostics Framework is 20% coded**
- **Upcoming demonstrations**
  - **Power control will be demonstrated in October 2004**
  - **Mode control and diagnostics framework demonstrated on a fully developed Testbed in February 2005**
- **Coding and unit testing for all functions complete on 11/15/04**