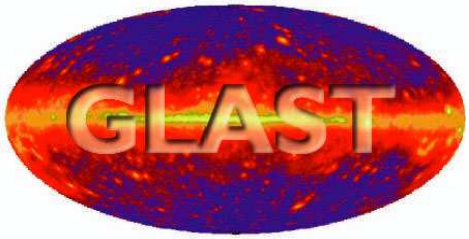


# *LAT Flight Software*

# LIM Package Design

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A description of the design of the LAT Instrument Manager (LIM) package and its control of the operating mode of the LAT Flight Software.

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# 0 Introduction

The LAT Instrument Manager (LIM) package contains functions and command handlers that run on the SIU CPU and manage the ***operating mode*** of the LAT flight software. The operating mode determines the types of operations the LAT flight software is allowed to perform, based on the current state of the LAT instrument. LIM is responsible for the transitions between the operating modes and ensures that the flight software performs only the actions appropriate for the current mode.

Most transitions of the LAT operating mode are initiated by commands sent to LIM from the ground, the spacecraft, and other flight software tasks. When LIM receives one of these commands, it performs all actions necessary to make the transition to the new operating mode, such as applying power to various parts of the instrument or notifying other flight software components that a mode change has occurred.

LIM intercepts commands intended for certain other flight software tasks to ensure that only allowed actions are performed. If LIM determines that a command is valid for the current operating mode, it forwards the command to the intended target task. By filtering commands in this manner, other flight software does not have to be aware of the current LAT operating mode.

# 1 Modes and States

The LIM software manages the operating mode of the LAT flight software. LIM uses a number of factors to determine the current instrument operating mode:

- Commands and messages received from the spacecraft, ground, and other flight software tasks
- Internal events such as timer expirations
- States of various flight software tasks

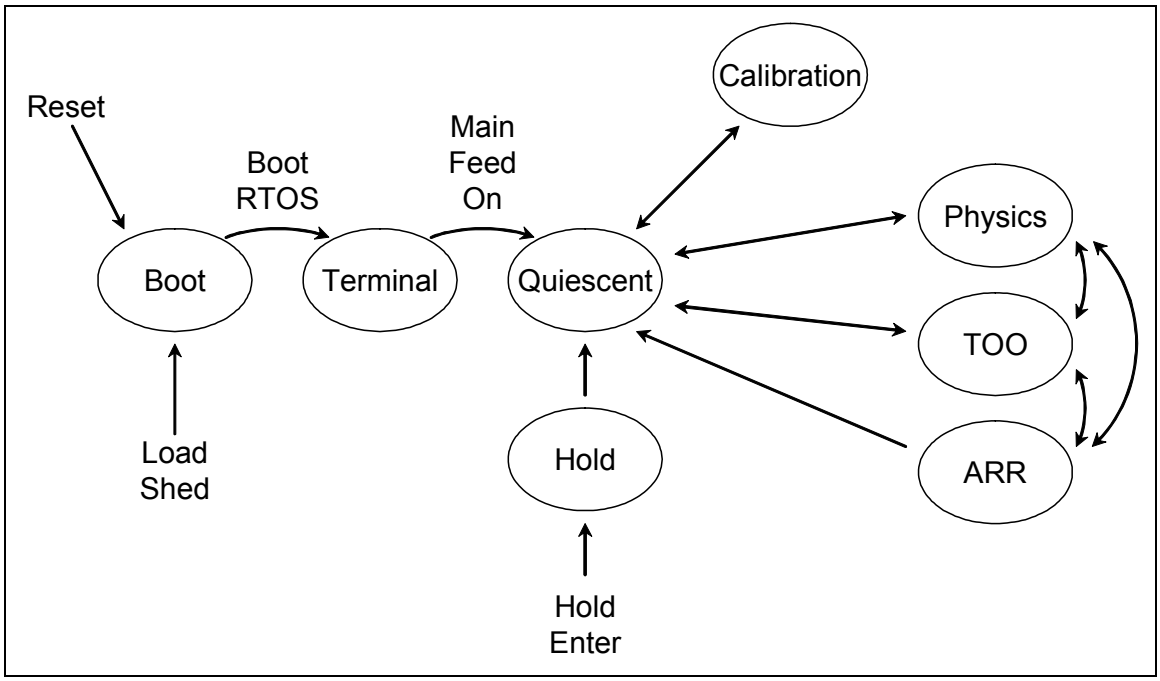
## 1.0 Operating Modes

At any given time, the LAT instrument can be in one of several operating modes, as described in Table 1. Transitions between these modes are initiated by commands, messages, and internal LIM events. Figure 1 is a diagram of these transitions and identifies some, but not all, of these initiating commands.

Table 1 – LIM Operating Modes

| Name | Description |
|---|---|
| Boot | Primary Boot Code (PBC) running and LIM ***not*** running |
| Terminal | Initial LIM mode |
| Quiescent | Ready for physics observations or calibration |
| Hold | Stable mode for troubleshooting |
| Calibration | Charge injection calibration functions are active |
| Physics | Normal sky survey or pointed observation activity is in progress |
| TOO | Target of Opportunity observation activity is in progress |
| ARR | Autonomous Repoint Request activity is in progress |

Figure 1 – LIM Operating Mode Transition Diagram




The spacecraft, LAT instrument, and LAT flight software also operate within their own sets of states and modes – some of which are determined by the LIM operating modes. Table 2 shows the correlation between the LIM operating modes and some of these external states and modes.

Table 2 – Operating Mode Correlations

| External Mode/State | LIM Operating Mode |
|---|---|
| Primary Boot | Boot |
| Secondary Boot | LIM transitioning from Boot to Terminal |
| Load Shed | Boot |
| GASU/PDU Power | Quiescent |
| SAA Transit | Supported in all LIM modes |
| Engineering | Quiescent, Calibration, Hold |
| Sky Survey | Physics |
| Pointed Observation | Physics |
| LPA NORMAL mode | Physics |
| Repointed Observation: TOO | TOO |
| LPA TOO mode | TOO |
| Repointed Observation: ARR | ARR |
| LPA GRB0, GRB1, and GRB2 modes | ARR |

# 1.0.0 BOOT Mode

Immediately after reset, the SIU is in a mode in which only the Primary Boot Code (PBC) is running. No other flight software (including LIM) is running in this mode, and the SIU is the only

LAT component that is powered. Even though LIM is not running, this mode of SIU operation is identified as LIM's BOOT mode because it is the mode into which LIM places the SIU when it receives a Load-Shed command.

From the BOOT mode, LIM transitions to the TERMINAL mode when the secondary boot process starts the LIM task. The secondary boot process is initiated by the PBC when it receives the LBTRTOSEXEC (LPBCRTOSEXEC) command.

LIM returns to the BOOT mode when it receives the Load-Shed command, regardless of the current operating mode. LIM makes this transition by resetting the SIU as the final step of its Load-Shed command handling procedure.

### 1.0.1 TERMINAL Mode

When LIM is started by the secondary boot process, it begins operation in the TERMINAL mode. When LIM is in this operating mode, all other flight software tasks are running as well, but some are idle. As is true during BOOT mode, the SIU is the only component of the LAT instrument that is powered during TERMINAL mode.

From the TERMINAL mode, LIM makes the transition to the QUIESCENT mode when it receives the LIMMAINFEEDON (Main-Feed-On) command.

### 1.0.2 QUIESCENT Mode

The primary purpose of the QUIESCENT mode is to provide a mode in which the LAT can be made ready for physics observations and charge injection calibrations. When LIM is in this mode, the GASU and PDU have been powered and LIM accepts commands to enable and configure power to other LAT components.

From this mode, LIM transitions to a number of different modes, depending on the type of activity requested (e.g. physics observations or charge injection calibrations).

### 1.0.3 HOLD Mode

The HOLD mode exists to provide a stable environment in which commands can be sent to the LAT instrument for error investigation and recovery. While in this mode, LIM rejects all commands except those that affect the safety of the instrument (SAA-Enter, SAA-Exit, and Load-Shed) and the command that causes a transition out of the HOLD mode (Hold-Exit). This keeps the LAT instrument in a stable state even if the spacecraft continues to send previously-scheduled commands.

LIM enters the HOLD mode only when it receives a Hold-Enter command. It remains in this mode until it receives a Hold-Exit command, at which time it transitions to the QUIESCENT mode. (As in most other modes, LIM will also leave the HOLD mode if it receives a Load-Shed command.)

### 1.0.4 CALIBRATION Mode

The CALIBRATION mode is used to perform charge injection calibrations. While in this mode, LIM forwards all intercepted LCI commands to the LCI task. (LIM rejects intercepted LCI commands when not in the CALIBRATION mode.)

LIM transitions to this mode when it receives a Calibration-Start (LCI-CALIBRATE) command while in the QUIESCENT mode.

LIM remains in the CALIBRATION mode until it receives a message from the LCI task indicating that the calibration procedure has completed, at which time LIM returns to the QUIESCENT mode. The LCI task sends this completion message either as a result of a Calibration-Abort (LCI-ABORT) command or the completion of a pre-determined calibration procedure. If the LCI task fails to send this completion message, LIM remains in the CALIBRATION mode until it receives a Load-Shed or Hold-Enter command.

## 1.0.5 PHYSICS Mode

When LIM is in the PHYSICS mode, it allows the LPA task to perform normal Physics Observation operations. This mode encompasses the Sky Survey and Pointed Observation LAT observation modes, which are identical from the perspective of LIM.

LIM transitions to this mode from the QUIESCENT mode when it receives a Physics-Start (LPA-START) command. LIM remains in the PHYSICS mode until it receives a message from the LPA task indicating that the physics observation has completed, at which time LIM returns to the QUIESCENT mode. The LPA task sends this completion message as a result of a Physics-Stop (LPA-STOP) command or an internal LPA error.

A physics observation can be interrupted by a repointed observation initiated by a TOO-Start command, a trigger signal or message from the GBM, or a message from LPA itself. When LIM receives one of these repoint indications, it instructs LPA to change to the appropriate LPA-TOO or LPA-GRB mode and then makes the transition to the TOO or ARR operating mode. If the LPA task is RUNNING at the completion of the repointed observation, LIM returns to the PHYSICS mode and instructs LPA to return to the LPA-NORMAL mode. (If the LPA task is not RUNNING at that time, however, LIM returns to the QUIESCENT operating mode.)

## 1.0.6 TOO Mode

The Target of Opportunity (TOO) mode is entered when the ground wants to interrupt a scheduled activity to observe an unanticipated target. When LIM receives the TOO-Start command, it instructs LPA to change to the LPA-TOO mode (if LPA is RUNNING) or it starts a new observation run in the LPA-TOO mode (if LPA is IDLE). In both cases, LIM makes the transition to the TOO operating mode.

LIM remains in the TOO mode until the end of the TOO period, the length of which is specified in the TOO-Start command. At the conclusion of the TOO period, if the LPA task is RUNNING, LIM makes a transition back to the PHYSICS mode and instructs LPA to return to the LPA-NORMAL mode. If the LPA task is IDLE, however, LIM returns to the QUIESCENT mode.

The TOO operating mode can be interrupted by an ARR observation, as described below. Also, if a TOO-Start command arrives within the ARR operating mode, LIM starts its internal TOO timer but remains in the ARR mode. It's not until the end of the ARR observation that LIM makes the transition to the TOO mode and instructs LPA to change to the LPA-TOO mode (unless the TOO timer expired while in the ARR operating mode).

## 1.0.7 ARR Mode

The Autonomous Repoint Request (ARR) mode is entered when the LPA task or the GBM wants to interrupt a scheduled normal physics run or TOO observation to observe an unanticipated target. When LIM receives a trigger signal or message from the GBM or a GRB message from the LPA task, it instructs LPA to change to one of the LPA-GRB modes and then makes the transition to the ARR operating mode.

At the completion of the ARR observation, LIM returns to the TOO or PHYSICS operating mode and instructs LPA to change to its corresponding mode. If the LPA task is not RUNNING, however, LIM returns to the QUIESCENT operating mode.

## 1.1 SAA

When LIM receives the SAA-Enter command, it alters the ACD configuration to place it in a state that is safe for SAA transit. It also updates its internal state to indicate that a transit is in progress. LIM holds the ACD in this safe state until it receives the SAA-exit command, at which point it restores the ACD to its nominal state.

If the LPA task is RUNNING when the SAA-Enter command is received, LIM sends a Physics-Stop command to the LPA task. If the current operating mode is PHYSICS, this causes a transition to the QUIESCENT operating mode. During the SAA transit, LIM rejects all Physics-Start commands that it receives.

If the current mode is TERMINAL, HOLD, or QUIESCENT when LIM receives the SAA-Enter command, it operates normally, with the restriction that it holds the ACD in a safe state.

## 1.2 Target of Opportunity

One of the 'higher priority' activities that the LAT instrument can perform is a Target-of-Opportunity (TOO) repointed observation initiated by a TOO-Start command. When LIM receives this command, its response depends on the current operating mode:

- In the QUIESCENT operating mode, LIM sends a Physics-Start command to LPA to start a new observation run in the LPA-TOO mode. LIM also starts a timer to countdown the requested repoint period and makes the transition to the TOO operating mode.
- If LIM is in the PHYSICS operating mode when a TOO-Start command arrives, it starts a timer to countdown the requested repoint period, instructs the LPA task to change to the LPA-TOO mode (if the LPA task is RUNNING), and makes the transition to the LIM TOO operating mode.
- If LIM is in the ARR operating mode when a TOO-Start command arrives, it starts a timer to countdown the requested repoint period but it remains in the ARR operating mode. If the TOO timer has not expired when the ARR observation ends, LIM at that time instructs the LPA task to change to LPA-TOO mode and makes the transition to the LIM TOO operating mode.
- In the TERMINAL, CALIBRATION, or HOLD operating mode, LIM rejects TOO-Start commands because the LAT instrument is not ready to perform physics observations.

While the TOO timer is active, LIM rejects TOO-Start commands because the LAT instrument is already performing a TOO observation or is ready to perform one. This is generally the case when LIM is in the TOO operating mode, but it could also be true in the ARR operating mode.

## 1.3 Autonomous Repoint Request

Another 'higher priority' activity that the LAT instrument can perform is an Autonomous Repoint observation. This type of observation is initiated either by the LPA task when it sends a GRB command to LIM, or by the GBM when it sends a message or asserts a trigger signal.

When LIM receives an ARR indication, its response depends on the current operating mode:

- In the TERMINAL, HOLD, CALIBRATION, or QUIESCENT operating mode, LIM ignores the ARR indication and remains in the current operating mode.

- If LIM is in the PHYSICS or TOO operating mode when the ARR indication arrives, it instructs LPA to change to one of the LPA-GRB modes and then makes the transition to the LIM ARR operating mode.
- In the ARR operating mode, LIM handles GRB indications as described in the GRB Handling chapter.

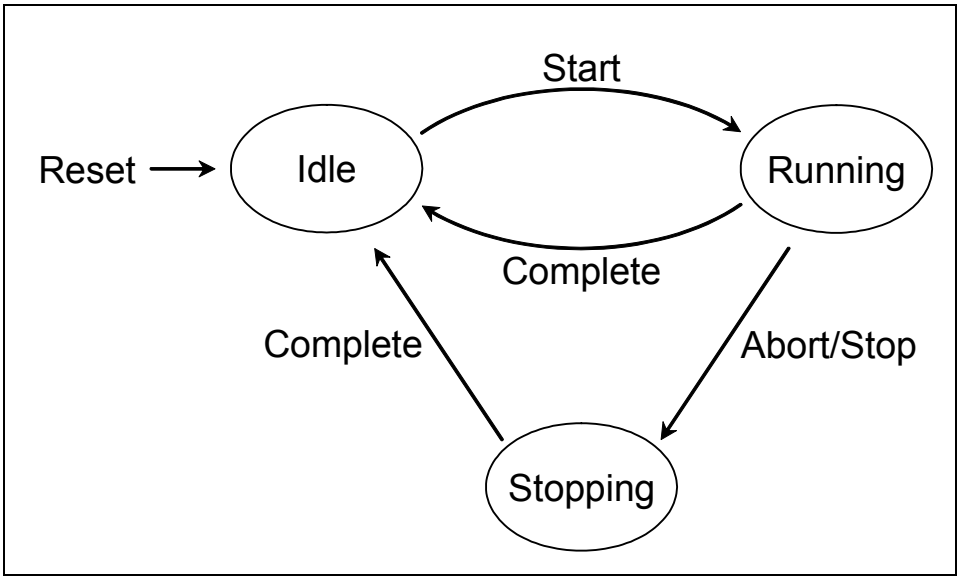
## 1.4 LCI and LPA 'Other-Task' State

To determine the current operating mode, LIM keeps track of the current 'state' of the two 'other' tasks with which it interacts – LAT Charge Injection (LCI) and LAT Physics Acquisition (LPA). At any time, LIM considers these tasks to be IDLE, RUNNING, or STOPPING. The tasks themselves are not aware of these states, however, since they are only for the convenience of LIM.

Initially, LIM considers a task to be IDLE, as shown in Figure 2. When LIM forwards a 'Start' command to a task, it changes the task's state to RUNNING. LIM changes the state back to IDLE when it receives a 'Completion' message from the task.

While in the RUNNING state, if LIM forwards an 'Abort' or 'Stop' command to a task, it changes the task's state to STOPPING. This state indicates that LIM is waiting for the task to acknowledge that it has completed its operation. When the task sends it 'Completion' message, LIM changes its state back to IDLE.

Figure 2 – LCI and LPA States



# 2 GRB Handling

LIM manages the flow of GRB-related messages and signals within the LAT instrument. These messages can be sent to LIM from the Gamma-Ray Burst Monitor (GBM) and the LAT Physics Acquisition (LPA) task. The GBM can also assert a discrete trigger signal which can be handled by the LIM task as an interrupt.

## 2.0 GRB Messages from LPA

The LPA task sends three GRB-related messages to LIM.

- GRB Suspected — The purpose of this message is to catch the initial moments of a GRB. LPA sends this message when the on-board GRB detection algorithm exceeds a pre-defined confidence level. It indicates that there is sufficient evidence of a GRB-detection to warrant increasing the LAT's photon sensitivity, but insufficient evidence and/or information to justify a repoint request.

  The GBM equivalent to this message is the trigger signal that it asserts when it suspects that it has detected a GRB.

- GRB Confirmed — The purpose of this message is to request a spacecraft repoint. LPA sends this message when the on-board GRB detection algorithm has acquired a fix on the location of a GRB. It indicates that sufficient evidence and information exist to say with a high degree of confidence that there is a GRB at a particular location.

  The GBM equivalent to this message is the LFSWCREPRECOM command that it sends to the LAT to recommend a spacecraft repoint.

- GRB Finished — The purpose of this message is to reduce bandwidth by restoring the filters to a less sensitive configuration. LPA sends this message when the on-board GRB detection algorithm has determined that the GRB activity has a reached a level that is low enough to declare the end of the GRB epoch. It indicates that the GRB has passed below the detection threshold and is likely over.

  The GBM equivalent to this message is the LFSWCLOSEOUT command that it sends to the LAT to indicate the end of a GRB.

## 2.1 GRB States

To record the progress of gamma-ray bursts (GRBs), LIM defines three distinct states within the ARR operating mode. The current GRB state determines how LIM responds to the GRB messages and signals that it receives. These states are:

- GRB0 — A potential GRB has been detected, but the spacecraft has not been repointed. In this state the LPA filter and trigger settings are configured to optimize GRB science data collection.
- GRB1 — This state is identical to GRB0, with the exception that the spacecraft is currently repointing.
- GRB2 — The spacecraft is still repointing, but the LPA filter and trigger settings are possibly no longer configured for GRB science data collection.
- IDLE — No GRB activity is in progress. LIM is defined to be in this GRB state when it is not in the ARR operating mode.

For each of these GRB states there is a corresponding LPA mode – LPA-GRB0, LPA-GRB1, LPA-GRB2, and LPA-NORMAL, respectively. In practice the LPA-GRB0 and LPA-GRB1 modes will probably be identical, as will the LPA-GRB2 and LPA-NORMAL modes. Defining a separate LPA mode for each state, though, allows for flexibility in the future.

Note the distinction here between the LPA modes, the LIM GRB states, and the LIM operating modes. Even though there is a one-to-one correspondence between the GRB states and the LPA modes, it is possible to be in one of the GRB states when LPA is not running. In these cases, the LPA mode is not defined. In addition, LIM will always be in the ARR operating mode when LPA is in one of its LPA-GRB modes.

## 2.2 GRB State Transitions

Typically, transitions between GRB states occur as follows:

- Idle to GRB0 — The LAT instrument transitions from the PHYSICS operating mode to the GRB0 state of the ARR operating mode when either (1) it receives a trigger signal from the GBM, or (2) the LAT instrument detects a GRB (indicated by a GRB-Suspected message from LPA to LIM).

  When this transition occurs, LIM instructs the LPA task to change to the LPA-GRB0 mode. Note that even in the case where LPA has determined that a GRB may be occurring, LPA does not enter its LPA-GRB0 mode until LIM instructs it to do so.
- GRB0 to GRB1 — This transition occurs when the spacecraft sends a positive slew-request reply indicating that it has repointed the spacecraft. While in the GRB0 state, either the GBM (via the LFSWCREPRECOM command) or the LPA task (via the GRB-Confirmed message) may send a message requesting a repoint of the spacecraft. In both cases, LIM sends a slew-request to the spacecraft but remains in the GRB0 state. Only when the spacecraft sends a positive reply does the LAT instrument make the transition to the GRB1 state. If the spacecraft sends a negative slew-request reply (indicating that it did not honor the request), the LAT instrument remains in the GRB0 state.

  When this transition occurs, LIM instructs the LPA task to change to the LPA-GRB1 mode.
- GRB1 to GRB2 — This transition occurs upon a request from the LPA task (indicated by a GRB-Finished message from LPA to LIM). The LPA task could, for

example, request this transition when it determines that the GRB activity has dropped below a certain threshold, or perhaps after a predetermined amount of time has elapsed since the transition to the GRB0 state.

When this transition occurs, LIM honors the LPA task's request by instructing it to change to the LPA-GRB2 mode.

– GRB2 to Idle — The LAT instrument transitions from the GRB2 state of the ARR operating mode to the PHYSICS operating mode at the completion of the spacecraft repointing period. The LIM task starts a timer when it receives a positive reply to a slew-request command that it had sent to the spacecraft, and assumes that the repointing period ends when this timer expires.

When this transition occurs, LIM instructs the LPA task to change to the LPA-NORMAL mode (if the LPA task is RUNNING), and LIM leaves the ARR operating mode.

There are some other GRB state transitions that could occur, but they are not expected to happen frequently.

– GRB0 to Idle — This transition occurs upon a request from the LPA task. It is analogous to the GRB1-to-GRB2 transition, except in this case the spacecraft is not repointing (either because a slew-request has not been sent or the spacecraft rejected the slew-request).

When this transition occurs, LIM instructs the LPA task to change to the LPA-NORMAL mode (if the LPA task is RUNNING), and LIM leaves the ARR operating mode.

– GRB1 to Idle — The LAT instrument transitions from the GRB1 state to the PHYSICS operating mode at the completion of the spacecraft repointing period. This transition is analogous to the GRB2-to-Idle transition, except in this case the LPA task has not yet requested a GRB2 configuration change.

When this transition occurs, LIM instructs the LPA task to change to the LPA-NORMAL mode (if the LPA task is RUNNING), and LIM leaves the ARR operating mode.

The following table summarizes the GRB state transitions.

Table 3 – GRB State Transitions

| | Normal | GRB0 | GRB1 | GRB2 |
|---|---|---|---|---|
| **Normal** | | GBM Trigger<br>GRB Suspected<br>GRB Confirmed | X | X |
| **GRB0** | GRB Finished | | Positive Slew-Request Response | X |
| **GRB1** | S/C Repoint End | X | | GRB Finished |
| **GRB2** | S/C Repoint End | X | X | |

# 3 Command Handling

LIM responds to various commands by performing actions such as changing its operating mode, updating its internal state, applying power to LAT components, and notifying other tasks of mode and state changes. LIM also intercepts commands intended for other tasks, determines if they are valid for the current operating mode, and forwards them to the intended target task if appropriate.

In addition to handling commands, LIM responds to other types of activity, such as trigger signal interrupts from the GBM, response messages from other tasks, and internal timer expirations. These other activities also cause LIM to perform various actions.

This chapter describes the manner in which LIM responds to the commands and other activities that it recognizes.

## 3.0 Calibration Commands

The LAT Charge Injection task (LCI) handles instrument calibration procedures. LIM intercepts all commands sent to LCI and forwards those that are appropriate for the current operating mode and LCI task state. LIM also receives Calibration-Complete messages sent by the LCI task at the completion of a calibration procedure, as well as the status responses for the commands that LIM sends to LCI.

LIM uses the Calibration-Start (LCICALIBRATE) command and the Calibration-Complete message to determine operating mode transitions. When in the QUIESCENT mode, LIM transitions to the CALIBRATION mode whenever it forwards a Calibration-Start command to LCI. The operating mode changes back to QUIESCENT when LIM receives the Calibration-Complete message.

### 3.0.0 Calibration Start (LCICALIBRATE)

Description: This command is a request to start a calibration procedure. LIM intercepts this command and, in the QUIESCENT operating mode, sends a copy of it to the LCI task and makes the transition to the CALIBRATION operating mode.

Parameters: LIM does not interpret any of the parameters that this command may contain.

Actions: In the QUIESCENT operating mode

- send a copy of the command to LCI (LIMACTCALSTART)
- indicate that the LCI task is RUNNING (LIMACTLCISTATE)
- move to the CALIBRATION operating mode (LIMACTOPMODECH)
- return LIM_PKTSENT status

In all other operating modes

- reject the command and return LIM_BADMODE status

### 3.0.1 Calibration Start Status

Description: This is the status that the LCI task returns for a Calibration-Start command that LIM sends. If the status indicates that the Calibration-Start was not successful, LIM assumes that the calibration procedure has ended (as if it received a Calibration-Complete message).

Actions: In all cases

- report the status in LIM-State telemetry (LIMACTCALSTRTST)

Additionally, in the CALIBRATION operating mode, if LIM is expecting the status but it indicates that the Calibration-Start command was not successfully executed

- indicate that the LCI task is IDLE (LIMACTLCISTATE)
- move to the QUIESCENT operating mode (LIMACTOPMODECH)

### 3.0.2 Calibration Abort (LCIABORT)

Description: This command is a request to abort a calibration procedure. LIM intercepts this command and forwards it to the LCI task. LIM can also create its own copy of this command and send it to the LCI task, which it does when it determines that it needs to stop the LCI task (e.g., during load-shedding)

Parameters: LIM does not interpret any of the parameters that this command may contain. When LIM creates its own copy of this command, it sets all parameter values to zero.

Actions: In all operating modes except TERMINAL and HOLD

- forward the command to LCI (LIMACTCALABORT)
- if the LCI task is RUNNING or STOPPING
  - indicate that the LCI task is STOPPING (LIMACTLCISTATE)
- if the LCI task is IDLE
  - indicate that the LCI task is IDLE (LIMACTLCISTATE)
- allow LCI to return the status for the command

In the TERMINAL and HOLD operating modes

- reject the command and return LIM_BADMODE status

### 3.0.3 Calibration Abort Status

Description: This is the status that the LCI task returns for a Calibration-Abort command that LIM sends.

Actions: In all cases

- report the status in LIM-State telemetry (LIMACTCALABRTST)

### 3.0.4 Calibration Complete

Description: This message indicates that the LCI task has completed a calibration procedure.

Parameters: LIM does not interpret or report any of the parameters that this message may contain.

Actions: In all cases

- report that the message was received (LIMACTCALCOMP)
- indicate that the LCI task is IDLE (LIMACTLCISTATE)

Additionally, in the CALIBRATION operating mode

- move to the QUIESCENT operating mode (LIMACTOPMODECH)

### 3.0.5 Other LCI Commands

Description: These commands direct the operation of the LCI task during a calibration procedure. LIM intercepts these commands and forwards them to the LCI task in the CALIBRATION operating mode if the LCI task is RUNNING.

Parameters: LIM does not interpret any of the parameters that these commands may contain.

Actions: In the CALIBRATION operating mode

- if the LCI task is RUNNING
  - forward the command to LCI (LIMACTCALOTHER)
  - allow LCI to return the status for the command
- if the LCI task is STOPPING
  - reject the command and return LIM_OTHSTOP status

In all other operating modes

- reject the command and return LIM_BADMODE status

## 3.1 Physics Commands

The LAT Physics Acquisition task (LPA) handles physics observations in both pointed and repointed modes of operation. As with the LCI task, LIM intercepts all commands sent to LPA and forwards those that are appropriate for the current operating mode and for the current LPA task state. LIM also receives Physics-Complete messages sent by the LPA task at the completion of a physics observation, as well as the status responses for the commands that LIM sends to LPA.

LIM uses a number of different LPA commands, along with the Physics-Complete message, to determine operating mode transitions.

## 3.1.0 Physics Start (LPASTART)

Description: This command is a request to start a physics observation run. LIM intercepts this command and sends a copy of it to the LPA task if it is appropriate for the current operating mode and LPA task state.

Parameters: This command contains a number of parameters. LIM is aware of only two of these parameters:

- the RUN-ID to associate with the observation run
- the initial LPA MODE for the run

Actions: In the QUIESCENT operating mode, if the LAT is not within the SAA

- send a copy of the command to LPA (LIMACTLPASTART)
- indicate that the LPA task is RUNNING (LIMACTLPASTATE)
- move to the PHYSICS operating mode (LIMACTOPMODECH)
- return LIM_PKTSENT status

In the TOO operating mode, if the LAT is not within the SAA and the LPA task is IDLE

- replace all the command parameters except the RUN-ID with those from the TOO-Start command that initiated the TOO observation
- set the MODE command parameter to 'TOO'
- send a copy of the modified command to LPA (LIMACTLPASTART)
- indicate that the LPA task is RUNNING (LIMACTLPASTATE)
- indicate that the TOO observation has STARTED (if it was not started previously) (LIMACTTOOSTATE)
- return LIM_PKTSENT status

In the ARR operating mode, if the LAT is not within the SAA and the LPA task is IDLE

- replace all the command parameters except the RUN-ID with those from the most-recent Physics-Start command that LIM sent to the LPA task
- set the MODE command parameter for the current GRB state ('GRB0', 'GRB1', or 'GRB2')
- send a copy of the modified command to LPA (LIMACTLPASTART)
- indicate that the LPA task is RUNNING (LIMACTLPASTATE)
- return LIM_PKTSENT status

If the current operating mode is not QUIESCENT, TOO, or ARR

- reject the command and return LIM_BADMODE status

If the LAT is within the SAA

- reject the command and return LIM_SAA status

If the LPA task is RUNNING

- reject the command and return LIM_OTHRUN status

If the LPA task is STOPPING

- reject the command and return LIM_OTHSTOP status

### 3.1.1 Physics Start Status

Description: This is the status that the LPA task returns for a Physics-Start command that LIM sends. If the status indicates that the Physics-Start was not successful, LIM assumes that the physics run has ended (as if it received a Physics-Complete message).

Actions: In all cases

- report the status in LIM-State telemetry (LIMACTLPASTRTST)

Additionally, in the PHYSICS, TOO, and ARR operating modes, if LIM is expecting the status but it indicates that the Physics-Start command was not successfully executed

- indicate that the LPA task is IDLE (LIMACTLPASTATE)
- move to the QUIESCENT operating mode if the current operating mode is PHYSICS (LIMACTOPMODECH)

### 3.1.2 Physics Stop (LPASTOP)

Description: This command is a request to stop a physics observation run. LIM intercepts this command and forwards it to the LPA task. LIM can also create its own copy of this command and send it to the LPA task, which it does when it determines that it needs to stop the LPA task (e.g., during load-shedding or SAA entry)

Parameters: LIM does not interpret any of the parameters that this command may contain. When LIM creates its own copy of this command, it sets all parameter values to zero.

Actions: In all operating modes except TERMINAL and HOLD

- forward the command to LPA (LIMACTLPASTOP)
- if the LPA task is RUNNING or STOPPING
  - indicate that the LPA task is STOPPING (LIMACTLPASTATE)
- if the LPA task is IDLE
  - indicate that the LPA task is IDLE (LIMACTLPASTATE)
- allow LPA to return the status for the command

In the TERMINAL and HOLD operating modes

- reject the command and return LIM_BADMODE status

### 3.1.3 Physics Stop Status

Description: This is the status that the LPA task returns for a Physics-Stop command that LIM sends.

Actions: In all cases

- report the status in LIM-State telemetry (LIMACTLPASTOPST)

### 3.1.4 Physics Complete

Description: This message indicates that the LPA task has stopped an observation run.

Parameters: This message contains a single parameter that LIM is aware of – the final STATUS of the observation run.

Actions: In all cases

- report the STATUS value within the message (LIMACTLPACOMP)
- indicate that the LPA task is IDLE (LIMACTLPASTATE)

Additionally, in the PHYSICS operating mode

- move to the QUIESCENT operating mode (LIMACTOPMODECH)

### 3.1.5 Active LPA Commands

Description: These commands direct the operation of the LPA task during a physics observation. LIM intercepts these commands and forwards them to the LPA task if the LPA task is RUNNING.

Parameters: LIM does not interpret any of the parameters that these commands may contain.

Actions: In the PHYSICS operating mode

- if the LPA task is RUNNING
  - forward the command to LPA (LIMACTLPAACTIVE)
  - allow LPA to return the status for the command
- if the LPA task is STOPPING
  - reject the command and return LIM_OTHSTOP status

In all other operating modes

- reject the command and return LIM_BADMODE status

### 3.1.6 Idle LPA Commands

Description: These commands configure the operation of the LPA task when a physics observation is ***not*** in progress. LIM intercepts these commands and forwards them to the LPA task if they are appropriate for the current operating mode and LPA task state.

Parameters: LIM does not interpret any of the parameters that these commands may contain.

Actions: In the TERMINAL, QUIESCENT, and CALIBRATION operating modes

- forward the command to LPA (LIMACTLPAIDLE)
- allow LPA to return the status for the command

In all other operating modes

- reject the command and return LIM_BADMODE status

# 3.2 TOO Commands

These commands inform LIM that a Target-of-Opportunity repointed observation should start or end.

## 3.2.0 TOO Start (TOOSTART)

Description: This command is a request to start a Target-of-Opportunity repointed observation. When LIM accepts this command, it starts a timer to countdown the TOO dwell period. Additionally, in the QUIESCENT and PHYSICS operating modes, this command causes a transition to the TOO operating mode.

Parameters: This command contains a parameter which specifies the dwell time for the TOO observation. It also contains the same parameters as a Physics-Start command, which LIM uses when sending Physics-Start commands to the LPA task during the TOO operating mode.

Actions: In the QUIESCENT operating mode

- start a timer to countdown the specified dwell time
- indicate that the TOO observation is READY (LIMACTTOOSTATE)
- if not in the SAA
  - create a Physics-Start command that contains the parameters from the TOO-Start command
  - set the MODE command parameter to 'TOO'
  - send the command to LPA (LIMACTLPASTART)
  - indicate that the LPA task is RUNNING (LIMACTLPASTATE)
  - indicate that the TOO observation has STARTED (LIMACTTOOSTATE)
- move to the TOO operating mode (LIMACTOPMODECH)
- return LIM_ACCEPT status

In the PHYSICS operating mode

- start a timer to countdown the specified dwell time
- indicate that the TOO observation is READY (LIMACTTOOSTATE)
- if LPA is RUNNING
  - set the LPA MODE to 'TOO' (LIMACTLPASETMOD)
- move to the TOO operating mode (LIMACTOPMODECH)
- return LIM_ACCEPT status

In the ARR operating mode, if a TOO observation is not already READY

- start a timer to countdown the specified dwell time
- indicate that the TOO observation is READY (LIMACTTOOSTATE)
- return LIM_ACCEPT status

If a TOO observation is already READY

- reject the command and return LIM_ACTREADY status

In all other operating modes

- reject the command and return LIM_BADMODE status

### 3.2.1 TOO Abort (TOOABORT)

Description: This command is a request to abort a Target-of-Opportunity repoint activity. If LIM accepts this command, it terminates the TOO activity. Additionally, in the TOO operating mode, this command causes a transition to the PHYSICS or QUIESCENT operating mode.

Parameters: This command contains no parameters.

Actions: In all operating modes except TERMINAL and HOLD

- terminate the TOO dwell timer
- indicate that the TOO observation is not READY (LIMACTTOOSTATE)
- indicate that the TOO observation is not STARTED (LIMACTTOOSTATE)

Additionally, in the TOO operating mode

- if the LPA task is RUNNING
  - set the LPA MODE to 'NORMAL' (LIMACTLPASETMOD)
  - move to the PHYSICS operating mode (LIMACTOPMODECH)
- if the LPA task is STOPPING
  - move to the PHYSICS operating mode (LIMACTOPMODECH)
- if the LPA task is IDLE
  - move to the QUIESCENT operating mode (LIMACTOPMODECH)

In the TERMINAL and HOLD operating modes

- reject the command and return LIM_BADMODE status

### 3.2.2 TOO Dwell Timer Expiration

Description: The TOO dwell timer expires when the dwell time specified in a TOO-Start command has elapsed. In the TOO operating mode, expiration of this timer causes a transition to the PHYSICS or QUIESCENT operating mode.

Actions: In all cases

- indicate that the TOO observation is not READY (LIMACTTOOSTATE)
- indicate that the TOO observation is not STARTED (LIMACTTOOSTATE)

Additionally, in the TOO operating mode

- if the LPA task is RUNNING
  - set the LPA MODE to 'NORMAL' (LIMACTLPASETMOD)
  - move to the PHYSICS operating mode (LIMACTOPMODECH)
- if the LPA task is STOPPING
  - move to the PHYSICS operating mode (LIMACTOPMODECH)
- if the LPA task is IDLE
  - move to the QUIESCENT operating mode (LIMACTOPMODECH)

# 3.3 GBM Commands

The Gamma-Ray Burst Monitor (GBM) sends commands to the LAT instrument to indicate the status of its gamma-ray burst monitoring. These are the Calculated-Information, Candidate-Repoint-Recommendation (GBM-Repoint), and Closeout commands. If the LPA task is RUNNING when LIM receives one of these commands, the LIM task forwards the command to the LPA task, regardless of the operating mode. If LPA is STOPPING or IDLE, though, LIM may accept *positive* GBM-Repoint commands and always rejects Calculated-Information, *negative* GBM-Repoint, and Closeout commands. (A *positive* GBM-Repoint command is one in which a repoint is recommended.)

If LIM is configured to do so, it accepts the positive GBM-Repoint commands that it does not forward to the LPA task. In this situation, the LIM task sends a Repoint-Request command to the spacecraft on behalf of the GBM. All the parameters required by the Repoint-Request command are copied from the GBM-Repoint command, except the DWELL TIME parameter, which LIM sets to a default value of 18,000 (this default value can be changed by modifying the LIM_DB database).

The GBM also asserts a trigger signal when it detects a gamma-ray burst. When LIM detects this trigger signal, it informs the LPA task if the operating mode and LPA task state are appropriate.

## 3.3.0 GBM Trigger Signal Interrupt

Description: LIM is interrupted when the GBM asserts the trigger signal (if either the primary or redundant interrupt is enabled).

Actions: In all cases

- disable the primary and redundant GBM trigger interrupts
- if the GBM interrupt disable timer is not active
  - start the GBM interrupt disable timer with the time specified in the LIM_DB database (default is 10 minutes)
- report that the interrupt(s) occurred (LIMACTGBMINTPRI, LIMACTGBMINTRED)

Additionally, if the LPA task is RUNNING

- inform LPA that the interrupt occurred (LIMACTLPAGBMINT)
- set the ARR state to ‘GRB0’ (LIMACTARRSTATE)
- set the LPA MODE to ‘GRB0’ (LIMACTLPASETMOD)
- move to the ARR operating mode (LIMACTOPMODECH)

## 3.3.1 GBM Calculated Information (LPAGBMCALCINFO)

Description: The GBM sends this command to the LAT periodically during a burst sequence. It contains the best available calculated location of the burst and associated reliability parameters. LIM intercepts this command and forwards it to the LPA task if it is appropriate for the current operating mode and LPA task state.

Parameters: This command contains a number of parameters. LIM is aware of only two of these parameters:

- the TRIGGER-ID associated with the current burst
- the SEQUENCE-NUM of the command with respect to the current burst

Actions: In all cases

- if the TRIGGER-ID or SEQUENCE-NUM parameter is incorrect
  - reject the command with LIM_BADGBMID status
- else if the LPA task is RUNNING
  - forward the command to the LPA task (LIMACTGBMCMD)
- report that the message was received (LIMACTCALCINFO)

### 3.3.2 GBM Repoint Recommendation (LPAGBMCREPRECOM)

Description: The GBM sends this command to the LAT once during a burst sequence. It contains a recommendation of whether or not the spacecraft should be repointed to observe the burst. LIM intercepts this command and forwards it to the LPA task if it is appropriate for the current operating mode and LPA task state. If the LPA task is not RUNNING, LIM can be configured to request a spacecraft repoint on behalf of the GBM.

Parameters: This command contains a number of parameters. LIM is aware of five of these parameters:

- the TRIGGER-ID associated with the current burst
- the SEQUENCE-NUM of the command with respect to the current burst
- the RECOMMENDATION of whether or not to request a repoint
- the RIGHT-ASCENSION of the calculated burst location
- the DECLINATION of the calculated burst location

Actions: In all cases

- if the TRIGGER-ID or SEQUENCE-NUM parameter is incorrect
  - reject the command with LIM_BADGBMID status
- else if the LPA task is RUNNING
  - forward the command to the LPA task (LIMACTGBMCMD)
- else if the RECOMMENDATION parameter indicates that a repoint is recommended
  - if LIM is not configured to request repoints on behalf of the GBM
    - reject the command with LIM_REPDIS status
  - else if LIM is waiting for a response to a previous repoint request
    - reject the command with LIM_REPPEND status
  - else if the repoint timer is active
    - reject the command with LIM_REPACT status
  - else
    - create a Slew-Request (LIMSCSLEWREQUEST) command using the RIGHT-ASCENSION and DECLINATION parameters from the GBM command
    - use the upper four bytes of the TRIGGER-ID parameter as the transaction ID for the Slew-Request
    - set the dwell time for the Slew-Request to the value

specified in the LIM_DB database (default is 18,000 seconds)
    - send the Slew-Request to the spacecraft (LIMACTSLEWREQ)
    - indicate that LIM is waiting for a repoint response (LIMACTREPREQST)
    - send Repoint-Request alert telemetry (APID $344_h$)
- report that the message was received (LIMACTREPREC or LIMACTREPNOREC)

### 3.3.3 GBM Closeout (LPAGBMCLOSEOUT)

Description: The GBM sends this command to the LAT once during a burst sequence, as the last message it sends about a particular burst. LIM intercepts this command and forwards it to the LPA task if it is appropriate for the current operating mode and LPA task state.

Parameters: LIM does not interpret any of the parameters that this command may contain.

Actions: In all cases

- terminate the GBM trigger interrupt disable timer
- enable GBM trigger interrupts that are 'allowed' (LIMACTENGBMPRI, LIMACTENGBMRED)
- if the LPA task is RUNNING
    - forward the command to the LPA task (LIMACTGBMCMD)
- report that the message was received (LIMACTCLOSEOUT)

### 3.3.4 GBM Interrupt Disable Timer Expiration

Description: The GBM interrupt disable timer expires when the interrupt disable time specified in the LIM_DB database has elapsed.

Actions: In all cases

- enable GBM trigger interrupts that are 'allowed' (LIMACTENGBMPRI, LIMACTENGBMRED)

## 3.4 ARR Commands

The LPA task sends commands to LIM to initiate Autonomous Repoint Request (ARR) activity when it detects a gamma-ray burst (GRB). LIM reacts to these commands by entering the ARR operating mode.

### 3.4.0 GRB Suspected

Description: LPA sends this command when it suspects that a GRB is occurring.

Parameters: LIM does not interpret any of the parameters that this command may contain.

Actions: In the QUIESCENT, PHYSICS, or TOO operating mode

- report that the command was received (LIMACTGRBSUSPECT)

- set the ARR state to ‘GRB0’ (LIMACTARRSTATE)
- if the LPA task is RUNNING (which should be the case)
  - set the LPA MODE to ‘GRB0’ (LIMACTLPASETMOD)
- move to the ARR operating mode (LIMACTOPMODECH)

In the ARR operating mode

- reject the command with LIM_ACTREADY status
- report that the command was received (LIMACTGRBSUSPECT)

In all other operating modes

- reject the command with LIM_BADMODE status
- report that the command was received (LIMACTGRBSUSPECT)

### 3.4.1 GRB Confirmed

Description: LPA sends this command when it is requesting a spacecraft repoint as a result of determining that a GRB is occurring.

Parameters: This command contains a number of parameters. LIM is aware of four of these parameters:

- the TRANSACTION-ID associated with the repoint request
- the requested DWELL-TIME for the repoint request
- the RIGHT-ASCENSION of the burst location
- the DECLINATION of the burst location

Actions: In the QUIESCENT, PHYSICS, TOO, or ARR operating mode

- if the ARR state is ‘IDLE’
  - set the ARR state to ‘GRB0’ (LIMACTARRSTATE)
- if the ARR state is now ***not*** ‘GRB0’
  - reject the command with LIM_ACTREADY status
- else if LIM is waiting for a response to a previous repoint request
  - reject the command with LIM_REPPEND status
- else if the repoint timer is active
  - reject the command with LIM_REPACT status
- else
  - create a Slew-Request (LIMSCSLEWREQUEST) command using the RIGHT-ASCENSION, DECLINATION, TRANSACTION-ID, and DWELL-TIME parameters from the GRB-Confirmed command
  - send the Slew-Request to the spacecraft (LIMACTSLEWREQ)
  - indicate that LIM is waiting for a repoint response (LIMACTREPREQST)
  - send Repoint-Request alert telemetry (APID $344_h$)
- report that the command was received (LIMACTGRBCONFIRM)
- if the LPA task is RUNNING, but not in the GRB0 LPA mode
  - set the LPA MODE to ‘GRB0’ (LIMACTLPASETMOD)
- if the operating mode is not ARR,
  - move to the ARR operating mode (LIMACTOPMODECH)

In all other operating modes

- reject the command with LIM_BADMODE status
- report that the command was received (LIMACTGRBCONFIRM)

## 3.4.2 ARR Response

Description: The spacecraft sends this message as a response to a Slew-Request. It includes an indication of whether the Slew-Request was accepted or rejected.

Parameters: This message contains two parameters:

- a TRANSACTION-ID that associates this response with its request
- an ACCEPTANCE parameter that is nonzero if the request is accepted

Actions: In all cases,

- send Repoint-Response alert telemetry (APID $345_h$)
- if a repoint request is not pending, or the TRANSACTION-ID parameter is not the expected value
  - reject the command with LIM_REPUNEXP status
  - report that the message was received (LIMACTSLEWACCEPT or LIMACTSLEWREJECT)
- else (repoint request is pending and TRANSACTION-ID is the expected value)
  - report that the message was received (LIMACTSLEWACCEPT or LIMACTSLEWREJECT)
  - start the repoint timer for the dwell-time specified in the associated repoint request
  - indicate that a repoint request is no longer pending (LIMACTREPREQST)
  - if the repoint request was accepted
    - set the ARR state to 'GRB1' (LIMACTARRSTATE)
    - if the LPA task is running, set the LPA MODE to 'GRB1' (LIMACTLPASETMOD)

## 3.4.3 GRB Finished

Description: LPA sends this command when it determines that a GRB is finished.

Parameters: LIM does not interpret any of the parameters that this command may contain.

Actions: In the ARR operating mode

- if the ARR state is 'IDLE'
  - reject the command with LIM_ACTNOACT status
  - report that the command was received (LIMACTGRBFINISH)
- else if the ARR state is 'GRB0'
  - report that the command was received (LIMACTGRBFINISH)
  - set the ARR state to 'IDLE' (LIMACTARRSTATE)
  - if the TOO timer is active
    - if the LPA task is RUNNING, set the LPA MODE to 'TOO' (LIMACTLPASETMOD)

        - move to the TOO operating mode (LIMACTOPMODECH)
      - else if the LPA task is RUNNING
        - set the LPA MODE to 'NORMAL' (LIMACTLPASETMOD)
        - move to the PHYSICS operating mode (LIMACTOPMODECH)
      - else
        - move to the QUIESCENT operating mode (LIMACTOPMODECH)
  - else if the ARR state is 'GRB1'
    - report that the command was received (LIMACTGRBFINISH)
    - set the ARR state to 'GRB2' (LIMACTARRSTATE)
    - if the LPA task is RUNNING
      - set the LPA MODE to 'GRB2 (LIMACTLPASETMOD)
  - else if the ARR state is 'GRB2'
    - reject the command with LIM_ACTREADY status
    - report that the command was received (LIMACTGRBFINISH)

## 3.4.4 ARR Repoint Timer Expires

Description: The ARR repoint timer expires at the end of the repoint dwell period.

Actions: In the ARR operating mode

- indicate that a repoint request is not pending (LIMACTREPREQST)
- set the ARR state to 'IDLE' (LIMACTARRSTATE)
- if the TOO timer is active
  - if the LPA task is RUNNING
    - set the LPA MODE to 'TOO' (LIMACTLPASETMOD)
  - move to the TOO operating mode (LIMACTOPMODECH)
- else if the LPA task is RUNNING
  - set the LPA MODE to 'NORMAL' (LIMACTLPASETMOD)
  - move to the PHYSICS operating mode (LIMACTOPMODECH)
- else
  - move to the QUIESCENT operating mode (LIMACTOPMODECH)

## 3.4.5 ARR Abort

Description: This command is a request to abort an ARR repoint activity.

Parameters: This command contains no parameters.

Actions: In all cases

- terminate the GBM interrupt disable timer
- enable GBM trigger interrupts that are 'allowed' (LIMACTENGBMPRI, LIMACTENGBMRED)
- set the ARR state to 'IDLE' (LIMACTARRSTATE)
- terminate the ARR repoint timer
- indicate that a repoint request is not pending (LIMACTREPREQST)

In the ARR operating mode

- if the TOO timer is active
  - if the LPA task is RUNNING
    - set the LPA MODE to 'TOO' (LIMACTLPASETMOD)
  - move to the TOO operating mode (LIMACTOPMODECH)
- else if the LPA task is RUNNING
  - set the LPA MODE to 'NORMAL' (LIMACTLPASETMOD)
  - move to the PHYSICS operating mode (LIMACTOPMODECH)
- else
  - move to the QUIESCENT operating mode (LIMACTOPMODECH)

# 3.5 Miscellaneous Commands

These commands are sent to the LIM task directly.

## 3.5.0 Bias ACD

Description: This command is a request to set bias voltages for one or more ARC components within the LAT instrument. When LIM receives this command, it sets ARC bias voltages using appropriate PIG functions.

Parameters: This command contains parameters to indicate which ARC bias voltages to set and the values to which they should be set.

Actions: In the QUIESCENT operating mode

- call the PIG_bias_ACD function to set the ACD bias values (LIMACTBIASACD)

In all other operating modes

- reject the command with LIM_BADMODE status

## 3.5.1 Bias CAL

Description: This command is a request to set bias voltages for one or more CAL components within the LAT instrument. When LIM receives this command, it sets CAL bias voltages using appropriate PIG functions.

Parameters: This command contains parameters to indicate which CAL bias voltages to set and the values to which they should be set.

Actions: In the QUIESCENT operating mode

- call the PIG_bias_CAL function to set the CAL bias values (LIMACTBIASCAL)

In all other operating modes

- reject the command with LIM_BADMODE status

### 3.5.2 Bias TKR

Description: This command is a request to set bias voltages for one or more TKR components within the LAT instrument. When LIM receives this command, it sets TKR bias voltages using appropriate PIG functions.

Parameters: This command contains parameters to indicate which TKR bias voltages to set and the values to which they should be set.

Actions: In the QUIESCENT operating mode

- call the PIG_bias_TKR function to set the TKR bias values (LIMACTBIASTKR)

In all other operating modes

- reject the command with LIM_BADMODE status

### 3.5.3 Configure GBM

Description: This command is a request to configure the handling of commands and trigger signals from the GBM.

Parameters: This command contains three pairs of parameters which specify whether LIM is allowed to perform the following actions:

- send repoint requests to the spacecraft on behalf of the GBM
- enable the primary GBM trigger signal interrupt
- enable the redundant GBM trigger signal interrupt

Within each parameter pair is an ALLOWED parameter which specifies whether the corresponding LIM action is allowed and a VALID parameter which indicates if the ALLOWED parameter is valid. If a VALID parameter is zero, then LIM ignores the corresponding ALLOWED parameter and does not alter the configuration associated with that parameter.

Actions: If the LIMGBMREPVALID parameter is set

- configure LIM to allow or disallow repoint requests on behalf of the GBM, according to the value of the LIMGBMREPALLOW parameter (LIMACTGBMSTATE)

If the LIMGBMPRIVALID parameter is set

- configure LIM to allow or disallow enabling of the ***primary*** GBM trigger signal interrupt, according to the value of the LIMGBMPRIALLOW parameter value (LIMACTGBMSTATE)
- if not in the TERMINAL operating mode
  - enable or disable the primary GBM interrupt according to the LIMGBMPRIALLOW parameter value (LIMACTENGBMPRI)

If the LIMGBMREDVALID parameter is set

- configure LIM to allow or disallow enabling of the ***redundant*** GBM trigger signal interrupt, according to the value of the LIMGBMREDALLOW parameter value (LIMACTGBMSTATE)
- if not in the TERMINAL operating mode
  - enable or disable the redundant GBM interrupt according to the LIMGBMREDALLOW parameter value (LIMACTENGBMRED)

### 3.5.4 Configure HV

Description: This command is a request to configure the handling of the ACD high voltage.

Parameters: This command contains two parameters

- LIMHVALLOW which specifies whether LIM is allowed to enable the ACD high voltage
- LIMHVVALID which indicates if the LIMHVALLOW parameter is valid

If LIMHVVALID is zero, then LIM ignores the LIMHVALLOW parameter and does not alter the configuration of the ACD high voltage handling.

Actions: If the LIMHVVALID parameter is set

- configure LIM to allow or disallow enabling of the ACD high voltage, according to the value of the LIMHVALLOW parameter value (LIMACTHVSTATE)
- if not in the TERMINAL operating mode
  - if LIMHVALLOW is zero
    - call the PIG_enter_SAA function to set the ACD high voltage to SAA levels, as if SAA entrance just occurred (LIMACTSAACFG)
  - else if the instrument is not within the SAA
    - call the PIG_exit_SAA function to set the ACD high voltage to non-SAA levels, as if SAA exit just occurred (LIMACTNONSAACFG)

### 3.5.5 Configure PID

Description: This command is a request to configure the discrete signals (PIDs) that the spacecraft sends to the LAT instrument, i.e. the PIDs that the spacecraft drives and the LAT receives.

Parameters: This command contains a single parameter – LIMPIDPRI – which specifies whether the LAT should receive the primary or redundant PID input signals.

Actions: If the LIMPIDPRI parameter is zero

- call vxWorks functions to enable the reception of the redundant PID input signals (LIMACTPIDSELRED)

else

- call vxWorks functions to enable the reception of the primary PID input signals (LIMACTPIDSELPRI)

### 3.5.6 Hold Enter

Description: This command is a request to make the transition to the HOLD operating mode. When LIM receives this command, it immediately transitions to the HOLD operating mode.

Parameters: This command contains no parameters.

Actions: In all operating modes except TERMINAL and HOLD

- move to the HOLD operating mode (LIMACTOPMODECH)

In the TERMINAL and HOLD operating modes

- reject the command with LIM_BADMODE status

### 3.5.7 Hold Exit

Description: This command is a request to make the transition out of the HOLD operating mode. When LIM receives this command, it immediately moves from the HOLD to the QUIESCENT operating mode. In some cases, LIM will then make a transition to another operating mode after entering QUIESCENT mode (see the actions below).

Parameters: This command contains no parameters.

Actions: In the HOLD operating mode

- move to the QUIESCENT operating mode (LIMACTOPMODECH)
- if the ARR state is not 'IDLE'
  - move to the ARR operating mode (LIMACTOPMODECH)
- else if a TOO is READY
  - move to the TOO operating mode (LIMACTOPMODECH)
- else if the LPA task is not IDLE
  - move to the PHYSICS operating mode (LIMACTOPMODECH)

In all other operating modes

- reject the command with LIM_BADMODE status

### 3.5.8 LATC Record

Description: This command is a request to capture and consign LATC information.

Parameters: This command contains no parameters.

Actions: In all operating modes except the TERMINAL operating mode

- call the LATC_capture function
- call the LATC_consign function

In the TERMINAL operating mode

- reject the command with LIM_BADMODE status

### 3.5.9 Load Shed

Description: This command is a request to remove power from the LAT instrument. When LIM receives this command, it aborts the current activity (calibration or physics), sends an LTC-Stop command to the LTC task, waits five seconds, removes power from the LAT instrument using the PIG_shed function, then resets the SIU using the PBS_reboot function. At the conclusion of this process, the SIU is the only component of the instrument that is powered.

Parameters: This command contains no parameters.

Actions: In all cases

- send Load-Shed alert telemetry (APID $346_h$)
- if LCI is RUNNING
  - send LCI-Abort to the LCI task (LIMACTCALABORT)
  - indicate that the LCI task is STOPPING (LIMACTLCISTATE)
- if LPA is RUNNING
  - send LPA-Stop to the LPA task (LIMACTLPASTOP)
  - indicate that the LPA task is STOPPING (LIMACTLPASTATE)
- send LTC-Stop to the LTC task (LIMACTLTCSTOP)
- wait 5 seconds
- call the PIG_shed function (LIMACTSHEDBEGIN and LIMACTSHEDEND)
- report that the SIU will be rebooted (LIMACTSIUREBOOT)
- wait 1 second
- call the PBS_reboot function with parameter $CAFE2468_h$)

## 3.5.10 Look At Me

Description: This command is a request to send the LookAtMe command.

Parameters: This command contains no parameters.

Actions: In all operating modes except the TERMINAL operating mode

- call LEM functions to send the LookAtMe command

In the TERMINAL operating mode

- reject the command with LIM_BADMODE status

## 3.5.11 Main Feed On

Description: This command is a request to apply power to the GASU and PDU, and to initialize the SIU.

Parameters: This command contains parameters to indicate which primary and redundant components of the instrument should be powered and selected.

Actions: In the TERMINAL operating mode

- call the PIG_siu_init function to enable LAT power (LIMACTMAINFEED)
- enable GBM trigger interrupts that are ‘allowed’ (LIMACTENGBMPRI, LIMACTENGBMRED)
- move to the QUIESCENT operating mode (LIMACTOPMODECH)

In all other operating modes

- reject the command with LIM_BADMODE status

### 3.5.12 No-Op

Description: This command causes LIM to send a response, which confirms that LIM is capable of handling commands.

Parameters: This command contains no parameters.

Actions: In the TERMINAL operating mode

- return LIM_SUCCESS status.

### 3.5.13 Pig Record

Description: This command is a request to record PIG information.

Parameters: This command contains a single parameter which specifies the destination for the PIG information.

Actions: In all operating modes except the TERMINAL operating mode

- call the PIG_record function

In the TERMINAL operating mode

- reject the command with LIM_BADMODE status

### 3.5.14 Power Off

Description: This command is a request to remove power from components of the LAT instrument. When LIM receives this command, it removes power from the specified LAT components using appropriate PIG functions.

Parameters: This command contains parameters to indicate which LAT components should be unpowered.

Actions: In the QUIESCENT operating mode

- call the PIG_extract_evt function to remove the specified LAT components from the event fabric (LIMACTEVENTREM)
- call the PIG_extract function to remove power from the specified LAT components and remove them from the command/response fabric (LIMACTPOWEROFF)

In all other operating modes

- reject the command with LIM_BADMODE status

### 3.5.15 Power On

Description: This command is a request to apply power to components of the LAT instrument. When LIM receives this command, it applies power to the specified LAT components using appropriate PIG functions.

Parameters: This command contains parameters to indicate which LAT components should be powered.

Actions: In the QUIESCENT operating mode

- call the PIG_insert function to apply power to the specified LAT

components and add them to the command/response fabric (LIMACTPOWERON)
- call the PIG_insert_evt function to add the specified LAT components to the event fabric (LIMACTEVENTINS)
- if the LAT is within the SAA or LIM is not allowed to enable the ACD high voltage
  - call the PIG_enter_SAA function to set the ACD high voltage to SAA levels, as if SAA entrance just occurred (LIMACTSAACFG)
- else
  - call the PIG_exit_SAA function to set the ACD high voltage to non-SAA levels, as if SAA exit just occurred (LIMACTNONSAACFG)

In all other operating modes
- reject the command with LIM_BADMODE status

## 3.5.16 SAA Enter

Description: This command is a notification that the LAT instrument has entered the South Atlantic Anomaly (SAA). When LIM receives this command, it uses the PIG_enter_SAA function to remove the high-voltage from the ACD (unless the operating mode is TERMINAL). LIM also updates its internal state to indicate that an SAA transit is in progress.

Parameters: This command contains no parameters.

Actions: In all cases
- report that the LAT is within the SAA (LIMACTSAACHANGE)
- if the LPA task is RUNNING and LIM is not in the HOLD operating mode
  - send LPA-Stop to the LPA task (LIMACTLPASTOP)
  - indicate that the LPA task is STOPPING (LIMACTLPASTATE)
  - wait 5 seconds
- if LIM is not in the TERMINAL operating mode
  - call the PIG_enter_SAA function to set the ACD high voltage to SAA levels (LIMACTSAACFG)

## 3.5.17 SAA Exit

Description: This command is a notification that the LAT instrument has exited the South Atlantic Anomaly (SAA). When LIM receives this command, it uses the PIG_exit_SAA function to restore the high-voltage to the ACD (unless the operating mode is TERMINAL). LIM also updates its internal state to indicate that an SAA transit is no longer in progress.

Parameters: This command contains no parameters.

Actions: In all cases
- report that the LAT is not within the SAA (LIMACTSAACHANGE)
- if LIM is not in the TERMINAL operating mode and LIM is

allowed to enable the ACD high voltage

- call the PIG_exit_SAA function to set the ACD high voltage to non-SAA levels (LIMACTNONSAACFG)

## 3.5.18 Safe Mode

Description: This command is a request to enter Safe Mode. LIM does not support this command since the actions required are identical to those for the Load-Shed command.

Parameters: This command contains no parameters.

Actions: In all cases

- reject the command with LIM_UNSUP status.

# 4 Telemetry

LIM reports its actions and state changes by sending diagnostic and alert telemetry packets to the spacecraft.

## 4.0 Diagnostic (LIM-State) Telemetry

LIM responds to certain events by sending a LIM-State diagnostic telemetry packet to the spacecraft. This telemetry packet uses the APID $30f_h$ (783) and contains the following information:

- Action that caused the telemetry packet to be sent (LIMTACTION)
- MSG status code for the action (LIMTSTATUS)
- Current operating mode (LIMTOPMODE)
- Indication of whether an SAA transit is in progress (LIMTSAATRANSIT)
- Current states of the LCI and LPA tasks (LIMTLCISTATE and LIMTLPASTATE)
- Current state of TOO activity – including the time remaining in the activity (LIMTTOOREMAINSEC) and indications of whether the activity is active (LIMTTOOACTIVE), has been started (LIMTTOOSTARTED), or is ready to be started (LIMTTOOREADY)
- Current state of ARR activity – including the time remaining in the spacecraft repointing period (LIMTARRREMAINSEC), indications of whether the activity is active (LIMTARRACTIVE) or is ready to be started (LIMTARRREADY), indication of whether a repoint request is pending (LIMTARRREPPEND), and current GRB state (LIMTARRGRBSTATE)
- Current configuration of the ACD high-voltage interface (LIMTHVALLOW), GBM command handler (LIMTGBMREPALLOW), and GBM trigger signal interrupts (LIMTPRIINTALLOW, LIMTREDINTALLOW, and LIMTDISREMAINSEC)

## 4.1 LIM Actions

The LIM task uses the LIMTACTION values described in Table 4 (and defined in the LIM/LIM_pubdefs.h header file) to report its actions. Whenever one of these actions occurs, LIM sends a LIM-State diagnostic telemetry packet.

Table 4 – LIMTACTION Values

| Value | Name | Description |
|---|---|---|
| 0 | Unknown | Reserved value that LIM should not report. |
| 1 | Start | The **LIM_start** or **LIM_start_with_db** function started the LIM task. |

| | | |
|---|---|---|
| 2 | OpModeCh | LIM changed the operating mode. The new operating mode is indicated in the LIM-State telemetry packet. |
| 3 | MainFeed | The **Main-Feed-On** command handler called the PIG_siu_init function, which configured the command/response fabric, enabled power to the main feed, completed LCB initialization, and set the LAT address of the SIU. |
| 4 | PowerOn | The **Power-On** command handler called the PIG_insert function, which enabled power to one or more LAT components and inserted them into the command/response fabric. |
| 5 | PowerOff | The **Power-Off** command handler called the PIG_extract function, which removed one or more LAT components from the command/response fabric and disabled power from them. |
| 6 | <unused> | |
| 7 | EventIns | Either:<br>The **Power-On** command handler called the PIG_insert_evt function, which inserted one or more LAT components into the event fabric, or<br>The **Main-Feed-On** command handler called the PIG_insert_evt function to insert the SIU into the event fabric. |
| 8 | EventRem | The **Power-Off** command handler called the PIG_extract_evt function, which removed one or more LAT components from the event fabric. |
| 9 | ShedBegin | The **Load-Shed** command handler is about to call the PIG_shed function, which will disable power from all LAT components and the main feed in an orderly manner. |
| 10 | ShedEnd | The **Load-Shed** command handler called the PIG_shed function, which disabled power from all LAT components and the main feed in an orderly manner. |
| 11 | <unused> | |
| 12 | <unused> | |
| 13 | LpaStart | LIM sent a Physics-Start (LPASTART) command to the LPA task to start either a NORMAL or TOO observation. |
| 14 | LpaSetMod | LIM called the LPA_set_mode function to change the LPA observation mode. |
| 15 | LpaStop | LIM sent a Physics-Stop (LPASTOP) command to the LPA task to stop an observation run. |
| 16 | LtcStop | The **Load-Shed** command handler sent the LTC-Stop command to the LTC task. |
| 17 | SiuReboot | The **Load-Shed** command handler is about to call the PBS_reboot function, which will reboot the SIU CPU. |
| 18 | <unused> | |
| 19 | SaaCfg | The **Configure-HV**, **Power-On**, or **SAA-Enter** command handler called the PIG_enter_SAA function, which selected the SAA bias voltage for the ACD. |
| 20 | <unused> | |

| | | |
|---|---|---|
| 21 | NonSaaCfg | The **Configure-HV**, **Power-On**, or **SAA-Exit** command handler called the PIG_exit_SAA function, which selected the non-SAA bias voltage for the ACD. |
| 22 | CalStart | The **Calibration-Start** command handler sent a Calibration-Start (LCICALIBRATE) command to the LCI task. |
| 23 | CalAbort | The **Calibration-Abort**, **TOO-Start**, **ARR-Start**, or **Load-Shed** command handler sent a Calibration-Abort (LCIABORT) command to the LCI task. |
| 24 | CalOther | LIM forwarded an 'other' LCI command to the LCI task while in the CALIBRATION operating mode. |
| 25 | <unused> | |
| 26 | <unused> | |
| 27 | <unused> | |
| 28 | <unused> | |
| 29 | <unused> | |
| 30 | CalComp | LIM received a Calibration-Complete message from the LCI task. |
| 31 | <unused> | |
| 32 | LpaComp | LIM received a Physics-Complete message from the LPA task. |
| 33 | LciState | LIM changed the state of the LCI task. The new LCI task state is indicated in the LIM-State telemetry packet. |
| 34 | <unused> | |
| 35 | LpaState | LIM changed the state of the LPA task. The new LPA task state is indicated in the LIM-State telemetry packet. |
| 36 | <unused> | |
| 37 | ArrState | LIM changed the READY state of the ARR activity. The new ARR activity state is indicated in the LIM-State telemetry packet. |
| 38 | <unused> | |
| 39 | <unused> | |
| 40 | TooState | LIM changed the READY or STARTED state of the TOO activity. The new TOO activity state is indicated in the LIM-State telemetry packet. |
| 41 | <unused> | |
| 42 | LpaActive | LIM forwarded an 'other' LPA command to the LPA task while in the PHYSICS operating mode. |
| 43 | LpaIdle | LIM forwarded an 'other' LPA command to the LPA task while not in the PHYSICS operating mode. |
| 44 | <unused> | |
| 45 | SaaChange | The **SAA-Enter** or **SAA-Exit** command handler changed the SAA transit status. The new SAA transit status is indicated in the LIM-State telemetry packet. |
| 46 | <unused> | |

| | | |
|---|---|---|
| 47 | RepRec | LIM received a Repoint-Recommendation command from the GBM, which recommended a repoint. |
| 48 | RepNoRec | LIM received a Repoint-Recommendation command from the GBM, which did not recommend a repoint. |
| 49 | GbmCmd | LIM forwarded a command from the GBM to the LPA task. |
| 50 | SlewReq | The **ARR-Start** or **GBM-Repoint-Recommendation** command handler sent a Slew-Request command to the spacecraft. |
| 51 | SlewAccept | LIM received a response to a Slew-Request command that indicated the request was accepted. |
| 52 | SlewReject | LIM received a response to a Slew-Request command that indicated the request was rejected. |
| 53 | PidSelPri | The **Configure-PID** command handler, the **LIM_start** function, or the **LIM_start_with_db** function selected the primary PID input signals. |
| 54 | PidSelRed | The **Configure-PID** command handler, the **LIM_start** function, or the **LIM_start_with_db** function selected the redundant PID input signals. |
| 55 | Stop | The **LIM_stop** function stopped the LIM task. |
| 56 | BiasAcd | The **Bias-ACD** command handler called the PIG_bias_ACD function, which set one or more ACD bias voltages. |
| 57 | BiasCal | The **Bias-CAL** command handler called the PIG_bias_CAL function, which set one or more CAL bias voltages. |
| 58 | BiasTkr | The **Bias-TKR** command handler called the PIG_bias_TKR function, which set one or more TKR bias voltages. |
| 59 | GbmState | The **Configure-GBM** command handler changed the state of the GBM-REPOINT-ALLOW flag. The new flag value is indicated in the LIM-State telemetry packet. |
| 60 | HvState | The **Configure-HV** command handler changed the state of the HV-ALLOW flag. The new flag value is indicated in the LIM-State telemetry packet. |
| 61 | CalStrtSt | LIM received status from a Calibration-Start (LCICALIBRATE) command that it sent to the LCI task. The status for the command is indicated in the LIM-State telemetry packet. |
| 62 | <unused> | |
| 63 | LpaStartSt | LIM received status from a Physics-Start (LPASTART) command that it sent to the LPA task. The status for the command is indicated in the LIM-State telemetry packet. |
| 64 | CalAbrtSt | LIM received status from a Calibration-Abort (LCIABORT) command that it sent to the LCI task. The status for the command is indicated in the LIM-State telemetry packet. |
| 65 | <unused> | |
| 66 | LpaStopSt | LIM received status from a Physics-Stop (LPASTOP) command that it sent to the LPA task. The status for the command is indicated in the LIM-State telemetry packet. |
| 67 | EnGbmPri | LIM enabled the primary GBM trigger signal interrupt. |
| 68 | EnGbmRed | LIM enabled the redundant GBM trigger signal interrupt. |

| | | |
|---|---|---|
| 69 | GbmIntPri | LIM received an interrupt from the primary GBM trigger signal. |
| 70 | GbmIntRed | LIM received an interrupt from the redundant GBM trigger signal. |
| 71 | RepReqSt | LIM changed the state of the slew-request PENDING flag. The new flag value is indicated in the LIM-State telemetry packet. |
| 72 | CalcInfo | LIM received a 'Calculated Information' message from the GBM. |
| 73 | CloseOut | LIM received a 'CloseOut' message from the GBM. |
| 74 | DisGbmPri | LIM disabled the primary GBM trigger signal interrupt. |
| 75 | DisGbmRed | LIM disabled the redundant GBM trigger signal interrupt. |
| 76 | GrbSuspect | LIM received a GRB-Suspected message from the LPA task. |
| 77 | GrbConfirm | LIM received a GRB-Confirmed message from the LPA task. |
| 78 | GrbFinish | LIM received a GRB-Finished essage from the LPA task. |
| 79 | LpaGbmInt | LIM called the LPA_gbm_int function to notify the LPA task that a GBM interrupt has occurred. |

# 4.2 Alert Telemetry

LIM also sends alert telemetry when it sends repoint requests to the spacecraft and receives responses to these repoint requests. Per the LAT-GBM ICD, LIM sends LATAUTOREPREQTLM (APID $344_h$) alert telemetry whenever it requests a repoint via the SACSLEWREQUEST (APID $600_h$) command. When the spacecraft responds with a LSLEWREQREPLY (APID $661_h$) message, LIM sends LATARRRESPONSETLM (APID $345_h$) alert telemetry. These actions are summarized in the table below.

Table 5 – Alert Telemetry Conditions

| | | |
|---|---|---|
| LIM sends SACSLEWREQUEST ($600_h$) | => | LIM sends LATAUTOREPREQTLM ($344_h$) |
| LIM receives LSLEWREQREPLY ($661_h$) | => | LIM sends LATARRRESPONSETLM ($345_h$) |

# 5 Use Cases

This chapter describes the behavior of LIM in response to various scenarios and sequences of commands.

## 5.0 Normal Activity

These scenarios describe normal calibration and physics observation activities.

Normal calibration procedure

| Actions | Mode | LCI State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Calibration-Start command<br>- Forward to LCI | Calibration | Running |
| Receive other LCI commands<br>- Forward to LCI | “ | “ |
| Receive Calibration-Complete message from LCI | Quiescent | Idle |

Normal physics observation

| Actions | Mode | LPA State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Physics-Start command<br>- Forward to LPA | Physics | Running |
| Receive other LPA commands<br>- Forward to LPA | “ | “ |
| Receive Physics-Stop command<br>- Send Physics-Stop to LPA | “ | Stopping |
| - Wait for end of physics observation | “ | “ |
| Receive Physics-Complete message from LPA | Quiescent | Idle |

## 5.1 Aborted Activity

This scenario describes an aborted calibration activity.

Aborted calibration procedure

| Actions | Mode | LCI State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Calibration-Start command<br>- Forward to LCI | Calibration | Running |
| Receive other LCI commands<br>- Forward to LCI | " | " |
| Receive Calibration-Abort command<br>- Forward to LCI | " | Stopping |
| - Wait for end of calibration procedure, rejecting any LCI commands that may arrive | " | " |
| Receive Calibration-Complete message from LCI | Quiescent | Idle |

## 5.2 Target-of-Opportunity Activity

These scenarios describe Target-of-Opportunity (TOO) repointed observation activities.

Normal Target-of-Opportunity observation

| Actions | Mode | LPA State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive TOO-Start command<br>- Start TOO timer<br>- Send Physics-Start command to LPA | TOO | Running |
| TOO timer expires<br>- Change LPA mode | Physics | Running |

Target-of-Opportunity interrupts a physics observation, which continues after the TOO

| Actions | Mode | LPA State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Physics-Start command<br>- Forward to LPA | Physics | Running |
| Receive TOO-Start command<br>- Start TOO timer<br>- Change LPA mode | TOO | " |
| TOO timer expires | Physics | Running |

| | | |
|---|---|---|
| - Change LPA mode | | |
| Receive Physics-Stop command<br>- Forward to LPA | " | Stopping |
| - Wait for end of physics observation | " | " |
| Receive Physics-Complete message from LPA | Quiescent | Idle |

Target-of-Opportunity interrupts a physics observation, which ends during the TOO

| Actions | Mode | LPA State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Physics-Start command<br>- Forward to LPA | Physics | Running |
| Receive TOO-Start command<br>- Start TOO timer<br>- Change LPA mode | TOO | " |
| Receive Physics-Stop command<br>- Forward to LPA | " | Stopping |
| - Wait for end of physics observation | " | " |
| Receive Physics-Complete message from LPA | " | Idle |
| Receive Calibration-Start command<br>- Reject command | " | " |
| Receive Physics-Start command<br>- Forward to LPA | TOO | Running |
| Receive Physics-Stop command<br>- Forward to LPA | " | Stopping |
| - Wait for end of physics observation | " | " |
| Receive Physics-Complete message from LPA | " | Idle |
| TOO timer expires | Quiescent | " |

## 5.3 SAA Activity

These scenarios describe SAA transits during various other activities.

SAA during normal calibration procedure

| Actions | Mode | LCI State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Calibration-Start command<br>- Forward to LCI | Calibration | Running |
| Receive other LCI commands<br>- Forward to LCI | " | " |
| Receive SAA-Enter command<br>- Call PIG_enter_SAA to configure ACD high voltage | " | " |
| Receive SAA-Exit command<br>- Call PIG_exit_SAA to configure ACD high voltage | " | " |
| Receive Calibration-Complete message from LCI | Quiescent | Idle |

SAA during normal physics observation

| Actions | Mode | LPA State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Physics-Start command<br>- Forward to LPA | Physics | Running |
| Receive SAA_enter command<br>- Send Physics-Stop to LPA | " | Stopping |
| - Wait 5 seconds | " | " |
| - Call PIG_enter_SAA to configure ACD | " | " |
| Receive Phys-Complete message from LPA (this may arrive before the end of the 5 second waiting period) | Quiescent | Idle |
| Receive SAA_exit command<br>- Call PIG_exit_SAA to configure ACD | " | " |

SAA during interrupted physics observation

| Actions | Mode | LPA State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Physics-Start command<br>- Forward to LPA | Physics | Running |
| Receive TOO-Start command<br>- Start TOO timer | TOO | " |

| | | |
|---|---|---|
| - Change LPA mode | | |
| Receive SAA_enter command<br>- Send Physics-Stop to LPA | " | Stopping |
| - Wait 5 seconds | " | " |
| - Call PIG_enter_SAA to configure ACD | " | " |
| Receive Phys-Complete message from LPA (this may arrive before the end of the 5 second waiting period) | " | Idle |
| Receive SAA_exit command<br>- Call PIG_exit_SAA to configure ACD | " | " |
| TOO timer expires | Quiescent | " |

# 5.4 Invalid Command Sequences

This scenario describes invalid command sequences for which LIM rejects one or more commands.

Nested physics observation

| Actions | Mode | LPA State |
|---|---|---|
| Initial condition | Quiescent | Idle |
| Receive Physics-Start command<br>- Forward to LPA | Physics | Running |
| Receive a second Physics-Start command<br>- Reject the command | " | " |
| Receive Physics-Stop command<br>- Forward to LPA | " | Stopping |
| - Wait for end of physics observation | " | " |
| Receive Physics-Complete message from LPA | " | Idle |
| Receive a second Physics-Stop command<br>- Forward to LPA | " | " |

# 6 Control and Status

The LIM package provides functions that control the operation of the LIM task and command handlers. It also contains a function that reports the status of the LIM task. These functions act as the interface to the LIM package.

All of the LIM functions described here return a MSG status code which indicates whether the function succeeded or failed.

## 6.0 LIM_initialize

The LIM_initialize function allocates resources used by the LIM package and sets configuration values to their default state. It accepts a single parameter:

- The ID of the LIM task.

## 6.1 LIM_init_with_db

The LIM_init_with_db function is a wrapper for the LIM_initialize function that uses the LIM_DB configuration database to determine the LIM task ID. It requires no parameters.

## 6.2 LIM_start

The LIM_start function starts the LIM task. It accepts a single parameter:

- A pointer to an attribute structure for the LIM task. If this pointer value is NULL, LIM uses the CPU_DB configuration database to determine the task attributes.

## 6.3 LIM_start_with_db

The LIM_start_with_db function is a wrapper for the LIM_start function that uses the CPU_DB configuration database to determine the LIM task attributes. It requires no parameters.

## 6.4 LIM_stop

The LIM_stop function stops the LIM task. It requires no parameters.

## 6.5 LIM_shutdown

The LIM_shutdown function frees resources allocated by the LIM package. It requires no parameters.

## 6.6 LIM_getInfo

The LIM_getInfo function returns information about the state of the LIM package. This state includes the same type of information as is found in the LIM telemetry packet (see chapter 4). This function requires a single parameter, which is a pointer to a buffer into which the LIM information should be stored.

## 6.7 LIM_capture_cal

The LIM_capture_cal function instructs LIM to capture all commands with the specified APID and handle them as if they were calibration commands intended for the LCI task. It accepts three parameters:

- The APID of the commands to capture.
- The function code of the Calibration-Start command. If this value is '-1' LIM assumes that the Calibration-Start command uses a different APID.
- The function code of the Calibration-Abort command. If this value is '-1' LIM assumes that the Calibration-Abort command uses a different APID.

This function may be called only after the LIM_initialize and LCI_initialise functions have been called and before the LIM_start and LCI_startTask functions have been called.

This command may be called multiple times – once for each APID used by the calibration commands. If it is called more than once, the Calibration-Start function code parameter can be non-negative in only one of these function calls. Likewise for the Calibration-Abort function code parameter.

## 6.8 LIM_capture_cal_with_db

The LIM_capture_cal_with_db function is a wrapper for the LIM_capture_cal function that uses the CPU_DB configuration database to determine the APIDs and function codes of the LCI commands. It requires no parameters

## 6.9 LIM_capture_physics

The LIM_capture_physics function instructs LIM to capture all commands with the specified APID and handle them as if they were physics commands intended for the LPA task. It accepts four parameters:

- The APID of the commands to capture.
- The function code of the Physics-Start command. If this value is '-1' LIM assumes that the Physics-Start command uses a different APID.
- The function code of the Physics-Resume command. If this value is '-1' LIM assumes that the Physics-Resume command uses a different APID.
- The function code of the Physics-Stop command. If this value is '-1' LIM assumes that the Physics-Stop command uses a different APID.

This function may be called only after the LIM_initialize and LPA_initialize functions have been called and before the LIM_start and LPA_start functions have been called.

This command may be called multiple times – once for each APID used by the physics commands. If it is called more than once, the Physics-Start function code parameter can be non-

negative in only one of these function calls. Likewise for the Physics-Resume and Physics-Stop function code parameters.

## 6.10 LIM_capture_physics_with_db

The LIM_capture_physics_with_db function is a wrapper for the LIM_capture_physics function that uses the CPU_DB configuration database to determine the APIDs and function codes of the LPA commands. It requires no parameters.