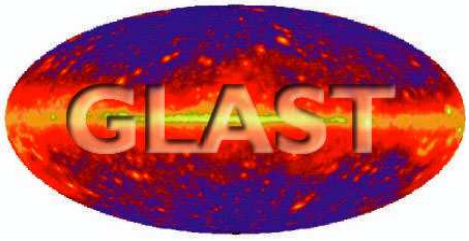

LAT Flight Software

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 transitioning between the operating modes and ensuring 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 transition to the new 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 mode, it forwards the command to the intended target task. In some cases, LIM delays forwarding these commands until the LAT instrument enters an appropriate operating mode. 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 repoint observation timer expirations,
- State of various flight software tasks.

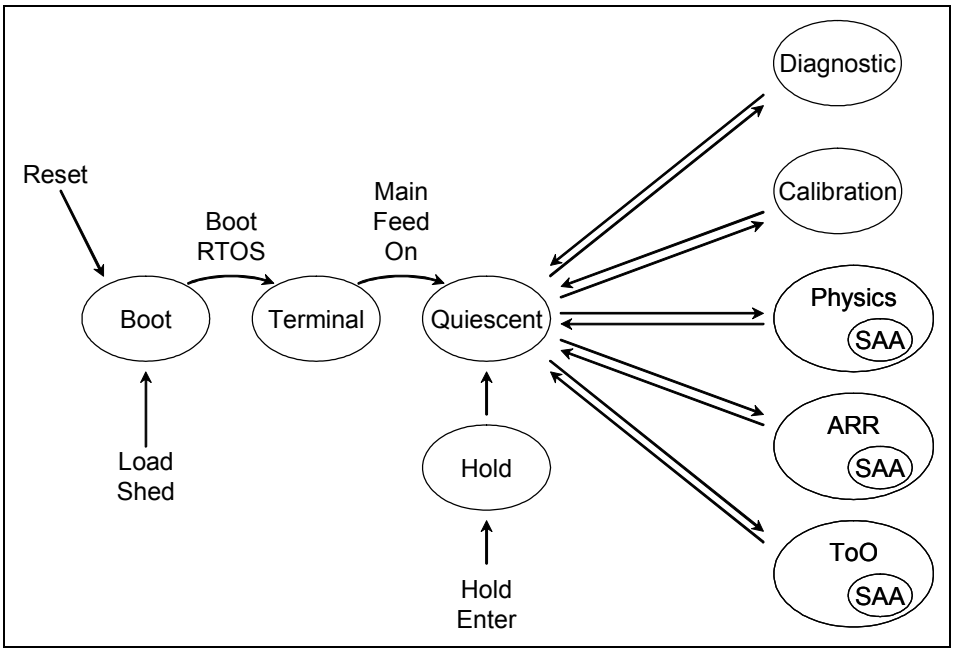
1.0 Operating Modes

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, calibration, or diagnostics.
Hold	Stable mode for troubleshooting.
Diagnostic	Diagnostic functions are active.
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 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 and some of these external states and modes.

Table 2 – Operating Mode Correlations

External Mode/State	LIM 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, Diagnostic, Calibration, Hold
Sky Survey	Physics
Pointed Observation	Physics
Repointed Observation: ToO	ToO
Repointed Observation: ARR	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 Boot-RTOS command.

LIM returns to the BOOT mode when it receives the Load-Shed command, regardless of the current 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 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.

While in this mode, LIM accepts only those commands that affect the safety of the instrument (SAA-Enter, SAA-Exit, and Load-Shed) and the command that causes a transition to the QUIESCENT mode (Main-Feed-On). All other commands are rejected, including commands intercepted by LIM but intended for other tasks.

From the TERMINAL mode, LIM transitions to the QUIESCENT mode when it receives the 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, diagnostic procedures, and charge injection calibrations. When LIM is in this mode, the GASU and PDU have been powered and LIM accepts commands to enable power to other LAT components.

From this mode, LIM transitions to a number of different modes, depending on the type of activity requested (physics observations, diagnostic procedures, or charge injection calibrations). Once one of these activities has started, LIM must return to the QUIESCENT mode before a new activity can begin.

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 DIAGNOSTIC Mode

The DIAGNOSTIC mode is used to perform testing and troubleshooting procedures that cannot be performed in TERMINAL mode. While in DIAGNOSTIC mode, LIM forwards all intercepted

LDF commands to the LDF task. (LIM rejects intercepted LDF commands when not in the DIAGNOSTIC mode.)

LIM transitions to this mode when it receives a Diagnostic-Start command while in the QUIESCENT mode.

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

1.0.5 CALIBRATION Mode

The CALIBRATION mode is a specialized form of the DIAGNOSTIC mode. When 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.

1.0.6 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 perspectives of LIM and LPA. During this mode, LIM forwards all intercepted LPA commands to the LPA task.

LIM transitions to this mode from the QUIESCENT mode when a Physics-Start command is available for execution. If LIM accepts a Physics-Start command while in the QUIESCENT mode, it transitions to the PHYSICS mode immediately. If LIM accepts this command while in some other mode, however, the command is saved and made available for execution when LIM next returns to the QUIESCENT mode.

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 only as a result of a Physics-Stop command. Unlike diagnostic and calibration procedures, the LPA task ends a physics observation only when told to do so by command. If the LPA task fails to send this completion message, LIM remains in the PHYSICS mode until it receives a Load-Shed or Hold-Enter command.

A physics observation can be interrupted by a repointed observation initiated by a ToO-Start command or an ARR-Response message. When LIM receives one of these messages, it suspends the current physics observation and transitions to the ToO or ARR mode (via the QUIESCENT mode). At the completion of the repoint period, LIM resumes the suspended physics observation and returns to the PHYSICS mode. (Depending on the virtual mode, though, LIM may not resume the suspended physics operation – see section 1.2).

1.0.7 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 ends the current diagnostic procedure, calibration procedure, or physics observation and starts a repointed observation. While in ToO mode, LIM rejects Diagnostic-Start and Calibration-Start commands, but keeps track of Physics-Start and Physics-Stop commands and maintains a virtual mode that it uses to determine which mode to enter when the repointed observation is completed.

LIM remains in the ToO mode until the end of the repoint period. The length of the repoint period is specified in the ToO-Start command.

At the conclusion of the repoint period, if the virtual mode indicates that an interrupted physics observation should still be active, LIM transitions back to the PHYSICS mode and resumes the interrupted observation. If the virtual mode indicates that a new physics observation should be started, LIM transitions to the PHYSICS mode and starts the new observation with the saved Physics-Start command. If neither of these conditions is true, LIM returns to the QUIESCENT mode. Note that LIM will not resume a diagnostic or calibration procedure that was in progress when the ToO-Start command arrived.

1.0.8 ARR Mode

The Autonomous Repoint Request (ARR) mode is entered when the LPA task wants to interrupt a scheduled physics run to observe an unanticipated target. When LIM receives an acceptance response to an Autonomous Repoint Request while in PHYSICS mode, it suspends the current physics observation run and starts the ARR run. Since Autonomous Repoint Requests are initiated by the LPA task, ARR responses are ignored when LIM is not in the PHYSICS mode.

At the completion of the time period specified in the ARR response, LIM stops the ARR observation run, resumes the suspended physics run, and transitions back to the PHYSICS mode. (Depending on the virtual mode, though, LIM may not resume the suspended physics run.)

1.1 SAA

When LIM receives the SAA-Enter command, it does not change its operating mode. Instead, LIM 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 current mode is PHYSICS, ToO, or ARR when the SAA-Enter command is received, LIM suspends the observation run by sending the Physics-Stop command to the LPA task. During the SAA transit, LIM continues to obey the mode transition rules, with the exception that it does not start or resume physics observations. When LIM receives the SAA-Exit command, it either resumes a suspended observation run by sending the Physics-Resume command to the LPA task, or transitions to the QUIESCENT mode to handle any saved commands (according to the virtual mode).

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

1.2 Virtual Mode

There are several situations in which a physics run must be delayed or interrupted while the LAT instrument performs a higher priority activity. This would be the case, for example, when an SAA transit begins during a physics run, or a Physics-Start command arrives during a Target-of-Opportunity observation. To handle these situations, LIM maintains a 'virtual' mode that it uses to determine which operating mode to enter once the higher priority activity is completed.

In addition to handling pre-emption by higher priority activities, LIM also uses the virtual mode to delay the start of a physics run until the completion of a diagnostic or calibration procedure. This is useful for avoiding dead time before a physics run when the length of a preceding diagnostic or calibration procedure is not known.

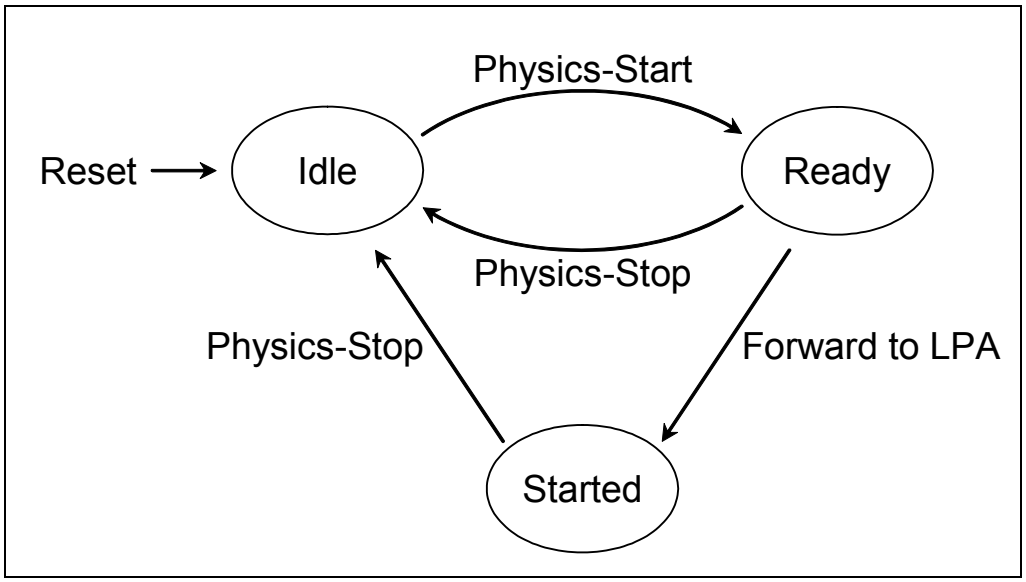
There are three virtual modes, as shown in Figure 2.

IDLE: LIM starts in the IDLE virtual mode, which indicates that no physics run is in progress or waiting to be started or resumed. Note that this mode does not necessarily indicate that the actual operating mode is QUIESCENT – it is only an indication that no physics run is being delayed by the current operation.

READY: This virtual mode indicates that LIM has received and saved a Physics-Start command. LIM remains in this virtual mode until it either forwards the saved command to the LPA task or receives a Physics-Stop command. In the former case, the virtual mode transitions to STARTED, and in the latter case it transitions to IDLE.

STARTED: This virtual mode indicates that a physics run has been started but not yet completed. LIM remains in this virtual mode until it receives a Physics-Stop command, at which point the virtual mode transitions to IDLE. While in this virtual mode, the physics run may be interrupted one or more times by higher priority activities. At the start of each interruption, LIM sends a Physics-Stop command to the LPA task. At the end of each interruption, LIM sends a Physics-Resume command. Unless LIM itself receives a Physics-Stop command during the interruption, the virtual mode remains as STARTED.

Figure 2 – LIM Virtual Modes



1.3 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 DIAGNOSTIC or CALIBRATION mode, LIM aborts the current procedure before starting a physics run for the ToO observation. In this case, LIM saves the ToO-Start command that initiated the ToO observation and forwards it to the LPA task when the Diagnostic-Complete or Calibration-Complete command is received. Note that the aborted diagnostic or calibration procedure is not restarted at the completion of the ToO observation.
- If LIM is in the PHYSICS or ARR mode when a ToO-Start command arrives, it suspends the current physics run by sending the Physics-Stop command to the LPA task. LIM expects the LPA task to save the current instrument configuration when it receives this Physics-Stop command, so that LIM can restore the configuration with a Physics-Resume command at the completion of the ToO observation.
- In the ToO mode, LIM rejects ToO-Start commands because the LAT instrument is already performing a ToO observation.
- In the TERMINAL or HOLD mode, LIM rejects ToO-Start commands because the LAT instrument is not ready to perform physics observations.

1.4 Autonomous Repoint Request

Another 'higher priority' activity that the LAT instrument can perform is an Autonomous Repoint observation. This type of observation is initiated by the LPA task when it sends the Autonomous Repoint Request (ARR) to the spacecraft. If the spacecraft accepts the request, it sends an ARR-Response to the LAT instrument. LIM intercepts this response message and uses it as a trigger to entering the ARR mode.

When LIM receives this command, its response depends on the current operating mode:

- In the DIAGNOSTIC or CALIBRATION mode, LIM ignores the ARR-Response because the physics observation run that requested the repoint is no longer active.
- If LIM is in the PHYSICS mode when the ARR-Response message arrives, it suspends the current physics run by sending the Physics-Stop command to the LPA task. LIM expects the LPA task to save the current instrument configuration when it receives this Physics-Stop command, so that LIM can restore the configuration with a Physics-Resume command at the completion of the ARR observation.
- In the ToO or ARR mode, LIM ignores ARR-Response messages because the LAT instrument is already performing a repointed observation.
- In the TERMINAL or HOLD mode, LIM ignores ARR-Response messages because the LAT instrument is not ready to perform physics observations.

1.5 LCI, LDF, and LPA State

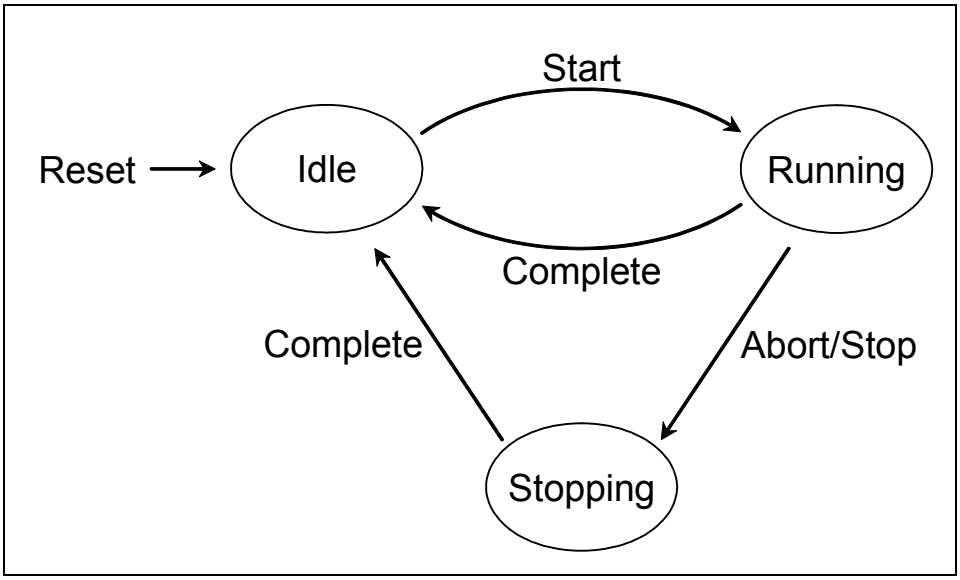
To help determine the current operating mode, LIM keeps track of the current 'state' of each of three other tasks – LAT Charge Injection (LCI), LAT Diagnostic Framework (LDF), and LAT Physics Acquisition (LPA). At any particular time, LIM considers each of these tasks to be either

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 3. 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 3 – LCI, LDF, and LPA States



2 Commands and Messages

LIM responds to certain commands by changing its operating mode, 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.

2.0 LCI Commands and Messages

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 for the current LCI task state (as described in section 1.5). LIM also receives Calibration-Complete messages sent by the LCI task at the completion of a calibration procedure.

LIM uses the Calibration-Start (LCI-CALIBRATE) 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.

2.0.0 Calibration Start (LCI-CALIBRATE)

Description: This command is a request to start a calibration procedure.

Action: LIM intercepts this command and forwards it to the LCI task if it is appropriate for the current operating mode and LCI task state. If not appropriate, LIM rejects this command.

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

Operating Mode: LIM accepts and forwards this command if either (1) the current operating mode is QUIESCENT or (2) the current mode is CALIBRATION and the LCI task is not in the **Stopping** state. In the first case, LIM transitions from the QUIESCENT mode to the CALIBRATION mode.

LCI State: If forwarded to the LCI task, this command causes LIM to change the LCI task state to **Running**.

Virtual Mode: This command does not affect the virtual mode.

2.0.1 Calibration Abort (LCI-ABORT)

Description: This command is a request to abort a calibration procedure.

Action: LIM intercepts this command and forwards it to the LCI task.

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

Operating Mode: LIM accepts and forwards this command in all operating modes except TERMINAL and HOLD. The receipt of this command does not affect the operating mode directly. Instead, LIM determines whether a mode transition is necessary when it receives the Calibration-Complete message that the LCI task sends in response to this command.

LCI State: If the LCI task is in the **Running** state when LIM forwards this command to LCI, it changes the LCI state to **Stopping**. Otherwise, LIM does not change the LCI task state and reports a warning (the command is still forwarded to the LCI task, though).

Virtual Mode: This command does not affect the virtual mode.

2.0.2 Calibration Complete

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

Action: LIM uses this message to change the operating mode and LCI task state.

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

Operating Mode: This message causes LIM to transition from the CALIBRATION mode to the QUIESCENT mode. If LIM is not in the CALIBRATION mode, though, LIM reports a warning and does not change the operating mode.

LCI State: This message causes LIM to change the LCI task state to **Idle**. LIM reports a warning if the LCI task is already in the **Idle** state.

Virtual Mode: This command does not affect the virtual mode.

2.0.3 Other LCI Commands

Description: These commands direct the operation of the LCI task during a calibration procedure.

Action: LIM intercepts these commands and forwards them to the LCI task if they are appropriate for the current operating mode and LCI task state. If not appropriate, LIM rejects these commands.

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

Operating Mode: LIM accepts and forwards these commands only in the CALIBRATION operating mode. They do not cause LIM to change the operating mode.

LCI State: LIM accepts and forwards these commands only if the current LCI task state is **Running**. They do not cause LIM to change the LCI state.

Virtual Mode: These commands do not affect the virtual mode.

2.1 LDF Commands and Messages

The LAT Diagnostic Framework task (LDF) handles instrument diagnostic procedures. As with the LCI task, LIM intercepts all commands sent to LDF and forwards those that are appropriate

for the current operating mode and for the current LDF task state. LIM also receives Diagnostic-Complete messages sent by the LDF task at the completion of a diagnostic procedure.

LIM uses the Diagnostic-Start command and the Diagnostic-Complete message to determine operating mode transitions. When in the QUIESCENT mode, LIM transitions to the DIAGNOSTIC mode whenever it forwards a Diagnostic-Start command to LDF. The operating mode changes back to QUIESCENT when LIM receives the Diagnostic-Complete message.

2.1.0 Diagnostic Start

Description: This command is a request to start a diagnostic procedure.

Action: LIM intercepts this command and forwards it to the LDF task if it is appropriate for the current operating mode and LDF task state. If not appropriate, LIM rejects this command.

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

Operating Mode: LIM accepts and forwards this command if either (1) the current operating mode is QUIESCENT or (2) the current mode is DIAGNOSTIC and the LDF task is not in the **Stopping** state. In the first case, LIM transitions from the QUIESCENT mode to the DIAGNOSTIC mode.

LDF State: If forwarded to the LDF task, this command causes LIM to change the LDF task state to **Running**.

Virtual Mode: This command does not affect the virtual mode.

2.1.1 Diagnostic Abort

Description: This command is a request to abort a diagnostic procedure.

Action: LIM intercepts this command and forwards it to the LDF task.

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

Operating Mode: LIM accepts and forwards this command in all operating modes, except TERMINAL and HOLD. The receipt of this command does not affect the operating mode directly. Instead, LIM determines whether a mode transition is necessary when it receives the Diagnostic-Complete message that the LDF task sends in response to this command.

LDF State: If the LDF task is in the **Running** state when LIM forwards this command to LDF, it changes the LDF state to **Stopping**. Otherwise, LIM does not change the LDF task state and reports a warning (the command is still forwarded to the LDF task, though).

Virtual Mode: This command does not affect the virtual mode.

2.1.2 Diagnostic Complete

Description: This message indicates that the LDF task has completed a diagnostic procedure.

Action: LIM uses this message to change the operating mode and LDF task state.

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

Operating Mode: This message causes LIM to transition from the DIAGNOSTIC mode to the QUIESCENT mode. If LIM is not in the DIAGNOSTIC mode, though, LIM reports a warning and does not change the operating mode.

LDF State: This message causes LIM to change the LDF task state to **Idle**. LIM reports a warning if the LDF task is already in the **Idle** state.

Virtual Mode: This command does not affect the virtual mode.

2.1.3 Other LDF Commands

Description: These commands direct the operation of the LDF task during a diagnostic procedure.

Action: LIM intercepts these commands and forwards them to the LDF task if they are appropriate for the current operating mode and LDF task state. If not appropriate, LIM rejects these commands.

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

Operating Mode: LIM accepts and forwards these commands only in the DIAGNOSTIC operating mode. They do not cause LIM to change the operating mode.

LDF State: LIM accepts and forwards these commands only if the current LDF task state is **Running**. They do not cause LIM to change the LDF state.

Virtual Mode: These commands do not affect the virtual mode.

2.2 LPA Commands and Messages

The LAT Physics Acquisition task (LPA) handles physics observations in both pointed and repointed modes of operation. As with the LCI and LDF tasks, 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.

LIM uses a number of different LPA commands, along with the Physics-Complete message, to determine operating mode transitions. This determination is complicated by two situations that LIM supports – (1) the interruption of a physics observation by a repointed observation (Target-of-Opportunity and Autonomous-Repoint-Request), and (2) the delay of a physics observation until the completion of a diagnostic or calibration procedure. The handling of these situations is described in chapter 1 and in the command descriptions below.

2.2.0 Physics Start

Description: This command is a request to start a physics observation.

Action: LIM intercepts this command and uses it to determine the current virtual mode. If the command is appropriate for the current operating and virtual modes, LIM accepts it and saves a copy of it to be forwarded to the LPA task at a later time. If the command is not appropriate, however, LIM rejects this command.

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

Operating Mode: LIM rejects this command if the operating mode is TERMINAL or HOLD. Otherwise, LIM accepts and saves a copy of this command (provided the virtual mode is IDLE).

LPA State: LIM changes the LPA state to **Running** when it forwards the saved copy of this command to the LPA task.

Virtual Mode: LIM accepts and saves a copy of this command only if the virtual mode is IDLE (provided the operating mode is not TERMINAL or HOLD). If the virtual mode is not IDLE, LIM rejects this command since that would imply two Physics-Start commands arrived without an intervening Physics-Stop command.

When LIM accepts and saves this command, it changes the virtual mode to READY. Later, if the saved command is forwarded to the LPA task, LIM changes the virtual mode to STARTED.

2.2.1 Physics Stop

Description: This command is a request to stop a physics observation.

Action: LIM uses this command in two different ways. First, when an external source (spacecraft, ground, other task, etc.) sends this command, LIM intercepts it and uses it to determine the current virtual mode. Unlike the Physics-Start command, LIM does not save copies of incoming Physics-Stop commands. Second, LIM creates and sends this command to the LPA task when it wants to stop or suspend the current physics observation.

Parameters: This command requires three parameters. The first two parameters indicate the task and queue to which LPA should send a Physics-Complete message when it has stopped the physics observation. The third parameter specifies which of two saved instrument configurations LPA should update before stopping the observation. LIM requires that LPA be able to save two separate instrument configurations, which LIM can resume at a later time using a Physics-Resume command.

Operating Mode: LIM rejects this command in the TERMINAL and HOLD operating modes. In all other operating modes, LIM accepts this command (provided the virtual mode is not IDLE).

LPA State: LIM sends this command to the LPA task only if the LPA task state is **Running**, at which point it changes the LPA task state to **Stopping**.

Virtual Mode: LIM changes the virtual mode to IDLE when it receives this command (provided the operating mode is not TERMINAL). If the virtual mode is already IDLE, however, LIM rejects this command since that would imply two Physics-Stop commands arrived without an intervening Physics-Start command.

2.2.2 Physics Resume

Description: This command is a request to resume a physics observation.

Action: LIM sends this command to the LPA task when it wants to resume a physics observation that was previously suspended.

Parameters: This command requires a single parameter that specifies which of two previously-saved instrument configurations should be used when resuming the physics observation.

Operating Mode: LIM sends this command only when the operating mode is ToO, ARR, or PHYSICS.

LPA State: LIM changes the LPA state to **Running** when it sends this command to the LPA task.

Virtual Mode: In the PHYSICS operating mode, LIM sends this command to the LPA task only if the virtual mode is STARTED, since the STARTED virtual mode indicates that a previously-suspended physics observation would still be in progress had it not been interrupted.

2.2.3 Physics Complete

Description: This message indicates that the LPA task has stopped a physics observation.

Action: LIM uses this message to change the LPA task state, which in turn may cause an operating mode change.

Parameters: This message contains no parameters.

Operating Mode: This message may cause LIM to transition to the QUIESCENT mode from the ToO, ARR, or PHYSICS mode. LIM makes this transition if a higher-priority activity is pending (so that it can then transition from QUIESCENT to ToO or ARR) or if no activity is pending (in which case it remains in QUIESCENT). If the current operating mode is QUIESCENT, CALIBRATION, DIAGNOSTIC, or TERMINAL, LIM reports a warning since the LPA task should not be active in these modes.

LPA State: This message causes LIM to change the LPA task state to **Idle**. LIM reports a warning if the LPA task is not in the **Stopping** state when this message arrives.

Virtual Mode: This command does not affect the virtual mode.

2.2.4 Other LPA Commands

Description: These commands direct the operation of the LPA task during a physics observation.

Action: LIM intercepts these commands and saves copies of them if they are appropriate for the current virtual mode. Later, when the operating mode is appropriate, LIM forwards the saved copies to the LPA task. If not appropriate, LIM rejects these commands.

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

Operating Mode: The saved copies of these commands are forwarded to the LPA task only in the PHYSICS operating mode. They do not cause LIM to change the operating mode.

LPA State: The saved copies of these commands are forwarded to the LPA task only if the current LPA task state is **Running**. They do not cause LIM to change the LPA state.

Virtual Mode: These commands are accepted and saved only in the READY and STARTED virtual modes. They do not cause LIM to change the virtual mode.

2.3 Repoint Commands and Responses

These commands inform LIM that a repointed observation should start or end.

2.3.0 ARR Response

Description: This response from the spacecraft indicates that an autonomous repoint request (ARR) was accepted or rejected.

Action: LIM intercepts this response and uses it to update the ARR State.

Parameters: This response contains two parameters – a transaction ID that associates this response with its request, and one that indicates whether the ARR was accepted or rejected.

Operating Mode: LIM accepts this response and updates the ARR state only in the ToO, ARR, and PHYSICS operating modes. In all other operating modes, LIM ignores this response and reports a warning. This response does not cause LIM to change the operating mode.

ARR State: LIM updates the ARR state to **Ready** when it accepts this response and the response indicates that the ARR was accepted. LIM reports a warning if the ARR state is already **Ready**.

Virtual Mode: This command does not affect the virtual mode.

2.3.1 ARR Abort

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

Action: LIM intercepts this command and uses it to update the ARR State.

Parameters: This command requires no parameters.

Operating Mode: LIM accepts this command in all operating modes. In the ARR mode, LIM sends a Physics-Stop command to the LPA task when it receives this command.

ARR State: LIM changes the ARR state to **Idle** when it receives this command. LIM reports a warning if the ARR state is already **Idle**.

Virtual Mode: This command does not affect the virtual mode.

2.3.2 ToO Start

Description: This command is a request to start a Target-of-Opportunity repointed observation.

Action: LIM intercepts this response and uses it to update the ToO State.

Parameters: LIM uses only a single parameter from this command, which indicates the length of time that the repointed observation will be active.

Operating Mode: LIM rejects this command in the TERMINAL and HOLD operating modes. In all other modes, LIM accepts this command and updates the ToO state. This command does not cause LIM to change the operating mode.

ToO State: LIM updates the ToO state to **Ready** when it accepts this command. LIM reports a warning if the ToO state is already **Ready**.

Virtual Mode: This command does not affect the virtual mode.

2.3.3 ToO Abort

Description: This command is a request to abort a Target-of-Opportunity repoint activity.

Action: LIM intercepts this command and uses it to update the ToO State.

Parameters: This command requires no parameters.

Operating Mode: LIM accepts this command in all operating modes. In the ToO mode, LIM sends a Physics-Stop command to the LPA task when it receives this command.

ToO State: LIM changes the ToO state to **Idle** when it receives this command. LIM reports a warning if the ToO state is already **Idle**.

Virtual Mode: This command does not affect the virtual mode.

2.4 Miscellaneous Commands

These commands are sent to the LIM task directly.

2.4.0 Hold Enter

Description: This command is a request to transition into the HOLD operating mode.

Action: When LIM receives this command, it immediately transitions to the HOLD operating mode.

Parameters: This command requires no parameters.

Operating Mode: LIM rejects this command in the TERMINAL and HOLD operating modes. In all other modes, LIM transitions immediately to the HOLD mode.

Virtual Mode: This command does not affect the virtual mode.

2.4.1 Hold Exit

Description: This command is a request to transition out of the HOLD operating mode.

Action: When LIM receives this command, it immediately transitions from the HOLD to the QUIESCENT operating mode.

Parameters: This command requires no parameters.

Operating Mode: LIM accepts this command only in the HOLD operating mode. In all other modes, LIM rejects this command.

Virtual Mode: This command does not affect the virtual mode.

2.4.2 Load Shed

Description: This command is a request to remove power from the LAT instrument.

Action: When LIM receives this command, it aborts the current activity (diagnostic, 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 requires no parameters.

Operating Mode: This command causes LIM to transition from any mode to the BOOT mode.

Virtual Mode: This command causes LIM to transition from any virtual mode to the IDLE virtual mode.

2.4.3 Main Feed On

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

Action: When LIM receives this command, it applies power to the GASU and PDU, and initializes the SIU, using appropriate PIG functions.

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

Operating Mode: This command causes LIM to transition from the TERMINAL mode to the QUIESCENT mode. LIM rejects this command if it is not in the TERMINAL mode.

Virtual Mode: This command does not affect the virtual mode.

2.4.4 Power Off

Description: This command is a request to remove power from components of the LAT instrument.

Action: When LIM receives this command, it removes power from the LAT components using appropriate PIG functions.

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

Operating Mode: LIM accepts this command only in the QUIESCENT mode. This command does not change the operating mode.

Virtual Mode: This command does not affect the virtual mode.

2.4.5 Power On

Description: This command is a request to apply power to components of the LAT instrument.

Action: When LIM receives this command, it applies power to the LAT components using appropriate PIG functions.

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

Operating Mode: LIM accepts this command only in the QUIESCENT mode. This command does not change the operating mode.

Virtual Mode: This command does not affect the virtual mode.

2.4.6 SAA Enter

Description: This command is a notification that the LAT instrument has entered the South Atlantic Anomaly (SAA).

Action: 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 requires no parameters.

Operating Mode: LIM accepts this command in all operating modes, but does not change the operating mode.

LPA State: If the LPA task is in the **Running** state, LIM suspends the current observation by sending the Physics-Stop command to the LPA task. LIM waits five seconds after sending this command before it calls the PIG_enter_SAA() function.

Virtual Mode: This command does not affect the virtual mode.

2.4.7 SAA Exit

Description: This command is a notification that the LAT instrument has exited the South Atlantic Anomaly (SAA).

Action: 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 requires no parameters.

Operating Mode: LIM accepts this command in all operating modes. In the PHYSICS, ToO, and ARR operating modes, LIM resumes the interrupted observation by sending the Physics-Resume command to the LPA task.

Virtual Mode: This command does not affect the LIM virtual mode.

3 Telemetry

LIM responds to certain events by sending a telemetry packet to the spacecraft. This telemetry packet contains the following information:

- Action that caused the telemetry packet to be sent.
- MSG status code for the action.
- Current operating mode.
- Current virtual mode.
- Indication of whether an SAA transit is in progress.
- Current states of the LCI, LDF, and LPA tasks,
- Indications of whether a TOO or ARR activity is ready to be started.
- Indications of whether a TOO or ARR activity is active.

4 Use Cases

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

4.0 Normal Activity

These scenarios describe normal calibration, diagnostic, and physics observation activities.

Normal calibration procedure

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

Normal diagnostic procedure

Actions	Mode	LDF State
Initial condition	Quiescent	Idle
Receive Diagnostic-Start command - Forward to LDF	Diagnostic	Running
Receive other LDF commands - Forward to LDF	“	“
Receive Diagnostic-Complete message from LDF	Quiescent	Idle

Normal physics observation

Actions	Mode	Virtual Mode	LPA State
Initial condition	Quiescent	Idle	Idle
Receive Physics-Start command - Save command	"	Ready	"
- Forward saved command to LPA	Physics	Started	Running
Receive other LPA commands - Forward to LPA	"	"	"
Receive Physics-Stop command - Send Physics-Stop(1) to LPA	"	Idle	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle

Physics observation before end of calibration procedure

Actions	Mode	Virtual Mode	LCI State	LPA State
Initial condition	Quiescent	Idle	Idle	Idle
Receive Calibration-Start command - Forward to LCI	Calibration	"	Running	"
Receive Physics-Start command - Save command	"	Ready	"	"
Receive Calibration-Complete from LCI	Quiescent	"	Idle	"
- Forward saved Physics-Start to LPA	Physics	Started	"	Running
Receive Physics-Stop command - Send Physics-Stop(1) to LPA	"	Idle	"	Stopping
- Wait for end of physics observation	"	"	"	"
Receive Physics-Cmplete message from LPA	Quiescent	"	Idle	Idle

4.1 Aborted Activity

These scenarios describe aborted calibration and diagnostic activities.

Aborted calibration procedure

Actions	Mode	LCI State
Initial condition	Quiescent	Idle
Receive Calibration-Start command - Forward to LCI	Calibration	Running
Receive other LCI commands - Forward to LCI	“	“
Receive Calibration-Abort command - 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

Aborted diagnostic procedure

Actions	Mode	LDF State
Initial condition	Quiescent	Idle
Receive Diagnostic-Start command - Forward to LDF	Calibration	Running
Receive other LDF commands - Forward to LDF	“	“
Receive Diagnostic-Abort command - Forward to LDF	“	Stopping
- Wait for end of diagnostic procedure, **rejecting any LDF commands that may arrive**	“	“
Receive Diagnostic-Complete message from LDF	Quiescent	Idle

4.2 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 - Start ToO timer - Forward command to LPA	ToO	Running
ToO timer expires - Send Physics-Stop(2) to LPA	"	Stopping
- Wait for end of physics observation	"	"
Receive Physics-Complete message from LPA	Quiescent	Idle

Target-of-Opportunity interrupts a calibration procedure

Actions	Mode	LCI State	LPA State
Initial condition	Quiescent	Idle	Idle
Receive Calibration-Start command - Forward to LCI	Calibration	Running	"
Receive ToO-Start command - Start ToO timer - Save ToO-Start command - Send Calibration-Abort to LCI	"	Stopping	"
- Wait for end of calibration procedure, **rejecting any LCI commands that may arrive**	"	"	"
Receive Calibration-Complete message from LCI	Quiescent	Idle	"
- Forward the saved ToO-Start command to LPA to start the ToO repointed observation	ToO	"	Running
ToO timer expires - Send Physics-Stop(2) to LPA	"	"	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA (Note that the interrupted calibration procedure is not restarted at the completion of the ToO)	Quiescent	"	Idle

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

Actions	Mode	Virtual Mode	LPA State
Initial condition	Quiescent	Idle	Idle
Receive Physics-Start command - Save command	“	Ready	“
- Forward saved command to LPA	Physics	Started	Running
Receive ToO-Start command - Start ToO timer - Save ToO-Start command - Send Physics-Stop(1) to LPA	“	“	Stopping
- Wait for end of physics observation	“	“	“
Receive Physics-Complete message from LPA	Quiescent	“	Idle
- Forward the saved ToO-Start command to LPA to start the ToO repointed observation	ToO	“	Running
ToO timer expires - Send Physics-Stop(2) to LPA	“	“	Stopping
- Wait for end of physics observation	“	“	“
Receive Physics-Complete message from LPA	Quiescent	“	Idle
- Send Physics-Resume(1) to LPA to resume the interrupted physics observation, since no Physics-Stop command was received during the ToO observation	Physics	“	Running
Receive Physics-Stop command - Send Physics-Stop(1) to LPA	“	Idle	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	Virtual Mode	LPA State
Initial condition	Quiescent	Idle	Idle
Receive Physics-Start command - Save command	"	Ready	"
- Forward saved command to LPA	Physics	Started	Running
Receive ToO-Start command - Start ToO timer - Save ToO-Start command - Send Physics-Stop(1) to LPA	"	"	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle
- Forward the saved ToO-Start command to LPA to start the ToO repointed observation	ToO	"	Running
Receive Physics-Stop command - Accept command, but change only the virtual mode	"	Idle	"
Receive Diagnostic-Start command - **Reject command**	"	"	"
Receive Calibration-Start command - **Reject command**	"	"	"
Receive Physics-Start command - Save command	"	Ready	"
ToO timer expires - Send Physics-Stop(2) to LPA	"	"	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle
- Forward the saved Physics-Start command to LPA since the interrupted physics observation ended during the ToO observation	Physics	Started	Running
Receive Physics-Stop command - Send Physics-Stop(1) to LPA	"	Idle	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle

4.3 SAA Activity

These scenarios describe SAA transits during various other activities.

SAA during normal diagnostic procedure

Actions	Mode	LDF State
Initial condition	Quiescent	Idle
Receive Diagnostic-Start command - Forward to LDF	Diagnostic	Running
Receive other LDF commands - Forward to LDF	"	"
Receive SAA-Enter command - Call PIG_enter_SAA to configure ACD high voltage	"	"
Receive SAA-Exit command - Call PIG_exit_SAA to configure ACD high voltage	"	"
Receive Diagnostic-Complete message from LDF	Quiescent	Idle

SAA during normal physics observation

Actions	Mode	Virtual Mode	LPA State
Initial condition	Quiescent	Idle	Idle
Receive Physics-Start command - Save command	"	Ready	"
- Forward saved command to LPA	Physics	Started	Running
Receive SAA_enter command - Send Physics-Stop(1) to LPA	"	"	Stopping
- Wait 5 seconds	"	"	"
- Call PIG_enter_SAA to configure ACD	"	"	"
Receive Physics-Complete message from LPA (this may arrive before the end of the 5 second waiting period)	"	"	Idle
Receive SAA_exit command - Call PIG_exit_SAA to configure ACD - Send Physics-Resume(1) to LPA	"	"	Running
Receive Physics-Stop command - Send Physics-Stop(1) to LPA	"	Idle	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle

SAA during interrupted physics observation

Actions	Mode	Virtual Mode	LPA State
Initial condition	Quiescent	Idle	Idle
Receive Physics-Start command - Save command	"	Ready	"
- Forward saved command to LPA	Physics	Started	Running
Receive ToO-Start command - Start ToO timer - Save ToO-Start command - Send Physics-Stop(1) to LPA	"	"	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle
- Forward the saved ToO-Start command to LPA to start the ToO repointed observation	ToO	"	Running
Receive SAA_enter command - Send Physics-Stop(2) to LPA	"	"	Stopping
- Wait 5 seconds	"	"	"
- Call PIG_enter_SAA to configure ACD	"	"	"
Receive Physics-Complete message from LPA (this may arrive before the end of the 5 second waiting period)	"	"	Idle
Receive SAA_exit command - Call PIG_exit_SAA to configure ACD - Send Physics-Resume(2) to LPA	"	"	Running
ToO timer expires - Send Physics-Stop(2) to LPA	"	"	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle
- Send Physics-Resume(1) to LPA to resume the interrupted physics observation, since no Physics-Stop command was received during the ToO observation or the SAA	Physics	"	Running
Receive Physics-Stop command - Send Physics-Stop(1) to LPA	"	Idle	Stopping
- Wait for end of physics observation	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle

4.4 Invalid Command Sequences

These scenarios describe invalid command sequences for which LIM rejects one or more commands.

Nested physics observation

Actions	Mode	Virtual Mode	LPA State
Initial condition	Quiescent	Idle	Idle
Receive Physics-Start command - Save command	"	Ready	"
- Forward saved command to LPA	Physics	Started	Running
Receive a second Physics-Start command - **Reject the command**	"	"	"
Receive Physics-Stop command - Send Physics-Stop(1) to LPA	"	Idle	Stopping
- Wait for end of physics observation	"	"	"
Receive a second Physics-Stop command - **Reject the command**	"	"	"
Receive Physics-Complete message from LPA	Quiescent	"	Idle

Calibration procedure before end of diagnostic procedure

Actions	Mode	LDF State
Initial condition	Quiescent	Idle
Receive Diagnostic-Start command - Forward to LDF	Diagnostic	Running
Receive Calibration-Start command - **Reject the command**	"	"
Receive Diagnostic-Complete message from LDF	Quiescent	Idle

5 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.

5.0 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.

5.1 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 starts the task with a priority of 100, a name of “tLIM”, and default values for the other task parameters.

5.2 LIM_stop()

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

5.3 LIM_shutdown()

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

5.4 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 3). This function requires a single parameter, which is a pointer to a buffer into which the LIM information should be stored.

5.5 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.

5.6 LIM_capture_diag()

The LIM_capture_diag() function instructs LIM to capture all commands with the specified APID and handle them as if they were diagnostic commands intended for the LDF task. It accepts three parameters:

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

This function may be called only after the LIM_initialize() and LDF_initialize() functions have been called and before the LIM_start() and LDF_start() functions have been called.

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

5.7 LIM_capture_physics()

The LIM_capture_diag() 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 Requirements

The LIM package is designed to satisfy many of the mode control requirements defined in the LAT Flight Software Specification (LAT-SS-00399).

6.0 (5.3.11) GRB Response

Requirement: The LAT FSW shall respond to GRB alert messages from all sources (a GRB alert message from the GBM, or an internally generated GRB alert) when in Sky Survey or Pointed Observation modes.

LIM intercepts GRB alert messages and forwards them to the LPA task for handling when the LPA task is in the appropriate state and LIM is in the appropriate operating mode.

6.1 (5.3.15) Mode Control

Requirement: The FSW shall support the observatory modes of (1) sky survey, (2) pointed observation, and (3) repointed observation.

LIM maps these three observatory modes into the PHYSICS, TOO, and ARR operating modes (see Table 2). The manner in which LIM supports these modes is described by this document.

6.2 (5.3.15.1) Ground Commanded Repointing

Requirement: Upon command, the FSW shall support transition to repointed observation mode from sky survey and pointed observation modes.

LIM transitions to the TOO mode upon receipt of the TOO-Start command (provided the operating mode is not BOOT, TERMINAL, or HOLD).

6.3 (5.3.15.2) Sequences of Observations

Requirement: The FSW shall support execution of sequences of pointed and sky survey observations from on-board command storage.

LIM handles the commands described in this document regardless of their source. LIM assumes that observation sequences are controlled by sets of scheduled commands that the spacecraft stores in its on-board storage and sends to LIM or LPA at the appropriate time.

6.4 (5.3.15.3) Automatic Resume

Requirement: Upon completion of a repointed observation that is performed autonomously, the FSW shall support the resumption of the previously interrupted sky survey or pointed observation.

When LIM interrupts an observation, it requests that the LPA task remember the current state of the instrument. At the completion of the repointed observation, LIM resumes the interrupted observation by sending the Physics-Resume command to the LPA task. LIM assumes that the LPA task will restore the instrument configuration when it receives this command.

6.5 (5.3.15.4) Mode Reporting

Requirement: The FSW shall report mode changes in telemetry.

LIM reports its status in two ways. First, the status of each command sent to LIM from the spacecraft is reported via the ITC command acknowledgment mechanism. Second, certain events, including mode changes, are actions that cause LIM to send a diagnostic telemetry packet. These packets include the current operating mode, as well as other pertinent LIM information.

6.6 (5.3.15.5) Responding to GRBs

Requirement: The FSW shall respond to GRBs with filter changes or an ARR only when the GRB is detected from Sky Survey, Pointed, or Repointed modes.

LIM assumes that the LPA task handles filter changes and Automatic Repoint Requests resulting from GRB detections. The fact that the LPA task is active only during PHYSICS, TOO, and ARR modes and that these modes correspond to the Sky Survey, Pointed, and Repointed observatory modes, ensures that the flight software responds to GRBs only when the spacecraft is in one of the allowed observatory modes.

6.7 (5.3.16.1.1) Safe Mode Notification from SC

Requirement: The SIU FSW shall receive and process a safe-mode notification message from the SC, then execute a set of actions designed to place the LAT in a predetermined LAT Safe Mode within 15 seconds.

LIM accepts the Safe-Mode command in all of its operating modes. When LIM receives this command, it performs a sequence of actions which places the LAT in a safe-mode configuration. This sequence includes two steps that consume significant amounts of time – a five-second warning to active tasks, and a controlled power-down sequence. The power-down sequence is designed to require no more than 6.2 seconds. When combined with the five second delay, the total time required to place the LAT in a safe-mode configuration is no more than 11.2 seconds from the receipt of the Safe-Mode command.

6.8 (5.3.16.1.2) Safe Mode Notification to Ground

Requirement: Assuming that power is available, the SIU FSW shall put a notification of transition to LAT Safe Mode as alert telemetry to the ground prior to entering LAT Safe Mode.

LIM sends alert telemetry before and after it places the LAT in the safe-mode configuration.

6.9 (5.3.16.2.1) Load Shedding Notification from SC

Requirement: The SIU FSW shall receive and process a load shedding notification message from the SC, then execute the necessary configuration commands within 15 seconds to power off all SIU-controlled LAT components and prepare for shutdown.

LIM accepts the Load-Shed command in all of its operating modes. When LIM receives this command, it performs a sequence of actions which removes power from the LAT components. This sequence includes two steps that consume significant amounts of time – a five-second warning to active tasks, and a controlled power-down sequence. The power-down sequence is designed to require no more than 6.2 seconds. When combined with the five second delay, the total time required to remove power from the LAT components is no more than 11.2 seconds from the receipt of the Load-Shed command.

6.10 (5.3.16.2.2) Load Shedding Notification to Ground

Requirement: Assuming that power is maintained during the 15 seconds, the SIU FSW shall put a notification of powering off due to load shedding into the telemetry stream to the ground, prior to powering off.

LIM sends alert telemetry before and after it removes power from the LAT components.

6.11 (5.3.18.1) Configure ACD for SAA

Requirement: Prior to SAA transit, the FSW shall configure the ACD as described in the ACD-LAT ICD.

When LIM receives the SAA-Enter command in a mode other than TERMINAL, it calls the PIG_enter_SAA() function. LIM assumes that this function configures the ACD to satisfy this requirement.

6.12 (5.3.18.2) Configure CAL for SAA

Requirement: Prior to SAA transit, the FSW shall disable CAL-LO and CAL-HI triggering.

When LIM receives the SAA-Enter command in a mode other than TERMINAL, it calls the PIG_enter_SAA() function. LIM assumes that this function takes the actions necessary to satisfy this requirement.

6.13 (5.3.18.3) Post-SAA Recovery

Requirement: The FSW shall support recovery from SAA transits to ensure that science data collected after SAA transit is performed with the planned configuration.

When LIM receives the SAA-Exit command in PHYSICS, TOO, or ARR mode, it resumes the interrupted observation by sending the Physics-Resume command to the LPA task. LIM assumes

that the LPA task will restore the instrument to the configuration that was saved when the SAA-Enter command was received, and that the LPA task will resume the observation.

6.14 (5.3.19.6) TCS – Shut-Down

Requirement: *The SIU FSW shall shut down active closed loop control of the TCS, upon receipt of command from the spacecraft.*

The spacecraft can send the LTC-Stop command directly to the LTC task, without intervention by LIM.

6.15 (5.3.19.7) TCS – Thermal Constraints for Power-On

Requirement: *The FSW shall ensure that thermal constraints, as defined in [26], stored onboard and updatable by telecommand, are met prior to enabling power-on of EPUs, TEMs, and TPSs.*

? ? Does PIG consult TCS before enabling EPU, TEM, or TPS power, or does LIM need to consult
? TCS before asking PIG to enable power? In general, does TCS interact only with PIG, or does it
? ? need to interact with LIM as well?

6.16 (5.3.19.8) TCS – Load Shedding Action

Requirement: *Upon receipt of a load shedding command from the spacecraft, the SIU FSW shall stop opening the TCS watchdog switch and send a signal to the spacecraft indicating the action taken.*

When LIM receives the Load-Shed command, one of the actions it performs is to send the LTC-Stop command to the LTC task. LIM then sends telemetry to indicate that it has sent this command.