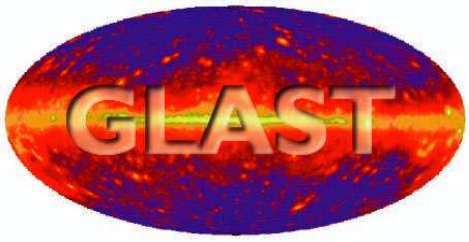

LAT Flight Software

LPA Manual

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Author:	S.Maldonado
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Manual for the LAT physics acquisition package.

Contents

0 Introduction

The LAT Physics Acquisition (LPA) software is a control module which mediates instrument configuration, physics event collection, and science telemetry packet delivery.

0.0 Overview

The function of the LPA package is to ensure collection and delivery of physics event data. This is achieved by interfacing to a host of service and utility packages which allow access to electronics modules, event formatting utilities, and data delivery services. LPA controls the configuration, starting and stopping of physics acquisition runs, as well as the formatting and delivery of science data telemetry packets.

Additionally, LPA supports the detection and reporting of gamma-ray burst events. LPA controls the operation of the GRB detection algorithm, and provides a telecommand interface to the GBM and spacecraft in order to exchange the GRB specific coordinates and science data. Upon detection of a GRB, LPA facilitates requests for an autonomous repoint of the observatory by formatting and issuing messages to the instrument mode controller, and the GBM. LPA also interfaces with the instrument mode controller (LIM) to allow for dynamic configuration changes in response to different observatory modes.

The primary control interface to the LPA software is through a set of CCSDS formatted telecommands. These commands are intercepted by the mode controller for validation, and then forwarded on to LPA for execution. LIM, in turn, processes feedback from LPA in order to verify successful physics mode transitions.

1 Package Description

This section describes the CMX package layout for LPA.

1.0 Shareables

LPA exports the following shareable libraries.

Module	Description
liblpa_siu.o	The SIU specific LPA library
liblpa_epu.o	The EPU specific LPA library
liblpa.o	The physics acquisition control library (EPU)
liblpa_output.o	The physics event output library (EPU)
liblpa_grb.o	The gamma-ray burst library (SIU)

1.1 Dependencies

LPA is dependent on the following FSW packages:

Package	Description
MSG	Message reporting
LCBD	LCB driver
EDS	Event delivery services
LSE	Science event formatting
LSEP	Science physics event formatting

Package	Description
LSF	Science event formatting
PBS	Package basic OS services
VXW	Operating system
ITC	Inter-task communications
CPU_DB	CPU database
LPA_DB	LPA database
EDS_DB	Event delivery database
CDM	Database services
IMM	Instrumented memory manager
LATC	Electronics configuration utility
LEM	Electronics command formatting utility
LCS	LCB communications service
CCSDS	Packet formatting
ATT	Attitude transform utility
THS	Time hack services
GRB	Gamma-ray burst alert algorithm

2 Implementation

This section provides an overview of the LPA software implementation.

2.0 Task Descriptions

LPA utilizes up to 4 primary tasks, one executing on the SIU and one on each active EPU.

The LPA master SIU specific task performs the following primary actions:

- Command handling and validation
- SIU to EPU messaging
- Start/stop run control
- Instrument electronics configuration
- GRB message routing
- Mode control messaging

The LPA slave EPU specific tasks perform the following primary actions:

- EPU to SIU messaging
- Event handler configuration
- GRB photon candidate delivery
- Output stream configuration
- Data compression configuration

Additionally, LPA slave software executes in the context of the LCBD event task on each EPU, performing the following primary actions:

- Event datagram delivery
- Active operating mode changes
- Start/stop run processing

2.1 Event Input

Physics event data is acquired by the front end electronics modules and eventually forwarded to an event processing engine, or event handler. Selections of such event handlers are made available to LPA for insertion into the processing logic of a physics data acquisition run. LPA provides the interface to enable/disable event handlers, and alter their internal configurations.

See the EDS package manual for detailed information on event delivery services and event handlers.

2.2 Event Output

After an event handler has processed an event, it may post the resulting data to multiple output streams. There are currently two queues where an event might get posted:

Datagram output – compression, formatting, and delivery to the SSR for output to science stream

GRB output – forwarded to a “post-processor” for nomination of GRB photon candidates and delivered to SIU as input to the GRB detection algorithm

2.3 Run Configuration

Prior to starting a physics run, the event handler configurations must be established for each operating mode. LPA does not maintain a default configuration of which handlers will be enabled, and any start command will be rejected until a configuration is established. Additionally, any output configuration should be performed prior to executing a run.

2.3.0 Event Handler Configuration

Event handler configuration is controlled using the LPA_DB CDM files and a series of telecommands. The implementation of this configuration is a tiered structure. Up to 32 LPA_DB instances are allowed on each EPU. Up to 32 event handler processors can be defined in a single instance of the LPA_DB CDM database. In turn, each of the 32 event handler processors can define up to 32 internal configurations. Additionally, each handler can be set up to access one of its 32 internal configurations based on the current physics mode. The permutations created by this implementation allow for maximum configurability with minimal commanding. The suggested operating method is for the user to create a palette of configurations, which can then be selected by LPA_DB instance ID and operating modes.

2.3.0.0 Event Handler Installation

At initialization, all event handlers specified in each of the LPA_DB instances are installed into the event delivery framework. This process prepares each handler for processing of events, but does not activate them.

2.3.0.1 Event Handler Activation

At run time, the LPACONFIGURE telecommand selects from the available 32 event handlers in a single LPA_DB instance, which ones will be active for subsequent runs. A physics run may activate event handlers defined only in a single LPA_DB instance. This is achieved by passing in the desired LPA_DB instance ID in the telecommand parameter set. For each of the 8 operating modes, a set of event handler IDs can be selected for activation. The event handler IDs specified

in the LPACONFIGURE telecommand should be a subset of those installed from the appropriate LPA_DB instance. The values specified in the telecommand will apply to all subsequent physics runs.

2.3.0.2 Mode Association

Once the event handlers have been installed, and configured for activation, the internal configuration of individual handlers can be performed. By default, each handler defines which of its 32 available internal configurations it will use while operating in each physics mode. To override these default associations, the LPAASSOCIATE telecommand may be used. This command will take an internal handler configuration ID and associate it with the selected modes for each of the specified event handlers. The values specified in the telecommand will apply to all subsequent physics runs.

2.3.1 Output Configuration

Output data delivery and formatting can be updated at run time prior to executing a physics run.

2.3.1.0 Data Compression Level

The default datagram compression level can be overridden using the LPASETCOMPRESS telecommand. The values specified in the telecommand will apply to all subsequent physics runs.

2.3.1.1 Output Enabling

The event datagram and GRB output streams may be enabled or disabled using the LPASETOUTPUT telecommand. The values specified in the telecommand will apply to all subsequent physics runs.

Typically, this is useful for diagnostic and debugging purposes.

2.4 Run Control

To initiate and terminate a physics run, LPA must manage hardware and software resources on both the SIU and EPUs. Run control consists of a multi-stage process that involves message transfer and confirmation between the SIU master and each EPU slave. Synchronization among EPUs is achieved by using solicited marker events. This method ensures that each EPU starts the run at the same instant. If configured to do so, the physics event handlers will insert these marker events into the output stream, allowing for offline verification of start and stop run demarcation and timing.

For each step involving EPUs, the SIU will wait for the proper responses. If an action on any EPU results in failure or non-response, the SIU will issue a general abort message to all EPUs. This abort action will flush the output stream, if appropriate, and restore the SIU and EPUs to a non-data taking configuration.

2.4.0 Physics Start Run

To initiate physics run, the electronics and software must be fully configured for data taking. This involves the following actions:

Step	Action(s)	CPU
0	Receive and process start run command	SIU
1	Configure physics event handlers Start event delivery services Disconnect default event handler Connect marker event handler	EPU
2	Configure instrument hardware Solicit marker event Enable triggers	SIU
3	Receive and process marker event Disconnect marker event handler Connect event delivery services handler	EPU

2.4.1 Physics Stop Run

To terminate a physics run, the electronics and software must be returned to a quiescent state. This involves the following actions:

Step	Action(s)	CPU
0	Receive and process stop run command	SIU
1	Disconnect event delivery services handler Connect marker event handler	EPU
2	Solicit marker event Disable triggers	SIU
3	Receive and process marker event Disconnect marker event handler Connect default event handler Flush event handler datagram stream	EPU
4	Verify instrument configuration	SIU

2.4.2 Mode Change

During a physics run, the instrument mode controller may issue a mode change request. This request is intercepted by the SIU master task, and forwarded on to each EPU. Each EPU will select the event handlers and configurations that are appropriate for the given mode, and continue to process physics events using the updated configurations.

Additionally, a run can be commanded to enter a certain mode by setting the mode ID parameter in the LPASTART telecommand. This setting does not change the instrument mode, and LIM may override this setting during TOO and ARR/GRB modes.

Each event handler can be configured to respond to the following mode changes:

ID	Mode	Description
0	Normal Physics	Normal physics acquisition operating mode
1	TOO Physics	Target of opportunity physics
2	GRB 0	GRB suspected
3	GRB 1	GRB confirmed
4	GRB 2	GRB closeout
5	Solar Physics	Solar physics acquisition
6	Calibration Physics	Physics calibration
7	Diagnostics Physics	Diagnostic acquisition

Refer to the LIM package documentation for detailed information on instrument modes and mode control.

2.5 GRB Support

LPA supports processing of GRB photon events by interfacing directly to the GRB event handlers, and the GRB detection algorithm. Messages and data packets are passed from each EPU to the SIU, which are then forwarded on to the GRB processing engines. Mode control and run state messages are also communicated from the SIU to the GRB algorithm engine.

2.5.0 GRB Output Stream

A physics event handler, such as the gamma filter, can post an event to the GRB output stream. To support this activity, LPA has a set of specialized routines that interface directly to the GRB detection software. When an event is posted by a handler to the GRB stream, LPA intercepts and forwards the event to the GRB processor on the EPU. The GRB processor analyzes each event, and forms event summary packets, which are periodically delivered to the SIU via LPA. Once received on the SIU, LPA will forward these event summary packets to the GRB detection algorithm. The structure and content of these summary packets are transparent to LPA. LPA merely serves as a control and transport mechanism.

2.5.0.0 GRB Output Flushing

GRB summary packets may contain up to a configurable amount of events. LPA uses an event counter and a timer to periodically flush out these summary packets. When the summary packet has been filled, LPA will send it to the SIU, and the timer will be reset. If the timer expires, and the summary packet is partially populated, it will be sent as is to the SIU. This behavior ensures that all photon candidates are delivered to the SIU after encountering a period of GRB inactivity.

2.5.0.1 GRB Output Disable

For debugging and performance purposes, the GRB output stream can be disabled, by telecommand, at three levels:

- Posting of the event by the handler to the output processor (LPASETOUTPUT)
- Delivery of the event summary packets by the EPU to the SIU (LPASETGRB)
- Processing of event summary packets on the SIU (LPASETOUTPUT)

2.5.1 GRB Detection Messaging

LPA provides messaging callbacks to the GRB algorithm engine executing on the SIU. When a GRB is detected, the GRB algorithm issues messages to LPA. The content of these messages is used by LPA to construct a series of messages, telecommand, and telemetry packets for delivery to the mode controller, the spacecraft, and the GBM instrument.

Message	Description	Direction
Run Control	LPA generates notifies GRB of start/stop status	LPA->GRB
GRB Trigger/Suspect	GRB generates trigger message to LPA	GRB->LPA
	LPA generates suspect message to LIM	LPA->LIM
	LPA generates burst alert telemetry to SC	LPA->SC
	LPA generates burst alert telecommand to GBM	LPA->GBM
GRB Update	GRB generates update message(s) to LPA	GRB->LPA
	LPA generates update telemetry to SC	LPA->SC
GRB Confirm	GRB generates confirm message to LPA	GRB->LPA
	LPA generates confirm message to LIM	LPA->LIM
	LPA generates confirm telemetry to SC	LPA->SC
GRB Closeout	GRB generates closeout message to LPA	GRB->LPA
	LPA generates closeout message to LIM	LPA->LIM
	LPA generates burst closeout telemetry to SC	LPA->SC
	LPA generates burst closeout telecommand to GBM	LPA->GBM
GBM Calc	LPA receives GBM GRB calc telecommand	GBM->LPA

Message	Description	Direction
	LPA generates GRB calc message to GRB	LPA->GRB
GBM Repoint	LPA receives GBM GRB repoint request telecommand LPA generates repoint message to GRB	GBM->LPA LPA->GRB
GBM Close	LPA receives GBM GRB closeout telecommand LPA generates closeout message to GRB	GBM->LPA LPA->GRB

2.5.1.0 LIM Messages

LPA generates GRB messages to the instrument mode controller (LIM). These messages are used by LIM to signal transitions between the 3 GRB states which may result in an instrument mode change to ARR.

2.5.1.1 Spacecraft Alert Messages

LPA generates alert telemetry packets for delivery to the spacecraft. These packets engage the TDRIS link on the spacecraft for rapid notification of GRB detection to ground operators. Refer to the LAT GBM Interface Control Document for specifics on format and timing of these messages.

2.5.1.2 GBM Messages

LPA intercepts and forwards telecommand messages received from the GBM instrument. Addditionally, LPA construct telecommand messages to the GBM to notify it of LAT detected GRBs. The LPASETGRB command can enable and disable processing of telecommands from the GBM. Typically, this is useful for testing and debugging purposes. Refer to the LAT GBM Interface Control Document for specifics on format and timing of these messages.

3 Configuration

This section describes the process of configuration for the LPA package. LPA is configured by default at initialization by reading in CDM database files from the file system. Further configuration is accomplished by processing telecommands and applying the settings dynamically.

3.0 LPA_DB Configuration

The LPA configuration parameters are defined in a CDM database file. The schema for these files resides in the LPA_DB package. There can be multiple instances of the LPA_DB schema. The database instances are identified by their instance IDs. These instance IDs are to be used in telecommand parameters when accessing or updating the configuration values. Please refer to LPA_DB_schema.h in the LPA_DB package.

3.0.0 Event Handler Configuration

The LPA_DB schema specifies a multi-dimensional array that holds 4 parameters for up to 32 event handlers in LPA_DB_handler. Each event handler must export CDM identifiers for configuration purposes. At initialization, LPA uses these values to locate the appropriate configuration structures, which are used during event handler installation into the event delivery framework.

Array Index	Parameter	Description
0	Event handler ID	Integer ID for the event handler. Valid values are 0 to 31.
1	Event handler priority	Integer value for the requested event handler installation priority. This parameter controls the event callback priority for the event handler. Valid values are 0 to 31.
2	Event handler CDM schema ID	Integer ID for the event handler's CDM database schema.
3	Event handler CDM schema instance ID	Integer ID for the event handler's CDM database schema instance.

3.0.1 Datagram Configuration

The LPA_DB schema defines 4 configuration values for event datagram construction in LPA_DB_Datagram. Typically, these values do not need to be modified by a user.

Parameter	Description
level	The default data compression level. Valid values are 1 – 8.
origin	The science data origin code.
apid	An array of 4 science telemetry apid values for SIU, EPU0, EPU1, and EPU2, respectively.
dgm_id	An array of 4 datagram ID values for SIU, EPU0, EPU1, and EPU2, respectively.

3.0.2 Output Stream Configuration

The LPA_DB schema defines the structure used to install and manipulate the event output framework as LPA_DB_Output. These items are consumed by the event delivery framework at initialization and typically need not be modified by a user.

Parameter	Description
get	Function pointer to the output services get routine.
prm	User parameter to the output services get routine.
type	The type of output service. 0: datagram 1: GRB
outSize	Size in bytes of the output object. Refers to either the datagram size, or the GRB event summary size.
outCount	Count of output objects to be allocated at initialization.

3.0.3 GRB Configuration

The LPA_DB schema defines the structure for GRB summary parameters in LPA_DB_Grb.

Parameter	Description
postTimeout	The GRB summary post timeout (msec) Sets the elapsed time before the GRB summary buffer will be flushed from an EPU. Use 0 to disable

Parameter	Description
postCount	The GRB summary post count (events). Sets the count of posted events after which the GRB summary buffer gets flushed from an EPU to the SIU. Use 0 to disable

4 Programming

The LPA package provides several public control interfaces that are used to initialize and start the software.

4.0 Initialization

The LPA initialization call parameters include up to 2 configuration file IDs. The file IDs are 32bit unsigned integers representing files on the LAT file system.

LPA_siu_init ()

LPA_epu_init()

4.1 Application Control

LPA_siu_start() - launches the LPA master tasks

LPA_epu_start() - start the LPA slave task

LPA_set_mode() – For use by LIM to notify LPA of a mode change

5 Command and Telemetry

This section covers the command and telemetry interfaces of the LPA package.

5.0 LPA Telecommands

The user interface to LPA is via a set of telecommands. These commands are delivered via the spacecraft directly to the LPA SIU master task. All commands are CCSDS formatted. For specifics on payload size and field positioning, refer to the LAT Telecommand and Telemetry document.

To select the target EPUs for a command, use the LPACPUS parameter. This parameter is an enable mask of CPUS. A set bit in the mask will enable delivery to the corresponding CPU:

- bit 0 = SIU
- bit 1 = EPU0
- bit 2 = EPU1
- bit 3 = EPU2

Command	APID	Function Code	Description
LPACONFIGURE	0x674	0	Event Handler Configuration
LPAASSOCIATE	0x675	0	Event Handler Mode Association
LPASTART	0x674	1	Physics Start
LPASTOP	0x674	3	Physics Stop
LPASETCOMPRESS	0x675	5	Set Event Datagram Compression Level
LPASETOUTPUT	0x675	2	Configure Output Streams
LPASETGRB	0x675	3	Configure GRB Message Forwarding

Command	APID	Function Code	Description
LPANOOP	0x675	4	No Operation

5.0.0 LPACONFIGURE

This command configures LPA to activate a specified set of event handlers for each of 8 possible operating modes. The command uses 8 handler parameters which are 32 bit enable masks. To active a handler for a specific mode, first select the parameter appropriate to the desired mode. Next, encode the desired event handler ID, as specified in the LPA_DB instance, as a set bit in the enable mask parameter. Bit position 0 corresponds to event handler ID 0…, etc.

Parameter	Description
LPADBID	The LPA_DB instance ID.
LPACFGID	Unused
LPACPUS	Mask of target CPUs.
LPANORMHANDLERS	Normal physics event handler mask
LPATOOHANDLERS	TOO physics event handler mask
LPAGRB0HANDLERS	GRB state 0 event handler mask
LPAGRB1HANDLERS	GRB state 1 event handler mask
LPAGRB2HANDLERS	GRB state 2 event handler mask
LPASOLARHANDLERS	Solar physics event handler mask
LPACALIBHANDLERS	Calibration physics event handler mask
LPADIAGHANDLERS	Diagnostics physics event handler mask

5.0.1 LPAASSOCIATE

This command associates an event handler configuration ID for a specified set of event handlers for each of 8 possible operating modes. The command uses 8 handler parameters which are 32 bit enable masks. To associate the handler configuration ID for a specific mode, first select the parameter appropriate to the desired mode. Next, encode the desired event handler ID, as specified in the LPA_DB instance, as a set bit in the enable mask parameter. Bit position 0 corresponds to event handler ID 0…, etc. If an event handler enable mask has a set bit, the supplied event handler configuration ID will be selected when that handler has entered the associated mode.

Parameter	Description
LPADBID	The LPA_DB instance ID.
LPACFGID	The event handler configuration ID
LPACPUS	Mask of target CPUs.
LPANORMHANDLERS	Normal physics event handler mask
LPATOOHANDLERS	TOO physics event handler mask
LPAGRB0HANDLERS	GRB state 0 event handler mask
LPAGRB1HANDLERS	GRB state 1 event handler mask
LPAGRB2HANDLERS	GRB state 2 event handler mask
LPASOLARHANDLERS	Solar physics event handler mask
LPACALIBHANDLERS	Calibration physics event handler mask
LPADIAGHANDLERS	Diagnostics physics event handler mask

5.0.2 LPASTART

This command initiates a physics run. The LPAMODEID parameter can be used to command LPA to configure the event handlers for a specific mode. This setting does not change the instrument mode, and LIM may override this setting during TOO and ARR/GRB modes.

Parameter	Description
LPALATCCFGID	A 32 bit file ID corresponding to a LATC configuration
LPALATCIGNID	A 32 bit file ID corresponding to a LATC register ignore map
LPARUNID	A 32 bit run identifier
LPADBID	The LPA_DB instance ID
LPAMODEID	Physics mode identifier
LPALATCCNSFLG	LATC consignment flag used to request a telemetry dump of the hardware register configuration
LPACPUS	Mask of target CPUs.

5.0.3 LPASTOP

This command terminates the active physics run. No parameters are defined.

5.0.4 LPASETCOMPRESS

This command changes the default compression level for all science event datagram packets. Please refer to LSEP package documentation for a description on the allowed compression level values.

Parameter	Description
LPADBID	The LPA_DB instance ID
LPACPUS	Mask of target CPUs.
LPACOMPLEVEL	Compression level

5.0.5 LPASETOUTPUT

This command enables or disables certain components of the event output stream. The output streams are SSR and GRB, corresponding to bit positions 0 and 1 respectively. The LPAEVHOUTMASK parameter will enable or disable the posting of events, by an event handler, to the specified output stream. This parameter controls delivery of events from an event handler to the datagram formatting routines, and delivery of events from an event handler to the GRB photon candidate processor.

The LPAPOSTOUTMASK will enable or disable delivery of formatted data received on the specified stream. This parameter controls delivery of science event packets to the SSR, and delivery of GRB summary packets from an EPU to the SIU.

A bit set in an output mask will ENABLE that output stage. A bit not set will DISABLE that output stage.

Parameter	Description
LPADBID	The LPA_DB instance ID
LPACPUS	Mask of target CPUs.
LPAEVHOUTMASK	Event Handler Output enabled mask
LPAPOSTOUTMASK	Physical post output enable mask

5.0.6 LPASETGRB

This command enables or disables LPA forwarding of messages from the EPU and the GBM, to the GRB detection algorithm. A value of 0 indicates a DISABLED forwarding state, and a value of 1 indicates an ENABLED forwarding state.

The LPAGRBGBMSTATE parameter controls forwarding of GBM telecommands received by the LPA master task on the SIU, to the GRB detection algorithm.

The LPAGRBEPUSTATE parameter controls forwarding of EPU event summary packets received by the LPA master task on the SIU, to the GRB detection algorithm.

Parameter	Description
LPAGRBGBMSTATE	Enable state of GBM command forwarding
LPAGRBEPUSTATE	Enable state of EPU summary packet forwarding

5.0.7 LPANOOP

This command takes no parameters and if received will elicit a success response. The purpose of this command is to verify task communications without taking any action.

5.1 GRB Telecommands

LPA sends and processes commands defined for the GBM. For details on structure and content of these packets, refer to the LAT Telecommand and Telemetry document, and the LAT GBM Interface Control document.

Command	APID	Function Code	Description
LFSWCALCINFO	0x660	1	GBM GRB Calculated Information
LFSWCREPREC	0x660	2	GBM GRB Candidate Repoint Recommendation
LFSWCLOSEOUT	0x660	3	GBM GRB Closeout
GFSWLATTRIGGER	0x6f1	1	LAT Detected GRB Alert
GFSWLATCLOSEOUT	0x6f1	3	LAT Detected GRB Closeout

5.2 Telemetry

This section describes the telemetry interface for the LPA package. LPA delivers alert telemetry packets, and defines the apids for science event datagram packets. For details on the size and

structure of these packets, refer to the LAT Telecommand and Telemetry document, and the LAT GBM Interface Control document.

5.2.0 Packet Descriptions

Name	APID	Description
ALRTTRG	0x341	GRB Trigger Alert Telemetry
ALRTUPDATE	0x341	GRB Update Alert Telemetry
ALRTCLOSE	0x343	GRB Closeout Alert Telemetry
SIUEVTDAT	0x3bb	SIU Physics Event Data
EPU0EVTDAT	0x3bc	EPU0 Physics Event Data
EPU1EVTDAT	0x3bd	EPU1 Physics Event Data
EPU2EVTDAT	0x3be	EPU2 Physics Event Data