GLAST LAT SUBSYSTEM SPECIFICATION	Document # GE-00017-D1	Date Effective Draft 8/31/00
	Prepared by(s) Robert Johnson	Supersedes None
	Subsystem/Office Tracker Subsystem	
Document Title **LAT TKR Subsystem Specification - Level III Specification**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Tracker (TKR) Subsystem Specification

DOCUMENT APPROVAL

Prepared by:

____

Robert Johnson Date
TKR Subsystem Manager

Approved by:

____

Tim Thurston Date
LAT Systems Engineering

____

William E. Althouse Date
LAT Project Manager

____

Peter Michelson Date
Instrument Principal Investigator

____

Tune Kamae Date
Instrument Technical Lead

____

Steve Ritz Date

Instrument Scientist

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes

1 PURPOSE

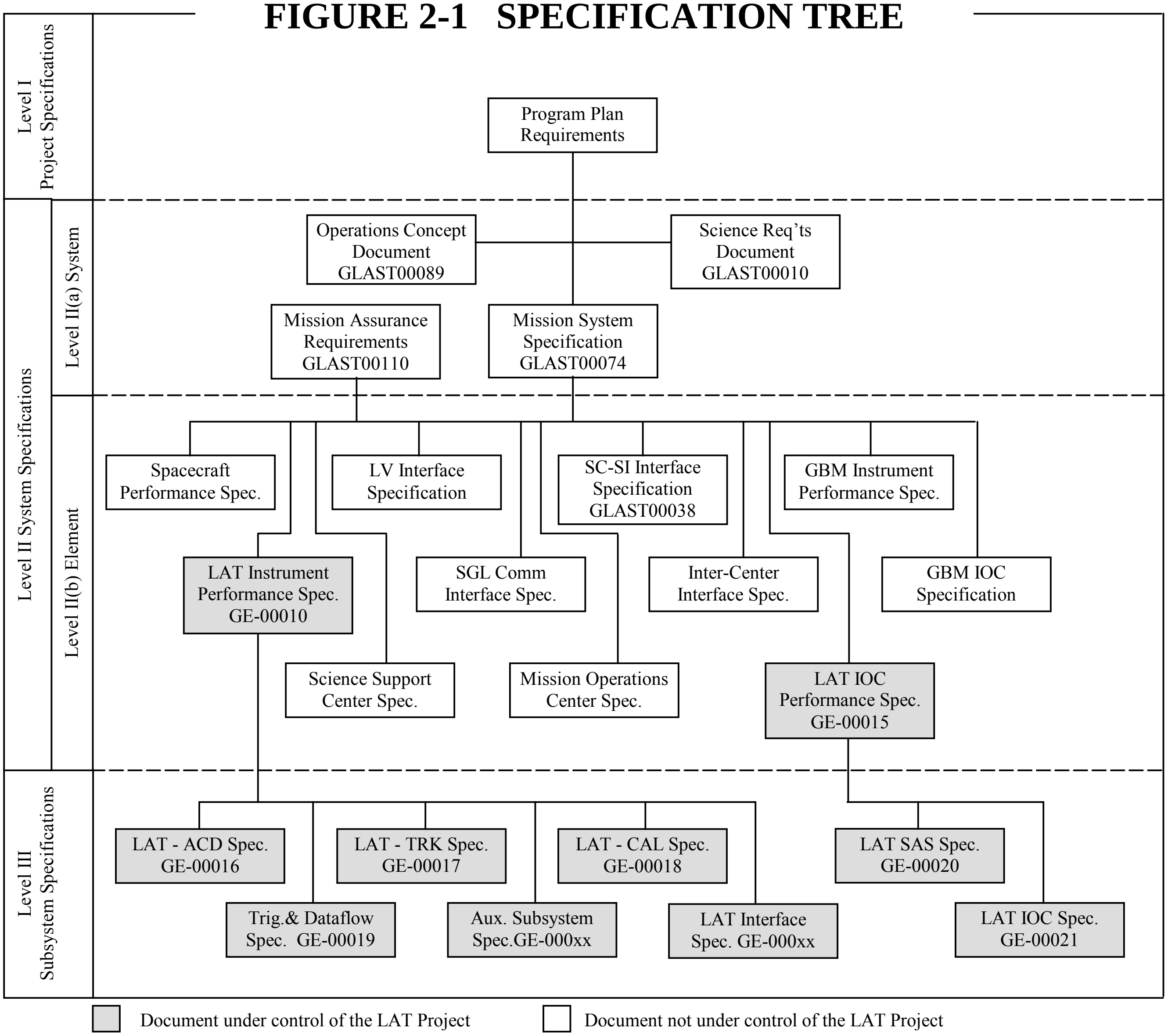
This document defines level III subsystem requirements for the GLAST Large Area Telescope (LAT) Tracker (TKR).

2 SCOPE

This specification captures the GLAST LAT requirements for the TKR. This encompasses the subsystem level requirements and the design requirements for the TKR. The verification methods of each requirement are identified.

This specification is identified in the specification tree of Figure 2-1.

FIGURE 2-1 SPECIFICATION TREE



3 DEFINITIONS

3.1 Acronyms

AGN – Active Galactic Nuclei

FOV – Field of View

FWHM – Full Width Half Maximum

GLAST – Gamma-ray Large Area Space Telescope

GN – Ground Network

GRB – Gamma-Ray Burst

IOC – Instrument Operations Center

IRD – Interface Requirements Document

LAT – Large Area Telescope

MC – Monte Carlo

MOC – Mission Operations Center

MSS – Mission System Specification

PI – Principal Investigator

SAS – Science Analysis Software

SDP – Science Data Processing

SI/SC IRD – Science Instrument – Spacecraft Interface Requirements Document

SRD – Science Requirements Document

SSC – Science Support Center

TBR – To Be Resolved

3.2 Definitions

γ – Gamma Ray

μsec, μs – Microsecond, 10^{-6} second

A_{eff} – Effective Area

Analysis – A quantitative evaluation of a complete system and /or subsystems by review/analysis of collected data.

Analysis platform – toolkit for doing analysis. Examples are IDL and Root.

Arcmin – An arcmin is a measure of arc length. One arcmin is 1/60 degree.

Arcsec – An arcsec is a measure of lengths of arc. One arcsec is 1/60 arcmin

Back Response – Response as measured in the thick layers of the Tracker

Background Rejection – The ability of the instrument to distinguish gamma rays from charged particles.

Backsplash – Secondary particles and photons originating from very high-energy gamma-ray showers in the calorimeter giving unwanted ACD signals.

Beam Test – Test conducted with high energy particle beams

cm – centimeter

Cosmic Ray Œ Ionized atomic particles originating from space and ranging from a single proton up to an iron nucleus and beyond.

Dead Time – Time during which the instrument does not sense and/or record gamma ray events during normal operations.

Demonstration – To prove or show, usually without measurement of instrumentation, that the project/product complies with requirements by observation of results.

eV – Electron Volt

Field of View – Integral of effective area over solid angle divided by peak effective area.

Front Response – Response as measured in the thin layers of the Tracker

G – unit of gravitational acceleration, g = 9.81 m/s^2

Geometric factor – is Field of View times Effective Area

GeV – Giga Electron Volts. 10^9 eV

Higher Level Processing – Processing of level 1 data into science products. Consists of generating exposure calculations, detecting sources, measuring their spectra, determining their time histories, and locating potential counterparts in other astronomical catalogs.

Inspection – To examine visually or use simple physical measurement techniques to verify conformance to specified requirements.

Level 0 processing – Processing of raw instrument data. Consists of time-ordering packets, removing incomplete or duplicate packets, and separating housekeeping, calibration, science, and engineering data streams.

Level 1 processing – Processing of level 0 data into level 1 data. Consists of creating a database of reconstructed gamma ray and cosmic ray events.

MeV – Million Electron Volts, 10^6 eV

ph – photons

Point Source Sensitivity – The weakest detectable gamma ray source.

s, sec – seconds

Simulation – To examine through model analysis or modeling techniques to verify conformance to specified requirements

sr – steradian, A steradian is the solid (3D) angle formed when an area on the surface of a sphere is equal to the square of the radius of the sphere. There are 4 Pi steradians in a sphere.

Testing – A measurement to prove or show, usually with precision measurements or instrumentation, that the project/product complies with requirements.

Validation – Process used to assure the requirement set is complete and consistent, and that each requirement is achievable.

Verification – Process used to ensure that the selected solutions meet specified requirements and properly integrate with interfacing products.

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the GLAST mission concept and its requirements include the following:

GE-00010, "GLAST LAT Performance Specification", August 2000

GLAST00010, "GLAST Science Requirements Document", P.Michelson and N.Gehrels, eds., July 9, 1999.

GLAST00038, "GLAST Science Instrument – Spacecraft Interface Requirements Document", Draft July 14, 2000

GLAST00074, "GLAST Mission System Specification", Draft, June 30, 2000

GLAST00089, "GLAST Operations Concept"

GLAST00110, "Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)", June 9, 2000

CCSDS 102.0-B-3, "Recommendation for Space Data Systems Standards. Packet Telemetry." October 1989

CCSDS 202.0-B-2, "Recommendation for Space Data Systems Standards. Telecommand, Part 2: Data Routing Service." October 1989

CCSDS 201.0-B-2, "Recommendation for Space Data Systems Standards. Packet Telecommand, Part 1: Channel Service."

CCSDS 201.0-B-1, "Recommendation for Space Data Systems Standards. Packet Telecommand, Part 2.1: Command Operation Procedures."

NPD 8010.2B, "NASA Policy Directive, Use of Metric System of Measurement in NASA Programs"

"Recommended Priorities for NASA's Gamma Ray Astronomy Program 1996-2010", Report of the Gamma Ray Astronomy Program Working Group, April 1997.

"The Evolving Universe: Structure and Evolution of the Universe Roadmap 2000 - 2020", roadmap document for the SEU theme, NASA Office of Space Science, June 1997.

"The Space Science Enterprise Strategic Plan: Origins, Evolution, and Destiny of the Cosmos and Life", NASA Office of Space Science, November 1997.

"Gamma Ray Large Area Space Telescope Instrument Technology Development Program", NRA 98-217-02, NASA Office of Space Science, January 16, 1998.

"GLAST Large Area Telescope Flight Investigation: An Astro-Particle Physics Partnership Exploring the High-Energy Universe", proposal to NASA, P. Michelson, PI, November, 1999.

SAE AS1773, "Fiber Optics Mechanization of a Digital Time Division Command/Response Multiplex Data Bus", Society of Automotive Engineers, September, 1995

5 REQUIREMENTS

5.1 System Description

The LAT science instrument (SI) consists of an Anticoincidence Device (ACD), a silicon-strip detector tracker (TKR), a hodoscopic CsI calorimeter (CAL), and a Trigger and Dataflow system (T&DF). The principal purpose of the SI is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The TKR converts gamma rays to charged particles and precisely measures the path of the charged particles within the TKR. Fast signals from tracks are examined in the T&DF system for likely gamma ray candidates. Once identified, and at the request of the trigger system, data are read out via the dataflow system. The dataflow system uses the data to assemble particle tracks and, coupled with the ACD and CAL, identify gamma rays.

5.2 Gamma Ray Conversion Efficiency

The TKR shall convert at least 65% (TBR) of the gamma rays with energy >10 GeV impinging upon the device at normal incidence.

5.3 Converter Configuration

At least 25% (TBR) of the gamma-ray conversions shall occur in converter foils no greater than 3.5% radiation lengths thick, with the remainder occurring in other material and converter material no more than 25% radiation lengths thick.

5.4 Other Material

At normal incidence and within the active area of the thin-converter region, no more than 25% (TBR) of the gamma-ray conversions shall occur in material more than 5 mm from the converter foils.

5.5 Geometric Area

The TKR shall have an active area at normal incidence of at least 19,000 cm^2.

5.6 Aspect Ratio

The ratio of height to width of the TKR shall not exceed 0.45 (for large field-of-view).

5.7 Charged Particle Detection

The TKR shall be capable of measuring immediately following each converter foil, in both *x* and *y* views and within the active area, the position of passage of a minimum ionizing particle at normal incidence with an efficiency of greater than 98% (TBR).

5.8 Spatial Measurement Resolution

The TKR shall be able to measure the direction of a charged particle of infinitely high momentum, in both *x* and *y* views and using just two consecutive measurement planes, to a precision of no worse than 0.2° (TBR).

5.9 Dead Area

The fraction of non-active area presented by the top of the TKR shall not exceed 8%.

5.10 Ionization Measurement

For an event with a single track detected, the TKR shall be able to distinguish, on the basis of charge deposition, a single minimum-ionizing particle from two minimum-ionizing particles to a level of at least 1-sigma (TBR).

5.11 Self Trigger

The TKR shall provide prompt signals (within 2 μs (TBR) of an event) that can be used by the T&DF system to form a trigger for readout of the TKR and other subdetectors.

5.12 Trigger Efficiency

The TKR trigger shall be on average at least 95% (TBR) efficient for the set of gamma-ray conversions from which the conversion products traverse the active areas of at least 3 consecutive measurement planes.

5.13 Trigger Noise

In the case that no charged particles or gamma rays are incident upon the TKR, the TKR trigger shall not exceed a rate of 500Hz (TBR).

5.14 Data Noise Occupancy

The noise occupancy in the TKR data stream shall not exceed one in 1000 (TBR) channels per trigger.

5.15 Trigger Saturation Recovery Time

The trigger signals from a TKR module shall not hold true for longer than 25 μs (TBR) in the case of passage of a high-momentum fully-ionized iron nucleus.

5.16 Dead Time

The dead time imposed by the TKR readout shall not exceed 10% at a cosmic-ray trigger rate of 10 kHz.

5.17 Tracker Mass

The mass of the TKR shall not exceed 620 kg.

5.18 Tracker Power

The power consumption of the TKR, including power conditioning, shall not exceed 308 W.

5.19 Environmental

The TKR shall be capable of normal operation after being subjected to the environmental conditions given in GE00010, Section 5.3.12, Environmental.

6 VERIFICATION STRATEGY

The verification strategy will test, analyze (may include modeling/simulation), inspect, or demonstrate all requirements of section 5 to ensure that the instrument meets its specified requirement. The matrix below indicates the methods of verification employed to verify the science performance.

Table 6-1. Requirements Verification Matrix

Note: Verification methods are T = Test, A = Analysis, D = Demonstrate, I = Inspect

Req't #	Title	Summary	Verif. Method
5.2	Gamma Ray Conversion Efficiency	Convert at least 65% (TBR) of all impinging gamma rays	A
5.3	Converter Configuration	At least 25% (TBR) of the gamma-ray conversions shall occur in converter foils no greater than 3.5% radiation lengths thick, with the remainder occurring in other material and converter material no more than 25% radiation lengths thick.	A
5.4	Other Material	<25% (TBR) of conversions shall occur in material >5 mm from the converters (normal incidence, active region)	A
5.5	Geometric Area	At least 19,000 cm^2	A
5.6	Aspect Ratio	Not to exceed 0.45	A
5.7	Charged Particle Detection	X,Y position of charged particles measured with efficiency >98%	T
5.8	Spatial Measurement Resolution	Direction of charged particle measured to precision no worse than 0.2° (TBR).	A,T
5.9	Dead Area	Not to exceed 8%	A
5.10	Ionization Measurement	For a single-track event, the TKR shall distinguish a single minimum-ionizing particle from two minimum-ionizing particles to a level of (TBD)-sigma.	A,T
5.11	Self Trigger	TKR shall provide prompt signals to the trigger subsystem.	D
5.12	Trigger Efficiency	TKR shall be at least 95% efficient for gamma-ray conversions from which the conversion products traverse at least 3 consecutive measurement planes.	A,T
5.13	Trigger Noise	Not to exceed 500 Hz (TBR).	T
5.14	Data Noise Occupancy	The noise rate in the TKR data stream shall not exceed one in 1000 (TBR) channels per trigger.	T
5.15	Trigger Saturation Recovery Time	<25 µs (TBR)	A,T
5.16	Dead Time	Not to exceed 10% at a cosmic-ray trigger rate of 10 kHz.	T
5.17	Tracker Mass	Not to exceed 620 kg.	I
5.18	Tracker Power	Not to exceed 308 W	T
5.19	Environmental	Must withstand environmental conditions in LAT Instrument Performance Spec.	T