Final Report

to

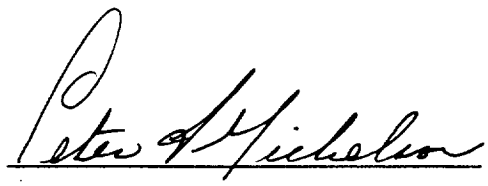
The National Aeronautics and Space Administration

on

The Gamma-ray Large Area Space Telescope (GLAST) Mission Concept Study

Grant: NAGW-4746

Period: 07/01/95 - 09/30/97



Peter F. Michelson
Principal Investigator

December 20, 1997

Introduction The Gamma-ray Large Area Space Telescope (GLAST), a next generation high-energy gamma-ray mission designed to observe cosmic sources of gamma-rays over the approximate energy range from 10 MeV to 300 GeV, was studied under this grant for possible flight in the next decade. The GLAST baseline mission studied will achieve a major advance in sensitivity beyond EGRET by the use of modern particle physics tracking technology. The baseline instrument design that has been extensively studied uses solid-state silicon strip detectors for particle tracking and efficient on-board data processing and event triggering to achieve more than an order of magnitude improvement in sensitivity compared to EGRET. Since the time the GLAST mission was selected for study by NASA in March 1995, Stanford University has been leading the mission study team that now includes 20 institutions. After the conclusion of the performance period of this grant (07/01/95 - 09/30/97), an extensive study of the GLAST mission by Goddard Space Flight Center was begun and GLAST was included in the NASA Space Science Enterprise Strategic Plan (November 1997). A report from GSFC to NASA Headquarters about the GLAST mission will be submitted in March 1998.

Summary of Mission Study The principal accomplishments of the Mission Concept Study activities, carried out with support provided under NAGW-4746, were the development of technology requirements, a technology development roadmap, and an initial cost estimate for the GLAST mission. Activity in all of these areas continues as part of the on-going GLAST Mission program. Appendix A of this report is a summary (in viewgraph format), presented to the NASA Technology Roadmap Review of GLAST (chaired by M. Cherry) on March 5-6, 1997, by the PI, Peter Michelson. Appendix B is a detailed description of the GLAST baseline instrument, reprinted from the Proceedings of the SPIE, vol. 2806, presented at the August 1996 SPIE meeting in Denver, CO.

APPENDIX A

Summary of GLAST Technology Roadmap

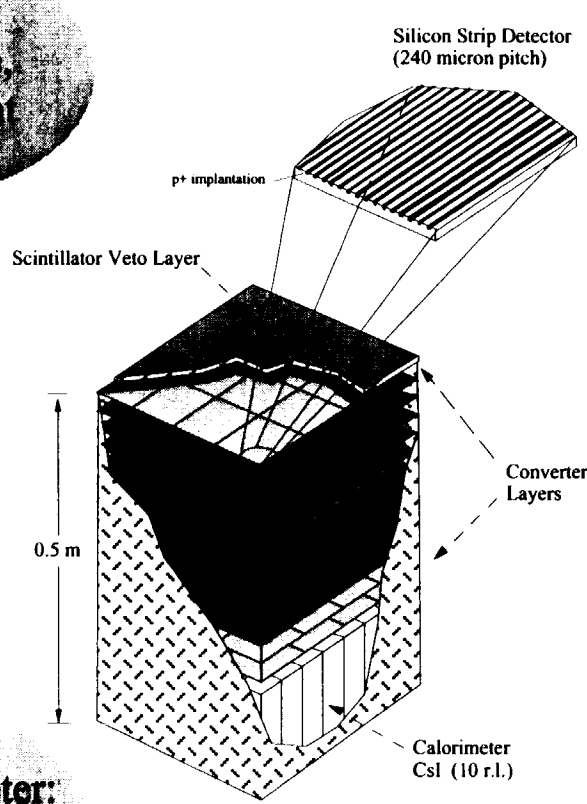
presented to

NASA Technology Roadmap Review of GLAST

Goddard Space Flight Center, March 5-6, 1997

Telescope Technology Requirements

Precision particle tracking: silicon-microstrip detectors



Integration and manufacture of telescope tracker planes

Large dynamic range, low-power electronics for crystal calorimeter readout

Imaging calorimeter: potential upgrade to baseline design

Structure and Evolution of the Universe

GLAST Technology Development Summary

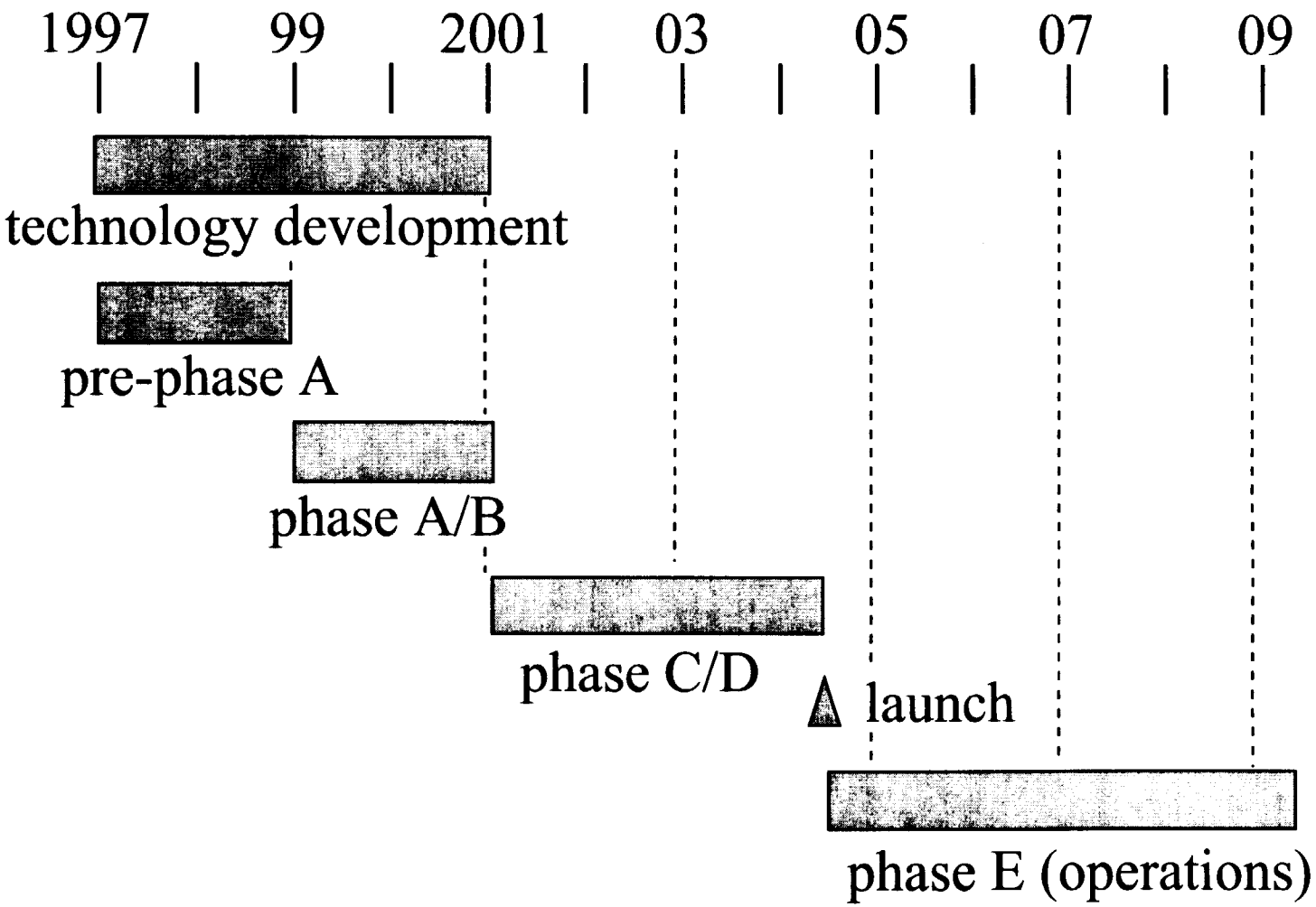
Technical Area	GLAST Requirements	Development Status
1. low-power VLSI Si-strip detector readout electronics	• baseline design requires •low-power: < 300μW/channel •low-noise: 0.2 fC enc ($\tau_{int} \leq 1$ μs) •sparse digital readout	• prototype front-end readout achieves < 200μW/ch. • fault tolerant, sparse digital readout: development time: 2 yrs
	• very low power (<100 μW/ch) will enhance performance (more tracker planes --> better angular resolution)	• development time: 3 yrs
2. ASIC readout electronics for crystal calorimeter	• baseline design requires •low-power: < 30 mW/channel •low-noise: < 0.5 MeV •large dynamic range: 3 x 10^5	• development time: 3 yrs • studies underway for lower power (<5 mW/ch.), --> 3D (imaging) calorimeter capability
3. Silicon microstrip detector arrays	• baseline design requires •single-sided detectors	• well-developed and available from several vendors
	• double-sided detectors, not required for baseline design, but will improve angular resolution &allow possibility of *polarization measurement*	• new bonding technology required for low-power, double-sided readouts and Si strip planes • development time: 3 yrs

Structure and Evolution of the Universe

GLAST Technology Development Summary

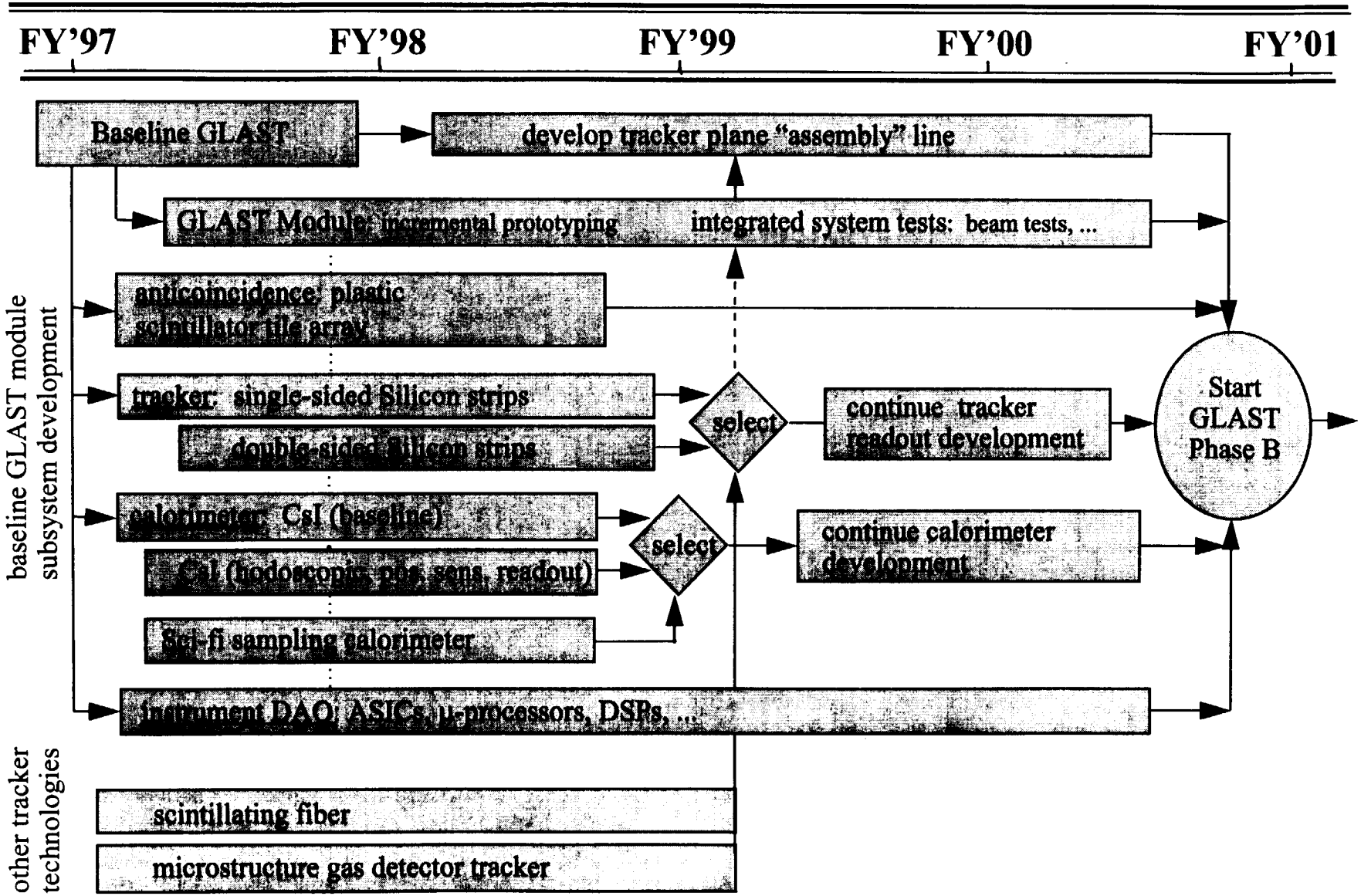
Technical Area	GLAST Requirements	Development Status
4. programmable, on-board trigger modes	• distributed processing required: 25-50 MIPS, implemented with space-qualified computers, DSPs, FPGAs	• 1st flight tests of 32 bit computers (RH3000, RH32, R6000) ;launch in 1997 • DAQ system design beginning; development time: 3 yr
5. integration & manufacture of tracker planes	• mechanical support of planar array (4x4) of detectors with minimum radiation lengths of material	• prototype 4x4 detector array development time: 1.5 yr
	• baseline design requires replication and testing of 1,200 4x4 detector arrays • achieve economies of scale in manufacturing & testing to minimize cost	• study begun of replication and testing procedures
6. imaging calorimeter	• not required for baseline design; would allow imaging of photon events that convert in the calorimeter --> approx. 3x increase in effective area at highest energies (E > 10 GeV)	• feasibility studies of several technical approaches underway: •3D, pixelated crystal calorimeters, •scintillating fiber sampling calorimeter

GLAST Mission Timeline



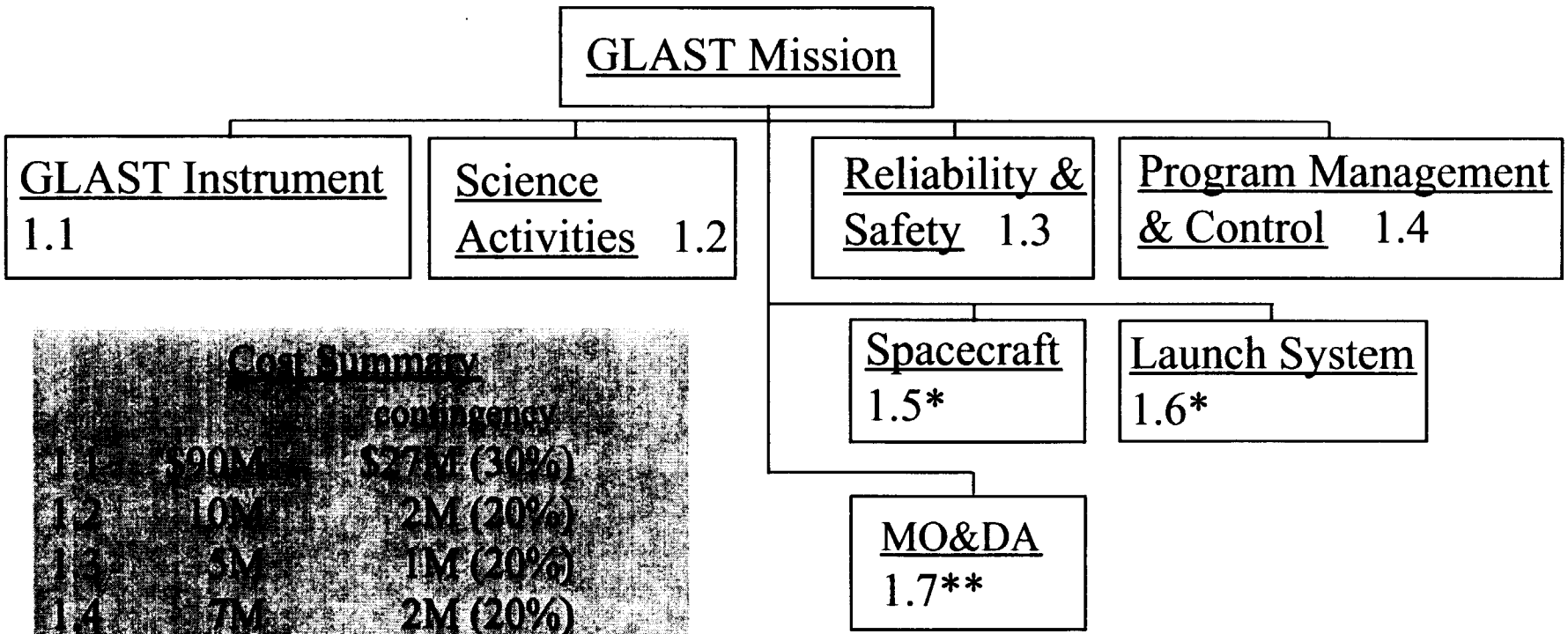
Structure and Evolution of the Universe

GLAST Technology Development Roadmap



GLAST Mission Scope

Level 1 WBS & Cost Summary



Cost Summary

		contingency
1.1	$90M	$27M (30%)
1.2	10M	2M (20%)
1.3	5M	1M (20%)
1.4	7M	2M (20%)
1.5	40M	8M (20%)
1.6	60M	12M (16%)
1.7	50M	5M (10%)

Estimated Life-Cycle Costs $319M
(including launch, & contingency)

* subcontracted purchase service
** 5 year mission

APPENDIX B

Paper presented at SPIE Meeting, Denver, CO

August 5-7, 1996