GLAST LAT TECHNICAL DOCUMENT	Document # **LAT-DS-00739-1**	Date Effective 11/30/01
	Prepared by(s) Bob Hartman	Supersedes None
	Subsystem/Office Anticoincidence Detector Subsystem	
Document Title **Specifications for ACD Photomultiplier Tubes**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Specifications for ACD Photomultiplier Tubes

ORDER FOR SUPPLIES OR SERVICES

IMPORTANT: **Mark all packages and papers with contract and/or order numbers.**

1. DATE OF ORDER
NOV. 30, 2001

2. CONTRACT NO. *(If any)*

3. ORDER NO.
S 60463 G

4. REQUISITION/REFERENCE NO.
740-09742A(1P)

5. ISSUING OFFICE *(Address correspondence to)*
NASA's Goddard Space Flight Center
ATTN: MS. VERONICA C. STUBBS
GREENBELT, MD 20771

6. SHIP TO:
a. NAME OF CONSIGNEE
NASA/GODDARD SPACE FLIGHT CENTER
b. STREET ADDRESS
GREENBELT ROAD
c. CITY
GREENBELT
d. STATE
MD
e. ZIP CODE
20771
f. SHIP VIA

7. TO:
a. NAME OF CONTRACTOR
HAMAMATSU CORPORATION
b. COMPANY NAME
HAMAMATSU CORPORATION
c. STREET ADDRESS
360 FOOTHILL ROAD
d. CITY
BRIDGEWATER
e. STATE
NJ
f. ZIP CODE
08807

8. TYPE OF ORDER
☒ a. PURCHASE
REFERENCE YOUR: _____.
Please furnish the following on the terms and conditions specified on both sides of this order and on the attached sheets, if any, including delivery as indicated.

☐ b. DELIVERY - Except for billing instructions on the reverse, this delivery order is subject to instructions contained on this side only of this form and is issued subject to the terms and conditions of the above-numbered contract.

g. PPC CODE
GF
h. STATE CODE

9. ACCOUNTING AND APPROPRIATION DATA
JON: 743-785-20-31-02;APP: 801/20110(01); BLI: A701
OC: 74-2550; AMT:$16,000.00; BN/C: 202

10. REQUISITIONING OFFICE

11. BUSINESS CLASSIFICATION *(Check appropriate box(es))*
☐ a. SMALL ☒ b. OTHER THAN SMALL ☐ c. DISADVANTAGED ☐ d. WOMEN-OWNED

12. F.O.B. POINT
NASA/GODDARD SPACE FLIGHT CENTER

13. PLACE OF
a. INSPECTION b. ACCEPTANCE

14. GOVERNMENT B/L NO.

15. DELIVER TO F.O.B.POINT ON OR BEFORE (Date)
MARCH 1, 2002

16. DISCOUNT TERMS

17. SCHEDULE *(See reverse for Rejections)*

ITEM NO. (A)	SUPPLIES OR SERVICES (B)	QUANTITY ORDERED ©	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)	QUANTITY ACCEPTED (G)
1	IN ACCORDANCE WITH THE ATTACHED STATEMENT OF WORK , ADDITIONAL TERMS, AND THE CONTRACTOR'S PROPOSAL DATED OCTOBER 8, 2001, THE CONTRACTOR SHALL PROVIDE PHOTOMULTIPLIER TUBES (PMT'S) TO BE USED IN THE GLAST ACD SEE ATTACHED FOR ADDITIONAL TERMS	10	EACH	$1,600.00	$16,000.00	

SEE BILLING INSTRUCTIONS ON REVERSE

18. SHIPPING POINT

19. GROSS SHIPPING

20. INVOICE NO.

$16,000.00 ◀ **17(h)TOT. (Cont. pages)**

21. MAIL INVOICE TO:
a. NAME
NASA GODDARD SPACE FLIGHT CENTER
b. STREET ADDRESS *(or P.O. Box*
ACCOUNTS PAYABLE CODE 155
c. CITY
GREENBELT
d. **MD**
e. ZIP CODE
20771

$16,000.00 ◀ **17(i) GRAND TOTAL**

22. UNITED STATES OF AMERICA BY *(Signature)* ▶

DATE

23. NAME *(Typed)*
JAMES S. KING
TITLE: CONTRACTING OFFICER

ORDER NUMBER S-60463-G
ADDITIONAL TERMS

Accounting and Appropriation Data

PCN: 740-09742A(1P)
JON: 743-785-20-31-02
APP: 801/20110(01)
BLI: A701
OC: 74-2550
AMT: $16,000.00

TOTAL: $16,000.00
BNC: 202

ADDITIONAL TERMS

Delivery Schedule

1. Basic Contract--Ten (10) Qualification Unit PMT's shall be delivered on or before

March 1, 2002.

2. Option 1--Forty (40) Engineering Unit PMT's shall be delivered on or before June 1, 2002.

3. Option 2--Two hundred ten (210) Flight Unit PMT's shall be delivered within ten (10) months after the exercise of this option.

Delivery shall be FOB Destination to the Goddard Space Flight Center Greenbelt, MD 20771.

OPTION FOR INCREASED QUANTITY. THE GOVERNMENT MAY INCREASE THE QUANTITY OF SUPPLIES CALLED FOR IN THE SCHEDULE AT THE UNIT PRICE SPECIFIED IN ACCORDANCE WITH FAR CLAUSE 52.217-6, OPTION FOR INCREASED QUANTITY AS FOLLOWS:

OPTION	DESCRIPTION	QUANTITY	UNIT PRICE	TOTAL PRICE
1	Engineering Unit PMT Tested to Level 3	40	$1,640.00	$65,600.00
2	Flight Models Tested to Level 3	210	$1,350.00	$283,500.00

Note: We expect to change the quantity from 210 to 240 to allow sufficient spares.

NO CHANGES ARE TO BE MADE TO THIS PURCHASE ORDER WITHOUT THE PROPER AUTHORIZATION FROM GSFC PROCUREMENT.

CONTRACTUAL INQUIRIES SHOULD BE DIRECTED TO VERONICA C. STUBBS, CODE 216, GSFC, GREENBELT, MD 20771, PHONE (301) 286-8386 OR FAX (301) 286-1773, EMAIL Veronica.C.Stubbs.1@gsfc.nasa.gov

PRICE PER WRITTEN QUOTE DATED OCTOBER 8, 2001 BY ANDREW ALLEN OF HAMAMATSU CORPORATION

VENDOR'S TAX IDENTIFICATION NUMBER: 13-2638233.

EQUIPMENT USER: DR. ROBERT HARTMAN, CODE 661, PHONE, (301) 286-7178.

THE CONTRACTOR'S INVOICE SHALL CITE ITS TAX IDENTIFICATION NUMBER.

STATEMENT OF WORK/SPECIFICATIONS
GLAST ACD PHOTOMULTIPLIER TUBES

The Gamma-ray Large Area Space Telescope (GLAST) Anticoincidence Detector (ACD) requires 230 small photomultiplier tubes. Photomultiplier tubes are the sensor of choice for the low light levels coming from the plastic scintillators. The high efficiency required for anticoincidence demands a photomultiplier tube with capability of detecting single photoelectrons. All tubes must be sufficiently reliable and tested for space flight use.

This procurement is for Photomultiplier Tubes that meet the Photomultiplier Tube (PMT) Requirements detailed below, to be delivered according to the schedule detailed elsewhere in this contract.

All test data shall be delivered with each PMT, either electronically (preferred) or by paper copy.

Failure reports shall be submitted on any PMT's that fail to meet the Performance Requirements after testing (see below).

PHOTOMULTIPLIER TUBE REQUIREMENTS

PHYSICAL REQUIREMENTS FOR THE PHOTOMULTIPLIER TUBES

1. Head-on type cylindrical tube

2. Bi-alkali cathode

3. Outside diameter less than or equal to 15.2 mm

4. Length less than or equal to 80 mm, not including leads

5. Flying lead connections at least 33 mm long, with ends tin-lead solderable to within 10 mm from the glass stem

6. Minimum cathode diameter 9 mm

7. As delivered, all PMT's shall be soldered to a temporary base to enable initial electrical testing.

PERFORMANCE REQUIREMENTS FOR THE PHOTOMULTIPLIER TUBES

1. Minimum current gain at maximum high voltage shall be 2,000,000 (2E+6).

2. Quantum efficiency shall be greater than 15.5% (15% for the qualification tubes) at a wavelength of 490 nm.

3. Anode dark current shall be less than 10 nanoamps at a gain of 5E+5 and a temperature of 20 C.

4. High voltage required at a gain of 2E+6 shall not exceed 1250 V.

5. Projected gain degradation shall be less than 30% (84% probability) after 50,000 hours of operation at a mean anode current of 30 nanoamps. The projection shall be based on accelerated life tests at higher currents with tubes of the same design. Proposals shall detail how such tests have been conducted. Except as required below, the PMT's to be delivered under this solicitation shall *not* undergo such extended accelerated life tests.

ENVIRONMENTAL REQUIREMENTS TO BE MET BY THE PHOTOMULTIPLIER TUBES

1. Temperature range: The PMT's shall operate within specification over a range -30 C to +45 C.

2. Temperature rate (dT/dt): the PMT's shall operate within specification while experiencing temperature change (within the above range) at a rate of (flight) 5 C/hr; and (test) 20 C/hr.

3. Temporal stability: At a constant temperature of 20 C, gain variation shall be less than 2% per 10 days.

4. Vibration: The PMT's shall operate within specification, and with parameter changes not exceeding the values shown below, after experiencing a Delta2 Qualification Level vibration environment in accordance with http://arioch.gsfc.nasa.gov/302/gevs-se/sec2-4.pdf.

5. Shock: The PMT's shall operate within specification, and with parameter changes not exceeding the values shown below, after experiencing Delta2 Qualification Level shock testing in accordance with http://arioch.gsfc.nasa.gov/302/gevs-se/sec2-4.pdf.

6. Radiation: the units shall operate within specification, and with parameter changes not exceeding the values shown below, after a total dose of 10 kRad.

Limits on Performance Changes Due to Vibration, Shock, or Radiation

Quantum efficiency shall not change by more than 10%;

Current gain shall not change by more than 25%;

Anode dark current (at a temperature of 20 C) shall not increase by more than 100% if it is initially greater than or equal to 1 nA. If the initial anode dark current is less than 1 nA, it shall not increase by more than a factor of 10 after vibration, shock, or radiation.

(All three of the parameters listed above must be within specification both before and after the vibration, shock, or radiation exposure.)

QUALITY REQUIREMENTS TO BE MET BY THE PHOTOMULTIPLIER TUBES

1. The Photomultiplier Tube Quality Plan shall be consistent with the following:

ISO-9001;

GSFC 433-MAR-0001, "The Mission Assurance Requirements for the Large Area Telescope;"

LAT Performance Assurance Implementation Plan (SLAC LAT-MD-00039);

"Quality Plan for the Anticoincidence Detector" (GSFC ACD-QA-8001).

2. The PMT's must be space flight qualifiable according to 433-SPEC-0001 (GLAST, Mission System Specification).

TESTING - QUALIFICATION UNIT PMT'S (LEVEL 2 TESTING):

1) Visual Inspection

2) DC Measurements (quantum efficiency at 490 nm, anode luminous sensitivity at 1250V, derived current gain at 1250V, nominal voltage for gain of 5E+5, anode dark current at gain of 5E+5). Any PMT that fails to meet the performance requirements listed above shall be rejected. Failure reports are *not* required on PMT's rejected at this point.

3) Random vibration - The ten (10) Qualification Unit PMT's shall be vibration tested by the contractor to the Delta2 Qualification Level specified in http://arioch.gsfc.nasa.gov/302/gevs-se/sec2-4.pdf. The PMT's shall meet the above performance requirements both before and after the vibration test. Furthermore, changes in performance parameters following the vibration test shall not exceed the limits shown above under "Limits on Performance Changes Due to Vibration, Shock, or Radiation."

4) Visual Inspection (window or envelope defects, loose particles, internal structure).

5) DC Measurements as in 2) - Any PMT that fails to meet the performance requirements listed above shall be rejected. Failure reports *are* required on PMT's rejected at this point.

6) 12-hour Burn-in

7) Visual Inspection (repeat item #1)

8) DC Measurements as in 2) - Any PMT that fails to meet the performance requirements listed above shall be rejected. Failure reports *are* required on PMT's rejected at this point.

All test data (from steps 2, 5, and 8 above) shall be delivered at the same time a PMT is delivered.

The Qualification Unit PMT's shall *not* be subjected to the 100-hour burn-in described below.

TESTING – ENGINEERING AND FLIGHT UNIT PMT'S (LEVEL 3 TESTING):

1) Visual Inspection (window or envelope defects, loose particles, internal structure)

2) DC Measurements - (quantum efficiency at 490 nm, anode luminous sensitivity at 1250V, derived current gain at 1250V, nominal voltage for gain of 5E+5, anode dark current at gain of 5E+5). Any PMT that fails to meet the performance requirements listed above shall be rejected. Failure reports are *not* required on PMT's rejected at this point.

3) Random vibration -

Following the testing described above, each PMT shall be vibration tested at Delta2 Flight Acceptance Level in accordance with http://arioch.gsfc.nasa.gov/302/gevs-se/sec2-4.pdf

4) Visual Inspection (repeat item #1)

5) DC Measurements (quantum efficiency at 490 nm, anode luminous sensitivity at 1250V, derived current gain at 1250V, nominal voltage for gain of 5E+5, anode dark current at gain of 5E+5)

Failure reports shall be submitted on any Engineering Unit or Flight Unit PMT's that fail to meet the Performance Requirements, or which demonstrate performance changes in excess of the limits shown above under "Limits on Performance Changes Due to Vibration, Shock, or Radiation" after vibration testing. Such failure shall be reported to the Technical Officer within two (2) working days. The failed PMT shall undergo failure analysis, the results of which shall be delivered at a mutually agreed upon time, based on the type of failure.

6) 100-hour Burn-in - Following the testing described above, each Flight Unit PMT shall be operated at 30 microamp anode current for 100 hours (gain drift characterization), with the Current Amplification measured initially and after 12, 24, 48 and 100 hours of operation.

7) Visual Inspection (repeat item #1)

8) DC Measurements - The full set of performance parameters (quantum efficiency at 490 nm, anode luminous sensitivity at 1250V, derived current gain, nominal voltage for gain of 5E+5, anode dark current at gain of 5E+5). Any PMT shall be rejected, and a Failure Report submitted, if its post-burn-in Cathode Luminous Sensitivity, Anode Dark Current (at 20 C temperature), or Current Gain differs from the pre-test value by more the limits shown above under "Limits on Performance Changes Due to Vibration, Shock, or Radiation", or if it no longer meets the Performance Requirements shown above. Furthermore, any PMT whose gain has decreased by more than 10% after the first 12 hours, or by more than 25% after the full 100 hours, shall be rejected; a Failure Report shall be submitted on such a PMT.

All test data from steps 2, 5, and 8, as well as the gain data from the gain tests at 0, 12, 24, 48, and 100 hours, shall be delivered at the time each Flight Unit PMT is delivered.