ICESat (GLAS) Science Processing Software Document Series

The Algorithm Theoretical Basis Document for Level 1A Processing Version 1.6

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Foreword

The GEOSCIENCE LASER ALTIMETER SYSTEM (GLAS) is a part of the EOS program. This laser altimetry mission will be carried on the spacecraft designated EOS ICESat (Ice, Cloud, and Land Elevation Satellite). The GLAS laser is a frequency-doubled, cavity-pumped, solid state Nd:YAG laser. The GLAS instrument will provide both surface laser altimetry and atmospheric lidar data. The science goals and requirements are documented in the GLAS Science Requirements Document which is listed in the Bibliography. This document provides the algorithms to convert the instrument data from raw counts into engineering units suitable for input to the science algorithms described in further ATBDs.

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Section 1
Introduction

The first process of the Geoscience Laser Altimeter System (GLAS) Science Algorithm Software converts the Level 0 data into the Level 1A Data Products. The Level 1A Data Products are the time ordered instrument data converted from counts to engineering units. This document defines the equations that convert the raw instrument data into engineering units. Required scale factors, bias values, and coefficients are defined in this document. Additionally, required quality assurance and browse products are defined in this document.

The GLAS Level 0 data consists of a number of different instrument packet types, each type having its own application identifier (APID). Each packet type generally contains data relative to one of the prime GLAS measurements or subsystems. The EOS Data and Operations System (EDOS) delivers the instrument packets to the ICESat Science Investigator-led Processing System (I-SIPS) in Production Data Sets (PDS). Each PDS is a time-ordered set of packets received during a telemetry dump for a particular APID. At EDOS, the packets are Reed-Solomon decoded; redundant packets associated with previous dumps are removed; and some frame error checking is done. The Level 0 APIDs are listed in Table 1-1 "GLAS Telemetry Packets". The level 0 data is described in Appendix B.

Table 1-1 GLAS Telemetry Packets

Packet Name	APID
Altimeter Digitizer Data-Large	12
Altimeter Digitizer Data-Small	13
Altimeter Digitize Engineering Mode	14
Photon Counter (PC) Science	15
PC Engineering	16
Cloud Digitizer (CD) Science	17
CD Engineering	18
Ancillary Science	19
Laser Profiler Array Data	26
Command History	39
Laser Monitor Board, Temperature Controller Module, Motor Control System & High Voltage Power Supply Housekeeping Telemetry	20
PDU Housekeeping Telemetry	21
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Table 1-1 GLAS Telemetry Packets (Continued)

Packet Name	APID
Housekeeping Temperatures #2 Telemetry	23
Small Software #1 Telemetry	24
Small Software #2 Telemetry	50
Large Software Telemetry #1	25
Large Software Telemetry #2	55
DSP Code Memory Dump	31
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The Level 1A Data Products produced by the algorithms described in this document are listed in Table 1-2 "The GLAS Level 1A Data Products". The Level 1A Data Products contents and format are defined in the *Level 1A Data Product Specification*; listed in the Bibliography in Section 5. Prior to storage in the Level 1A products the Level 1A data in engineering units are scaled to integer. The scale factors are defined in this document. The Level 0 and Level 1A detailed descriptions are not repeated in this document.

Table 1-2 The GLAS Level 1A Data Products

Product ID and Name	Description
GLA01 - Altimetry Data Product	Contains the waveforms and the altimeter and timing data required to produce higher level range and elevation products.
GLA02 - Atmosphere Data Product	Contains the normalized backscatter, photon counter, cloud digitizer, timing, and location data required to produce the higher level atmosphere data products.
GLA03 - Engineering Data Product	Contains the GLAS instrument's engineering and housekeeping data.
GLA04 - SRS and GPS Data Product	Contains the Global Positioning System data, Stellar Reference System data, and other instrument and spacecraft position and attitude data required to produce the precision orbit and precision attitude data.

Section 2
Algorithm Description

2.1 Level 0 to Level 1A Conversions

Generally, each measurement in an APID will have a calibration equation determined during GLAS system testing that will be used to convert the measured counts into engineering units. The conversions of the counts to engineering units will be one or more of several types: straight polynomial conversion based on the measurement counts; multi-variable conversions with dependence on additional measurements such as temperature; special conversions based on a complex dependence of several measurements, interpretation of data, table look-up, and geophysical based conversions. Some data will not require conversion and will be retained in counts. The Stellar Reference System (SRS) attitude and position data and the GPS data will be from standard existing systems similar to those used on other spacecraft. The SRS and GPS data along with the laser pointing monitor data will be packaged into the GLA04 data product and provided to the GLAS Science Team. This document will specify the algorithms that process the GLAS altimeter, lidar and housekeeping level 0 packets and the position and attitude data. Appendix B contains tables listing the GLAS instrument telemetry.

2.1.1 Polynomial Expansion Conversions

Most of the GLAS data will be converted by simple polynomial equations of fifth degree or less. Temperature, voltage, and current telemetry data are in this category.

The form for the conversion will be

A*(X**5) + B*(X**4) + C*(X**3) + D*(X**2) + E*(X) + F

where X is the raw measured value and A, B, C, D, E and F are constant coefficients.

The polynomial conversion factors for the telemetry data are defined in Appendix A. The table lists the telemetry data that is converted through polynomial expansion, the source APID, the conversion factors, and the resulting units.

2.1.2 Multi-variable Conversions

Multi-variable conversions will primarily be used to apply instrument temperature and voltage corrections to data. Below is a generic example of this type of correction.

Xeu = Xct* (A*(T1)**2 + B*(T1)) +C

where

Xeu = The telemetry value in engineering units
Xct = The raw telemetry value in counts
T1 = telemetry value upon which Xct is dependent
A, B, C = conversion coefficients

Some measurements may require more than one such type correction or are dependent on more than one temperature or other telemetry value.

For the PDU housekeeping data, the engineering unit conversions are dependent upon monitor calibration values that are telemetered within the PDU packet (APID=21). The conversion for the monitor calibration values and the conversion for the telemetry based on these values in contained in Appendix A, Section A.2.

2.1.3 Special Conversions

There are some conversions that will require special forms based on the analysis of instrument test data or simulations.

2.1.3.1 Bit Interpretation

The interpretation of flags and status words does not usually depend on conversion factors or biases. It is usually a matter of evaluating bits or bit patterns. Appendix A defines those telemetry values which require interpretation and explains how the values are to be interpreted.

2.1.3.1.1 Instrument State Flag

This flag describes the hardware state of the instrument. It describes which of the instrument's redundant systems is operating. The flag is stored in the data product headers and it is composed from the bit interpretation of several telemetered status words. The detailed description including source information is in Appendix A.24.

2.1.3.2 1064 nm Transmitted and Received Pulse Energy

To calculate the 1064 nm transmitted and received pulse energies, the telemetry data for the transmitted and received waveforms is inspected. For each, from the peak location, the waveform is searched (in both directions) until reaching 3% or less of the peak value. The waveform data between the two points is summed. The pulse energies are the product of the sum of the waveform data and a calibration constant. For now, the constant is set to 1.0.

2.1.3.3 Background Mean and Standard Deviation for all Filters

The background mean and standard deviation for the 4 nanosecond (ns) filter are given in telemetry.

The background mean for the other five filters (8 ns, 16 ns, 32 ns, 64 ns, 128 ns) equals the mean for the 4 ns filter. The standard deviation for each of the other filters is computed as shown in the following equation:

standard deviation for filter i =
standard deviation for filter (i-1)/(square root (2)) for (i=2,3,4,5,6)

where i=1 is the 4ns filter whose mean and standard deviation is downlinked, i=2 is the 8ns filter, etc.

2.1.3.4 Table Look-up

Some conversions will be table lookup, based on single or multiple parameters. On past projects it was found that for multiple single byte telemetry values requiring the same conversion factors (temperatures, for example) it was more efficient to use a lookup table to obtain the engineering unit value based on the telemetry counts rather than executing the equation. Table lookup will be implemented for the conversion of one byte telemetry values to engineering units, when that conversion is by polynomial expansion..

2.1.3.5 L1A Time Tagging

The L1A time tagging algorithm computes the exact UTC time for each laser shot and the UTC time for all associated data in order to process the GLAS data into L1A granules. See the report, *ICESat Observatory Timing and Event Time Reconstruction*, which is listed in the Bibliography in Section 5 for a description of the timing scheme used by the ICESat observatory. This report discusses how the precise times of events on the observatory can be reconstructed from the downlinked telemetry.

The time tagging algorithm requirements are listed in this section. The algorithm specification is contained in Appendix A. Background information for the data alignment and time tagging algorithm are contained in Appendix C.

<u>Algorithm Requirements - General</u>

1) GPS time is to be used as the prime time reference. If GPS is not available spacecraft time as determined from the spacecraft vehicle time code word (BVTCW) shall be used as the time reference.
2) The shot time (time of altimeter digitizer bin one (or zero)) in UTC is computed from the Fire Command Time in the ancillary science packet. The UTC time tag for each shot shall be computed by referencing its fire command time word to GPS or spacecraft time.
3) Oscillator frequency offsets and drift between various subsystems will be properly handled.
4) If the ancillary science packet is missing but other packets are present the expected, i.e. predicted, time tag will be assigned to those shots.
5) Time computed for an Expedited Data Set (EDS) will be the same for that data on its Production Data Set (PDS).
6) Alignment must be made to the SRS (LRS, IST, Gyro) data by assigning proper shot number and shot time.
7) Shot and data UTC times will be computed from the reference time that occurs prior to the time of the data, e.g. times will not be backwards interpolated.

<u>Algorithm Requirements - GPS is available</u>

8) GPS can reset and must be handled properly. It takes 10 minutes to recover and provide new position data. During this period the GPS does not provide the once per 10 second pulse, so there is no updated GPS reference time. The previous GPS reference time should be used. This condition can span across PDSs.
9) A record must be kept relating the GPS time used to every time computed.
10) Leapseconds shall be added to the GPS Time to get UTC. The leapseconds correction will be stored in a GPS to UTC Leapseconds file.
11) A constant shall be defined that is the GPS time of midnight January 1, 2000 (the UTC reference time). This constant will be negative because it used to remove from the laser shot GPS time the amount of GPS time occurring from the GPS time reference time (January 6, 1980) to the UTC reference time.

Algorithm Requirements - GPS is not available

12) Spacecraft time in UTC (as computed from BVTCW) will be used as the reference time if GPS is not available.
13) The time tagging algorithm will not automatically switch to the BVTCW time reference upon detection of missing GPS.
14) The BVTCW of the 10 hz LRS Data shall be aligned to the correct shot and its fire command time. The 10 Hz shot time shall then be computed based on the UTC of the BVTCW. The 40 Hz shot times and any other data times can be interpolated from the 10 Hz UTC BVTCW shot times.

2.1.3.6 GPS Black Jack to RINEX Format Conversion

A program will be provided from the GLAS Science Team that will convert the downlinked GPS data from the Black Jack format to the RINEX format. The RINEX is a standard ASCII format for the GPS data and is described at the following website: ftp://igscb.jpl.nasa.gov/igscb/data/format/rinex2.txt. The GPS data is stored in the GLA04 Data Product.

2.1.3.7 Position and Attitude Telemetry Data Storage in GLA04

The position and attitude data will be telemetered in a spacecraft packet known as the Position, Rate, and Attitude Packet (PRAP). The position and attitude data is collected from the following systems on-board the spacecraft:

- spacecraft star tracker (2), also known as Ball Star Tracker 1 (BST1) and Ball Star Tracker 2 (BST2),
- instrument star tracker (IST),
- gyro, also known as the IRU, and
- Laser Reference System (LRS).

The Laser Profiling Array (LPA) data will be telemetered via the instrument. The data from each system will be stored in a separate file in the GLA04 product. The PRAP data conversions are defined in the *Data Interface Control Document between the ICESat Spacecraft and the EOS Ground System (EGS)*, referenced in Section 5, the Bibliography.

2.1.4 Geophysical Conversions

Conversions for the Photon Counter and Cloud Digitizer LIDAR data and backgrounds are found in the *GLAS Atmospheric Data Products ATBD*, referenced in Section 5.

2.2 Quality Assurance

This section shall describe the quality assurance data for the Level 1A granules.

2.2.1 Altimetry Product (GLA01)

1) Expected number of Ancillary Science packets (APID 19) based on time span of data.
2) Actual number of Ancillary Science packets based on number read.
3) Percentage missing Ancillary Science packets: [1-(item 2 / item 1)] * 100.
4) Expected number of waveform packets (APIDs 12 and 13) based on time span of data.
5) Actual number of waveform packets based on number read.
6) Percentage missing waveform packets: [1-(item 5 / item 4)] * 100.
7) Percentage of total actual waveform packets that is:
    - long waveform data (based on number of APID 12 packets read),
    - short waveform data (based on number of APID 13 packets read),
    - no signal acquired (from threshold crossing flag in APID 12) for long waveform data,
    - no signal acquired (from threshold crossing flag in APID 13) for short waveform data,
8) Granule statistics (Maximum, Minimum, Average, Standard Deviation, Number of Points) for:
    - transmit peak location,
    - difference between last and next to last threshold crossing locations of the received waveform,
    - background mean for 4 ns filter,
    - background standard deviation for each filter,
    - 4 ns filter peak value,
    - peak value for each filter (based on when filters are selected by on-board algorithm),

- 1064 nm laser transmit energy,
- 1064 nm laser received energy,
- time between each shot, and
- A/D receiver gain setting.

9) Once per 16 second statistics (Maximum, Minimum, Average) for:
   - 1064 nm laser transmit energy,
   - 1064 nm laser received energy,
   - peak value for selected filter, and
   - difference between last and next to last threshold crossing locations of the received waveform.
10) Track the number of times each filter is selected for long waveform data (where signal is detected) over the period of the granule.
11) Track the number of times each filter is selected for short waveform data (where signal is detected) over the period of the granule.
12) Compute the average filter number and average surface type over 16 seconds (it can be a fraction) over the time of the granule. Set a flag indicating during the 16 seconds, whether the waveform type is predominately long or short.

2.2.2 Atmosphere Product (GLA02)

1) Expected number of photon counter packets (APID 15)
2) Actual number of photon counter packets (APID 15)
3) Percentage missing photon counter packets (APID 15)
4) Expected number of cloud digitizer packets (APID 17)
5) Actual number of cloud digitizer packets (APID 17)
6) Percentage missing cloud digitizer packets (APID 17)
7) Expected number of ancillary science packets (APID 19)
8) Actual number of ancillary science packets (APID 19)
9) Percentage missing ancillary science packets (APID 19)
10) Percentage saturated bins for 10 to -1 km profile
11) Percentage saturated bins for 20 to 10 km profile
12) Percentage saturated bins for 40 to 20 km profile
13) Granule statistics (Maximum, Minimum, Average, Number of Points) for:

- 532 nm laser transmit energy at 40 Hz,
- 1064 nm laser transmit energy at 40 Hz,

- 532 nm Backgrounds (4) at 40 Hz,
- 1064 nm Backgrounds (4) at 40 Hz,
- Cloud Return Peak Signal,
- Ground Return Peak Signal,
- Ground Return Peak location, and
- Dual Pin A / 532 transmit energy at 40 Hz.

14) Average 532 integrated return over 16 seconds.
15) Number of 532 laser transmit energy values at 40 Hz from 0 to 10 mJ
16) Number of 532 laser transmit energy values at 40 Hz from 10 to 20 mJ
17) Number of 532 laser transmit energy values at 40 Hz from 20 to 30 mJ
18) Number of 532 laser transmit energy values at 40 Hz from 30 to 40 mJ
19) Number of 532 laser transmit energy values at 40 Hz from above 40 mJ
20) Number of 1064 laser transmit energy values at 40 Hz from 0 to 10 mJ
21) Number of 1064 laser transmit energy values at 40 Hz from 10 to 20 mJ
22) Number of 1064 laser transmit energy values at 40 Hz from 20 to 30 mJ
23) Number of 1064 laser transmit energy values at 40 Hz from 30 to 40 mJ
24) Number of 1064 laser transmit energy values at 40 Hz from above 40 mJ

2.2.3 Engineering Data Product (GLA03)

1) Expected number of records per APID (for all APIDs) based on time.
2) Actual number of records per APID based on number read for each APID.
3) Percentage missing data per APID: [1-(item 2 / item 1)] * 100.
4) Change in instrument configuration and time of change.
5) Final instrument configuration.
6) Granule statistics (Maximum, Minimum, Average, Standard Deviation, Number of points, Number of Times Out of Limits) for each temperature, voltage, and current.
7) Once per hour (3600 seconds) statistics (Maximum, Minimum, Average, Standard Deviation, Number of Points) for each temperature, voltage and current.
8) For each status indicator over the granule, compute number of times status changed, and final status.
9) Granule statistics (Maximum, Minimum, Average, Standard Deviation, Number of Points) for:

- the difference between the laser fire command time and the laser fire acknowledge time,
- the difference between the spacecraft time (BVTCW) of the spacecraft time and position packet and the GLAS MET of the spacecraft time and position packet,
- sum of Post-Delay pulse waveform bin values (32 bins); average and standard deviation only,
- the peak of the Post-Delay Laser pulse,
- the pulse width of the Post-Delay Laser pulse,
- the peak of the four OTS laser pulse, and
- the pulse width of the four OTS laser pulses.

10) Etalon tuning QA - TBD

2.2.4 Global Stellar Reference and Global Positioning System Data Product (GLA04)

1) Expected number of records of LPA data (APID 26) based on time.
2) Actual number of records of LPA data based on number read.
3) Percentage missing LPA data: [1-(item 2 / item 1)] * 100.
4) Expected number of records of PRAP data (APID 1984) based on time.
5) Actual number of records of PRAP data based on number read.
6) Percentage missing PRAP data: [1-(item 5 / item 4)] * 100.
7) For the LPA data, store the following data to arrays:
   - Computed centroid location statistics over 60 seconds (Maximum, Minimum, Average, Number of Points).
   - Area above noise of Transmit waveform statistics over 60 seconds (Maximum, Minimum, Average, Number of Points). Noise = 30 counts; area is equivalent to sum of data from each bin (48) where data is greater than 30 counts. Note: Subtract off the 30 counts of noise prior to summing the data.
   - Time of Transmit waveform peak statistics over 60 seconds (Maximum, Minimum, Average, Number of Points).
   - Sample time: time of first shot in the first and last frames included in the average. These will be the only times stored in the along-track record.
8) For the LPA data for each granule, store:
   - First and last LPA 20x20 image.
   - Mean and standard deviation of the LPA 20x20 image.

9) For the first valid star for each virtual tracker in the LRS data, store the following data to arrays:
   - Encircled energy statistics over 60 seconds (Maximum, Minimum, Average, Number of Points).
   - Background bias statistics over 60 seconds (Maximum, Minimum, Average, Number of Points).
   - Centroid row statistics over 60 seconds (Maximum, Minimum, Average, Number of Points).
   - Centroid column statistics over 60 seconds (Maximum, Minimum, Average, Number of Points).
   - Sample time: time of first shot in the first and last frames included in the average. These will be the only times stored in the along-track record.
10) First and last valid LRS laser images of the granule with the start and end times of the record in which they occur.
11) For the LRS data, collect once per granule data for:
   - Number of points processed
   - Number of shot numbers that are zero
   - Number of messages incomplete
   - Number of time tag rollovers
   - Number of valid and invalid stars by tracker: star, laser, and CRS.
   - Number of stars by star tracker by magnitude from 0 to 6.3 with .5 magnitude categories.
   - For each valid virtual tracker for the laser and CRS (Maximum, Minimum, Mean, Standard Deviation, and Number of Points): Encircled energy, Background bias, Centroid row, and Centroid column
   - CCD temperature (Minimum, Maximum, Mean, Standard Deviation, and Number of Points)
   - Lens Cell temperature (Minimum, Maximum, Mean, Standard Deviation, and Number of Points)
12) Once per 60 seconds statistics (Maximum, Minimum, Mean, Standard Deviation, Number of points) on each valid Gyro's (A, B, C, D) integrated angle data. Also report the number of invalid integrated angles for each Gyro.
13) For the first valid star for each virtual tracker in the Instrument Star Tracker (IST) data, store the following data to arrays at 60 second intervals:
   - Sample time
   - Encircled energy

- Background bias
- Star magnitude
- Boresight H
- Boresight V

14) For the Instrument Star Tracker (IST) data, collect the once per granule data for:
    - Number of points processed
    - Number of shot numbers that are zero
    - Number of messages incomplete
    - Number of time tag rollovers
    - Number of valid and invalid stars by tracker: star, laser, and CRS.
    - Number of stars by magnitude from 0 to 6.3 with .5 magnitude categories.
    - CCD temperature (Minimum, Maximum, Mean)
    - Lens Cell temperature (Minimum, Maximum, Mean)
15) For the first valid star for each virtual tracker in the Ball Star Tracker (BST) data (two BSTs), store the following data to arrays at 60 second intervals:
    - Sample time
    - Star position X and Y
    - Star intensity
16) For both BSTs, collect once per granule data of:
    - Number of points processed
    - Number of commands received and rejected
    - For each tracker, the number of stars by magnitude from 0 to 6.3 with .5 magnitude categories.
    - CCD temperature (Minimum, Maximum, Mean)
    - Lens Cell temperature (Minimum, Maximum, Mean)
    - +8 Volt supply voltage (Minimum, Maximum, Mean)
    - Background reading (Minimum, Maximum, Mean)
17) For the spacecraft data, for the first valid point, store the following data to arrays at 60 second intervals:
    - Sample time
    - Solar array 1 position
    - Solar array 2 position

- Solar Array 1 autonomous flag
- Solar Array 2 autonomous flag
- Quaternions 1 through 4

18) For the spacecraft data, compute for the granule:
    - Number of times solar array 1 is in fixed position and total time in fixed position
    - Number of times solar array 2 is in fixed position and total time in fixed position
    - Number of times solar arrays are in fixed position simultaneously and total time in fixed position
    - Number of times GPS time changes

2.3 Browse Products

This section defines the browse products for the Level 1A granules.

2.3.1 Altimetry Product (GLA01)

1) Table (for the granule) showing:
- percent missing waveform packets,
- percent missing ancillary science packets,
- percent data is long waveform data,
- percent data is short waveform data,
- percent of long waveform data where no signal was acquired, and
- percent of short waveform data where no signal was acquired.

2) Statistics table (for the granule) which includes the Maximum, Minimum, Average, Standard Deviation, and Number of Points for:
    - transmit peak location,
    - sum of transmit waveform bins (average and standard deviation only),
    - difference between last and next to last threshold crossing locations,
    - background mean for 4 ns filter,
    - background standard deviation for each filter,
    - 4 ns filter peak value,
    - peak value for each filter (based on when filters are selected by on-board algorithm),
    - 1064 nm laser transmit energy,
    - 1064 nm laser received energy,

- time between each shot, and
- A/D receiver gain setting.

3) Color coded plot of the ground track, with colors indicating whether the flight algorithms selected long or short waveforms for a location,
4) Histogram of 1064 nm laser transmit energy averaged n per second,
5) Histogram of 1064 nm laser received energy averaged n per second,
6) Histogram of the received waveform average peak value per selected filter per second,
7) Histogram of the difference between last and next to last threshold crossing locations averaged n per second,
8) Color coded plot of the ground track, with colors indicating the average selected filter number for a location,
9) Color coded plot of the ground track, with colors indicating the average transmitted and received energy for a location,
10) Histogram of the long waveform data selected filter numbers, and
11) Histogram of the short waveform data selected filter numbers.

2.3.2 Atmosphere Product (GLA02)

1) Table (for the granule) showing:

- percent missing photon counter packets,
- percent missing cloud digitizer packets,
- percent missing ancillary science packets,
- percentage of saturated bins for the 10 to -1 km profile,
- percentage of saturated bins for the 20 to 10 km profile, and
- percentage of saturated bins for the 40 to 20 km profile.

2) Statistics table (for the granule) which includes the Maximum, Minimum, Average, and Number of Points for:
   - 532 laser transmit energy at 40 Hz,
   - 1064 laser transmit energy at 40 Hz,
   - 532 backgrounds (4) at 40 Hz,
   - 1064 backgrounds (4) at 40 Hz,
   - cloud return peak signal,
   - ground return peak signal,
   - ground return peak location, and
   - Dual pin A /532 transmit energy at 40 Hz.

3) Color coded plot of the ground track, with colors indicating 532 integrated return value for a location
4) Histograms of 532 and 1064 transmit energy

- Number of 532 laser transmit energy values at 40 Hz from 0 to 10 mJ,
- Number of 532 laser transmit energy values at 40 Hz from 10 to 20 mJ,
- Number of 532 laser transmit energy values at 40 Hz from 20 to 30 mJ,
- Number of 532 laser transmit energy values at 40 Hz from 30 to 40 mJ,
- Number of 532 laser transmit energy values at 40 Hz from above 40 mJ,
- Number of 1064 laser transmit energy values at 40 Hz from 0 to 10 mJ,
- Number of 1064 laser transmit energy values at 40 Hz from 10 to 20 mJ,
- Number of 1064 laser transmit energy values at 40 Hz from 20 to 30 mJ,
- Number of 1064 laser transmit energy values at 40 Hz from 30 to 40 mJ, and
- Number of 1064 laser transmit energy values at 40 Hz from above 40 mJ.

2.3.3 Engineering Data Product (GLA03)

1) Plots of average temperatures per hour,
2) Plots of average voltages per hour,
3) Plots of average currents per hour,
4) Table of operating laser, detector, digitizer, oscillator and time instrument configuration changed during granule,
5) Table of granule statistics, and
6) Etalon tuning - TBD.

2.3.4 Global Stellar Reference and Global Positioning System Data Product (GLA04)

1) Table and bar chart (for the granule) showing:
   - Percentage and number missing LPA data.
   - Percentage and number missing PRAP data.
2) Statistics table/bar chart (for the granule) which includes:
   - LRS CCD temperature (Minimum, Maximum, Mean)
   - LRS Lens Cell temperature (Minimum, Maximum, Mean)
   - IST CCD temperature (Minimum, Maximum, Mean)
   - IST Lens Cell temperature (Minimum, Maximum, Mean)
   - BST1 and BST2 CCD temperature (Minimum, Maximum, Mean)
   - BST1 and BST2 Lens Cell temperature (Minimum, Maximum, Mean)

  - BST1 and BST2 +8 Volt supply voltage (Minimum, Maximum, Mean)
  - BST1 and BST2 Background reading (Minimum, Maximum, Mean)
  - Mean and standard deviation of the LPA 20x20 images

3) Star magnitude histogram for the LRS, IST, BST1, and BST2 indicating for each tracker, the number of stars by magnitude from 0 to 6.3 with .5 magnitude categories.
4) First and last laser and LPA images in the granule. The SRS images in the granule cannot be tied unequivocally to a shot or frame number. Instead, the first and last good images in the granule should be labelled with the times of the first and last shots in the frames in which they are found.
5) Number of times solar array 1 is in fixed position and total time in fixed position for the granule.
6) Number of times solar array 2 is in fixed position and total time in fixed position for the granule.
7) Number of times solar arrays are in fixed position simultaneously and total time in fixed position for the granule.
8) Number of times GPS time changes for the granule.
9) Color coded plots of the granule timeline, with colors indicating when Solar Array 1 autonomous flag is set to auto (1) or off (0).
10) Color coded plots of the granule timeline, with colors indicating when Solar Array 2 autonomous flag is set to auto (1) or off (0).
11) Histograms of:
    - Computed centroid location
    - Area above noise of Transmit waveform.
    - Time of Transmit waveform peak.

Section 3

Implementation Considerations

The GLAS data level 1A conversion does not require any complicated or interactive processing. The data rate is 500 kbps.

3.1 Standards

The GLAS Level 1A algorithm implementation will follow the software development process defined in the *GLAS Science Software Management Plan* listed in Section 5.

3.2 Ancillary Inputs

3.2.1 Predict (Operational) orbit

The best available orbit predicts will be used to append location to the level 1 A data. No corrections will be applied to the data based on the predicted location data. This position data will be replaced on higher level products with the precision orbit data. The predicted location will be used to help with the QA and any quick look analysis of the GLAS data.

3.2.2 GLAS Coefficients and Constants File

Provides the coefficients and constants that are subject to modification based on: pre-flight testing, on-orbit performance, or electronic component aging. To avoid creating and delivering new versions of software due to changes in operating parameters, the GLAS Coefficients and Constants File provides a location to store those software parameters.

Include in the GLAS Coefficients and Constants File, the QA statistical sampling rate in seconds for each L1A product. Therefore, if the sampling rates are modified, the L1A Code will not have to be changed. A CR will be written to update this ATBD and the value(s) in the GLAS Coefficients and Constants File.

3.3 Accuracy

All level 1A data conversions will be designed to meet the accuracy of the science requirements. Where the capability to invert from the level 1A data back to the level 0 raw counts is needed, there will not be any loss of accuracy. GLAS measurement capabilities will not be degraded during the creation of the level 1A product.

3.4 Computational: CPU and Disk Storage

GLAS level 1A processing can be done easily within the capabilities of a large work-station. A processing load has been estimated by using the TOPEX Radar Altimeter SDR processing resources and scaling them by the ratio of the data rate. This is considered to be a worst case analysis. Disk storage space has been estimated based on the design of the level 1A data product.

3.5 Software Validation

The validation of the software will be from processing known data from the GLAS instrument testing or the GLAS simulator into a level 1 A product. This product will be compared to the GLAS Instrument team results from ground testing or simulator outputs.

QA processes to automatically provide data product quality information are defined in Section 2.

Section 4

Constraints, Limitations, and Assumptions

4.1 Constraints and Limitations

The following is a list of the constraints and limitations that will exist on this algorithm.

1) The GLAS level 1A data products should be ready within 24 hours of the availability of the level 0.
2) The implementation of this algorithm will follow the software development life cycle described in the *GLAS Science Software Management Plan*, listed in the Bibliography in Section 6.
3) The Engineering Data Product (GLA03) should be produced first since data on that product may be used to further correct or calibrate the altimeter or lidar data.

4.2 Assumptions

The following are assumptions made for the definition, development and use of this algorithm.

1) Level 0 data will be time ordered and contain no duplicate data.
2) GLAS instrument data will be within the ground tested limits for the data to be valid. However, checks will be made on the data and flags set indicating data anomalies.

Section 5

Bibliography

1) *GLAS Level 0 Instrument Data product Specification,* Version 2.2, March 1998, NASA Goddard Space Flight Center, Wallops Flight Facility.
2) *GLAS Standard Data Products Specification - Level 1*, Version 2.0, December 1998, NASA Goddard Space Flight Center, Wallops Flight Facility.
3) *GLAS Science Software Management Plan*, Version 3.0, August 1998, NASA Goddard Space Flight Center, Wallops Flight Facility.
4) *GLAS Science Data Management Plan* (GLAS SDMP), Version 4.0, June 1999, NASA Goddard Space Flight Center Wallops Flight Facility, GLAS-DMP-1200.
5) *NASA Earth Observing System Geoscience Laser Altimeter System GLAS Science Requirements Document,* Version 2.01, October 1997, Center for Space Research, University of Texas at Austin.
6) *GLAS Atmospheric Data Products ATBD*, Version 3.0, July 1999, NASA Goddard Space Flight Center.
7) *ICESat Observatory Timing and Event Time Reconstruction*, Rev. G, February 2001
8) *I-SIPS Version 2 Delivery Package*, TBD
9) *Data Interface Control Document between the ICESat Spacecraft and the EOS Ground System (EGS)*, TBD

Appendix A
Conversion Tables

A.1 Conversion Description for Each APID

Table A-1 "Conversion Description for GLAS Telemetry Data" lists each telemetry value for all the GLAS APIDs, the conversion type, the conversion description, resulting units, and destination L1A product ID. The conversion type can be

- Interpretation (I)- Evaluates the values of a bit or bits in a telemetry word to determine the value. All flags and status words are assumed to be converted in this manner. The description of the bit values is in the Conversion Description column;
- Polynomial (P)- A polynomial equation for the conversion from raw counts to engineering units. The polynomial equation looks like:
  Y = A + B*(X) + C*(X**2) +...
  where
  Y is the resulting instrument value in engineering units
  X is the raw instrument value in counts
  and A, B, C,... are the polynomial coefficients.

  In the tables the coefficients are listed in the order A, B, C... in the Coefficient Description column;
- Multi-variable (M) - the conversion for a raw telemetry value requires additional telemetry values (raw or in engineering units), such as temperatures or voltages. Depending on the complexity of the algorithm, the Conversion Description column will include the algorithm or will reference another section containing the algorithm;
- Table-lookup (T) - Using the raw counts as an index to a table, the converted value is obtained;
- Geophysical (G) -;
- None (N) - No conversion is required; and
- Unknown (U) - the conversion algorithm is currently unknown or not documented.

A.2 Telemetry Pseudo Engineering Unit Conversion

Several more complicated conversion equations and conversion equations that are based on telemetered calibration values are titled by the flight software team to be Pseudo equations. These equations are defined in Table A-2 "Pseudo-Telemetry Conversions". Table A-1 references the appropriate equation by the equation number. In

Table A-1 Conversion Description for GLAS Telemetry Data

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
ALL	Primary Header	I			GLA03
ALL	Secondary Header (time stamp)	U			GLA03
20	LMB Laser 1 Reference Temperature	P	-33.84,5.368E-1, -1.622E-5,3.155E-6	Deg C	GLA03
20	Laser 1 Doubler Temperature	P	20.84,1.032E-1, -2.879E-5,1.446E-7	Deg C	GLA03
20	Laser 1 Oscillator Temperature	P	20.84,1.032E-1, -2.879E-5,1.446E-7	Deg C	GLA03
20	Laser 1 Electronics Temperature (MEU)	P	-33.84,5.368E-1, -1.622E-5,3.155E-6	Deg C	GLA03
20	LMB Laser 2 Reference Temperature	P	-33.84,5.368E-1, -1.622E-5,3.155E-6	Deg C	GLA03
20	Laser 2 Doubler Temperature	P	20.84,1.032E-1, -2.879E-5,1.446E-7	Deg C	GLA03
20	Laser 2 Oscillator Temperature	P	20.84,1.032E-1, -2.879E-5,1.446E-7	Deg C	GLA03
20	Laser 2 Electronics Temperature (MEU)	P	-33.84,5.368E-1, -1.622E-5,3.155E-6	Deg C	GLA03
20	LMB Laser 3 Reference Temperature	P	-33.84,5.368E-1, -1.622E-5,3.155E-6	Deg C	GLA03
20	Laser 3 Doubler Temperature	P	20.84,1.032E-1, -2.879E-5,1.446E-7	Deg C	GLA03
20	Laser 3 Oscillator Temperature	P	20.84,1.032E-1, -2.879E-5,1.446E-7	Deg C	GLA03
20	Laser 3 Electronics Temperature (MEU)	P	-33.84,5.368E-1, -1.622E-5,3.155E-6	Deg C	GLA03
20	Laser Osc Current	M	1.898 + 0.4878*(Laser Osc Current counts) - 1.406E-2*(Laser Monitor Board Temperature counts)	Amps	GLA03
20	Laser Amp Current	M	2.062 + 0.4865*(Laser Amp Current counts) - 1.406E-2*(Laser Monitor Board Temperature counts)	Amps	GLA03
20	Laser Dr Pulse Width	P	131.08,0.512	pulse width in usec	GLA03
50	OTS Level 1 readback	P	40, -0.15625	micro Amps	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
50	OTS Level 2 readback	P	40, -0.15625	micro Amps	GLA03
50	OTS Level 3 readback	P	40, -0.15625	micro Amps	GLA03
50	OTS Level 4 readback	P	40, -0.15625	micro Amps	GLA03
50	OTS Trigger Count 1 readback	P	0.0,0.256	micro-sec-onds	GLA03
50	OTS Trigger Count 2 readback	P	0.0,0.256	micro-sec-onds	GLA03
20	AD Detector Outgoing Gain read-back	P	-1, 0.0078125	Volts	GLA03
20	AD Detector Return Gain readback	P	-1, 0.0078125	Volts	GLA03
20	Laser and OTS Enable readbacks	I	See Section A.3	n/a	GLA03
20	Dual Pin A	M	0.5609 + 0.3823*(Dual Pin A counts) + 3.848E-5*(Dual Pin A counts^2) - 5.737E-3*(Laser Monitor Board Tem-perature counts)	%	GLA03
20	Dual Pin B	M	1.108 + 0.4143*(Dual Pin B counts) -8.671E-5*(Dual Pin B counts^2) - 1.159E-3*(Laser Monitor Board Tem-perature counts)	%	GLA03
20	532 Energy	M	-0.969 + 0.4095*(532 Energy counts) -6.601E-5*(532 Energy counts^2) + 8.765E-3*(Laser Monitor Board Tem-perature counts)	%	GLA03
20	Primary Altimeter Detector 550 V	P	0.0, 3.581	Volts	GLA03
20	Secondary Altimeter Detector 550 V	P	0.0, 3.581	Volts	GLA03
20	SPCM Detector #1 550 V	P	0.0, 3.581	Volts	GLA03
20	SPCM Detector #2 550 V	P	0.0, 3.581	Volts	GLA03
20	SPCM Detector #3 550 V	P	0.0, 3.581	Volts	GLA03
20	SPCM Detector #4 550 V	P	0.0, 3.581	Volts	GLA03
20	SPCM Detector #5 550 V	P	0.0, 3.581	Volts	GLA03
20	SPCM Detector #6 550 V	P	0.0, 3.581	Volts	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
20	SPCM Detector #7 550 V	P	0.0, 3.581	Volts	GLA03
20	SPCM Detector #8 550 V	P	0.0, 3.581	Volts	GLA03
20	Internal Temp #1	P	- 50.0, 0.781	Deg C	GLA03
20	C&T Positive Rail	P	9.0, 0.031	Volts	GLA03
20	Internal Temp #3	P	-50.0, 0.781	Deg C	GLA03
20	VC Motor Current	P	-100.0, 0.048828125	mAmps	GLA03
20	VC Motor Current	P	-100.0, 0.048828125	mAmps	GLA03
20	X Position	P	-10.0, 0.0048828125	Volts	GLA03
20	Y Position	P	-10.0, 0.0048828125	Volts	GLA03
21	Primary Monitor Calibration, Upper Byte	M	Pseudo Telemetry Eqn 7		GLA03
21	Primary Monitor Calibration, Lower Byte	M	Pseudo Telemetry Eqn 7/8		GLA03
21	+28V Bus A Instrument Voltage	M	Pseudo Telemetry Eqn 9	Volts	GLA03
21	Hybrid Supplies Current	M	Pseudo Telemetry Eqn 10	Amps	GLA03
21	HVPS Detector Supplies Current	M	Pseudo Telemetry Eqn 11	Amps	GLA03
21	Operational Heaters Current	M	Pseudo Telemetry Eqn 12	Amps	GLA03
21	Mechanical System Current	M	Pseudo Telemetry Eqn 13	Amps	GLA03
21	+28V Bus B Laser 1 Voltage	M	Pseudo Telemetry Eqn 14	Volts	GLA03
21	+28V Bus B Laser 1 Current	M	Pseudo Telemetry Eqn 15	Amps	GLA03
21	+28V Bus C Laser 2 Voltage	M	Pseudo Telemetry Eqn 16	Volts	GLA03
21	+28V Bus C Laser 2 Current	M	Pseudo Telemetry Eqn 17	Amps	GLA03
21	+28V Bus D Laser 3 Voltage	M	Pseudo Telemetry Eqn 18	Volts	GLA03
21	+28V Bus D Laser 3 Current	M	Pseudo Telemetry Eqn 19	Amps	GLA03
21	Secondary Monitor Calibration, Upper Byte	M	Pseudo Telemetry Eqn 20	n/a	GLA03
21	Secondary Monitor Calibration, Lower Byte	M	Pseudo Telemetry Eqn 20/21	n/a	GLA03
21	+ 5 V Hybrid # 1 Voltage	M	Pseudo Telemetry Eqn 22	Volts	GLA03
21	+ 5 V Hybrid # 1 Current	M	Pseudo Telemetry Eqn 23	Amps	GLA03
21	+12 V Hybrid # 2 Voltage	M	Pseudo Telemetry Eqn 24	Volts	GLA03
21	+ 12 V Hybrid # 2 Current	M	Pseudo Telemetry Eqn 25	Amps	GLA03
21	- 12 V Hybrid # 3 Voltage	M	Pseudo Telemetry Eqn 26	Volts	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
21	- 12 V Hybrid # 3 Current	M	Pseudo Telemetry Eqn 27	Amps	GLA03
21	+ 5 V Hybrid # 4 Voltage	M	Pseudo Telemetry Eqn 28	Volts	GLA03
21	+ 5 V Hybrid # 4 Current	M	Pseudo Telemetry Eqn 29	Amps	GLA03
21	- 5 V Hybrid # 5 Voltage	M	Pseudo Telemetry Eqn 30	Volts	GLA03
21	- 5 V Hybrid # 5 Current	M	Pseudo Telemetry Eqn 31	Amps	GLA03
21	- 5 V Hybrid # 6 Voltage	M	Pseudo Telemetry Eqn 32	Volts	GLA03
21	- 5 V Hybrid # 6 Current	M	Pseudo Telemetry Eqn 33	Amps	GLA03
21	+ 15 V Boost Post Register Voltage	M	Pseudo Telemetry Eqn 34	Volts	GLA03
21	- 15 V Boost Post Register Voltage	M	Pseudo Telemetry Eqn 35	Volts	GLA03
21	+12 V Prim Osc Thermal Control Current	M	Pseudo Telemetry Eqn 36	Amps	GLA03
21	+12 V Sec Osc Thermal Control Current	M	Pseudo Telemetry Eqn 37	Amps	GLA03
21	-2 V Discrete Voltage	M	Pseudo Telemetry Eqn 38	Volts	GLA03
21	Hybrid Heatsink Temperature	M	Pseudo Telemetry Eqn 39	Deg C	GLA03
21	FET Switch Bank Heatsink Temperature	M	Pseudo Telemetry Eqn 40	Deg C	GLA03
21	FET Switch Bank	I	See Section A.4	n/a	GLA03
21	HVPS +0 Volts Reference	P	0.0, 0.026	Volts	GLA03
21	HVPS +5 V Reference	P	0.0, 0.052	Volts	GLA03
21	MCS Mux Counter (4-bits)	N		Counts	GLA03
21	Optical Sensor Status	I	See Section A.5	n/a	GLA03
21	Status Cmd Telemetry	I	See Section A.6	n/a	GLA03
22	Housekeeping Board Temperature	P	-20.4, 0.3984	Deg C	GLA03
22	Instrument Processor System Board Temperature	P	-23.5, 0.3984	Deg C	GLA03
22	Photon Counter Board Temperature	P	-21.6, 0.3984	Deg C	GLA03
22	Cloud Digitizer/Frequency & Time Board Temperature	P	-21.6, 0.3984	Deg C	GLA03
22	Altimeter Digitizer 1 DSP Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	Altimeter Digitizer 2 DSP Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	Data Collection & Handling Board Temp	P	-20.7, 0.3984	Deg C	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
22	Laser Monitor Board Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	Temperature Controller Monitor Board Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	Oven-crystal-controlled Oscillator (OXCO)1 Board Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	OXCO 2 Board Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	Oscillator Board Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	OTS Board Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	LPA Temperature 1	P	-21.0, 0.3984	Deg C	GLA03
22	LPA Temperature 2	P	-21.0, 0.3984	Deg C	GLA03
22	AD 1 ECLA Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	AD 2 ECLA Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	AD 1 ECLB Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	AD 2 ECLB Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	AD 1 ADC Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	AD 2 ADC Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	SPCM Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Telescope Mount Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Telescope Baffle Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	AD 1 Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	AD 2 Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Face 1 LTR to SRS Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Face 2 LTR to SRS Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Fiber Delay Line Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Fiber Box Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Face 1 Fold Around Bench Temper-ature	P	-18.113, 0.3083	Deg C	GLA03
22	Face 2 Fold Around Bench Temper-ature	P	-18.113, 0.3083	Deg C	GLA03
22	Face 1 LTR CRS Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	Face 2 LTR CRS Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	SRS Parabola Temperature	P	-18.113, 0.3083	Deg C	GLA03
22	PRT Cal Low	P	-18.113, 0.3083	Deg C	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
22	PRT Cal High	P	-18.113, 0.3083	Deg C	GLA03
22	Pin Diode Bias Voltage	P	0,0.2949	Volts	GLA03
22	AD1 High Speed Ram Temperature	P	-21.0, 0.3984	Deg C	GLA03
22	Spares	N		n/a	GLA03
23	Laser Select Mechanism 1 Temperature	P	-1456.13,0.5664055703	Deg C	GLA03
23	Laser Select Mechanism 2 Temperature	P	-1456.13,0.5664055703	Deg C	GLA03
23	Altimeter Digitizer Select Mechanism Temperature	P	-1456.13,0.5664055703	Deg C	GLA03
23	Laser Beam Select Mechanism Electronics Temperature	P	-1456.13,0.5664055703	Deg C	GLA03
23	Laser Beam Select Mechanism Mirror Temperature	P	-1456.13,0.5664055703	Deg C	GLA03
23	HOP1 Actuator Current - Heater 1	P	-2.0,976.5625E-6	Amps	GLA03
23	HOP1 Actuator Current - Heater 2	P	-2.0,976.5625E-6	Amps	GLA03
23	HOP2 Actuator Current - Heater 1	P	-2.0,976.5625E-6	Amps	GLA03
23	HOP2 Actuator Current - Heater 2	P	-2.0,976.5625E-6	Amps	GLA03
23	HOP3 Actuator Current - Heater 1	P	-2.0,976.5625E-6	Amps	GLA03
23	HOP3 Actuator Current - Heater 2	P	-2.0,976.5625E-6	Amps	GLA03
23	LHP 1 and 2 Heater Status	I	LHP 1 Heater Status, Mask=0x01, 0=Off, 1=On; LHP 2 Heater Status, Mask=0x02, 0=Off, 1=On	n/a	GLA03
23	Telescope Prim Mirror Heater Enable Readback	I	0=Disabled, 0xFF=Enabled	n/a	GLA03
23	Telescope Prim Mirror Heater Temp Setpoint Readback	P	0.1586, 0.1027, -4.253E-05, 3.833E-07	Deg C	GLA03
23	spares	N		n/a	GLA03
23	Telescope Tower Heater Enable Readback	I	0=Disabled, 0xFF=Enabled	n/a	GLA03
23	Telescope Tower Heater Temp Setpoint Readback	P	0.1392, 0.104, -5.962E-05, 4.304E-07	Deg C	GLA03
23	Etalon Heater Enable Readback	I	0=Disabled, 0xFF=Enabled	n/a	GLA03
23	Etalon Heater Temp Setpoint Readback	P	29.27, 0.09251, 9.919E-06, 1.022E-07	Deg C	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
23	LHP 1 Enable Readback	I	0=Disabled, 0xFF=Enabled	n/a	GLA03
23	LHP 1 Temp Setpoint Readback	P	0.02609, 0.1173, -6.871E-05, 2.629E-07	Deg C	GLA03
23	LHP 2 Enable Readback	I	0=Disabled, 0xFF=Enabled	n/a	GLA03
23	LHP 2 Temp Setpoint Readback	P	-7.696, 0.11, -5.1E-05, 2.007E-07	Deg C	GLA03
23	Thermistor Select - Tscope Prim Mirror - Status Readback	I	0=Thermistor 1, 0xFF=Thermistor 2	n/a	GLA03
23	Thermistor Select - Tscope Sec Mirror - Status Readback	I	0=Thermistor 1, 0xFF=Thermistor 2	n/a	GLA03
23	Thermistor Select Tscope Sec Support Structure Status Readback	I	0=Thermistor 1, 0xFF=Thermistor 2	n/a	GLA03
23	Thermistor Select LHP1(lasers) Status Readback	I	0=Thermistor 1, 0xFF=Thermistor 2	n/a	GLA03
23	Thermistor Select LHP2(rest of instrument) Status Readback	I	0=Thermistor 1, 0xFF=Thermistor 2	n/a	GLA03
23	Thermistor Select Etalon Status Readback	I	0=Thermistor 1, 0xFF=Thermistor 2	n/a	GLA03
23	Spare	N		n/a	GLA03
50	Telescope Primary Mirror Temperature	P	0.1586, 0.1027, -4.253E-05, 3.833E-07	Deg C	GLA03
50	Telescope Secondary Mirror Temperature	P	0.02506,0.1051, -6.469E-05,4.376E-07	Deg C	GLA03
50	Telescope Tower Temperature	P	0.1392, 0.104, -5.962E-05, 4.304E-07	Deg C	GLA03
50	Etalon Temperature	P	29.27, 0.09251, 9.919E-06, 1.022E-07	Deg C	GLA03
50	LHP 1 Temperature	P	0.02609, 0.1173, -6.871E-05, 2.629E-07	Deg C	GLA03
50	LHP 2 Temperature	P	-7.696, 0.11, -5.1E-05, 2.007E-07	Deg C	GLA03
50	Telescope Primary Mirror Heater drive current	P	0.0008, 0.003678	Amps	GLA03
50	Telescope Secondary Mirror Heater drive current	P	0.0008, 0.003113	Amps	GLA03
50	spares	N		n/a	GLA03
50	Etalon Drive Heater Current	P	1.35E-3, 0.003468	Amps	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
50	Delay Line All Temperature	P	-33.84, 0.5368, -1.622E-3, 3.155E-6	Deg C	GLA03
50	Delay Line Mid Temperature	P	-2.406, 0.06459, -7.58E-6, 5.591E-8	Deg C	GLA03
50	Delay Line Hi Temperature	P	13.33, 0.06518, -5.261E-6, 4.076E-8	Deg C	GLA03
50	Spares	N		n/a	GLA03
24	HS Task Cmd Processed Counter	N		n/a	GLA03
24	HS Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	CS Task Cmd Processed Counter	N		n/a	GLA03
24	CS Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	TC Task Cmd Processed Counter	N		n/a	GLA03
24	TC Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	SB Task Cmd Processed Counter	N		n/a	GLA03
24	SB Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	SM Task Cmd Processed Counter	N		n/a	GLA03
24	SM Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	RT Task Cmd Processed Counter	N		n/a	GLA03
24	RT Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	RT Task RCH3 (SA22-25, CSA 26) Commands Received	N		n/a	GLA03
24	RT Task RCH3 (SA22-25, CSA 26) Commands Rejected	N		n/a	GLA03
24	MD Task Cmd Processed Counter	N		n/a	GLA03
24	MD Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	AD Task Cmd Processed Counter	N		n/a	GLA03
24	AD Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	AD Target Status and Mode Flags	I	See Section A.30	n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
24	CD Task CMD Processed Counter	N		n/a	GLA03
24	CD Task CMD Rejected (or Error) Counter	N		n/a	GLA03
24	CD Status Flags	I	See Section A.7	n/a	GLA03
24	DC Task Cmd Processed Counter	N		n/a	GLA03
24	DC Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	DC Status flag	I	See Section A.8	n/a	GLA03
24	GP Task Cmd Processed Counter	N		n/a	GLA03
24	GP Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	GP Status Bits	I	See Section A.25	n/a	GLA03
24	GP Spare	N		n/a	GLA03
24	PC Task Cmd Processed Counter	N		n/a	GLA03
24	PC Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	PC Status Flag	I	See Section A.9	n/a	GLA03
24	CT Task Cmd Processed Counter	N		n/a	GLA03
24	CT Task Cmd Rejected (or Error) Counter	N		n/a	GLA03
24	CT Task Mode	I	See Section A.10	n/a	GLA03
25	HS Processor Previous Mode	I	0,1,4=Unknown, 2=PROM, 3=EEPROM	n/a	GLA03
25	HS Processor Current Mode	I	0,1,4=Unknown, 2=PROM, 3=EEPROM	n/a	GLA03
25	Subsystem Present Flags	I	See Section A.11	n/a	GLA03
25	HS Warm Restart Count	N		n/a	GLA03
25	HS Cold Restart Count	N		n/a	GLA03
25	HS Max Warm Restart Count	N		n/a	GLA03
25	HS Cold-Warm Flag	N		n/a	GLA03
25	HS OS Caused Reset Flag	N		n/a	GLA03
25	HS OS Tick Count	N		n/a	GLA03
25	HS HS Exec Count	N		n/a	GLA03
25	HS CS Exec Count	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
25	HS TC Exec Count	N		n/a	GLA03
25	HS SB Exec Count	N		n/a	GLA03
25	HS SM Exec Count	N		n/a	GLA03
25	HS RT Exec Count	N		n/a	GLA03
25	HS MD Exec Count	N		n/a	GLA03
25	HS AD Exec Count	N		n/a	GLA03
25	HS CD Exec Count	N		n/a	GLA03
25	HS DC Exec Count	N		n/a	GLA03
25	HS GP Exec Count	N		n/a	GLA03
25	HS PC Exec Count	N		n/a	GLA03
25	HS CT Exec Count	N		n/a	GLA03
25	HS FPU Underflow Count	N		n/a	GLA03
25	HS Timer 2 ISR Count	N		n/a	GLA03
25	HS FP ISR Count	N		n/a	GLA03
25	HS TC Fire Cmd ISR Count	N		n/a	GLA03
25	HS RT ISR Count - Low Priority	N		n/a	GLA03
25	HS Spare ISR Count	N		n/a	GLA03
25	HS CT ISR Count	N		n/a	GLA03
25	HS PCI Initiator ISR Count	N		n/a	GLA03
25	HS GPS UART ISR Count	N		n/a	GLA03
25	HS GPS 10 Sec ISR Count	N		n/a	GLA03
25	HS DC ISR Count	N		n/a	GLA03
25	HS PC ISR Count	N		n/a	GLA03
25	HS WD ISR Count	N		n/a	GLA03
25	HS AD ISR Count	N		n/a	GLA03
25	HS CD ISR Count	N		n/a	GLA03
25	HS OS Event Sequence Number	N		n/a	GLA03
25	HS Peak CPU Utilization	N		n/a	GLA03
25	HS Last CPU Utilization	N		n/a	GLA03
25	HS OS PCI Bus Target Enable and Interrupt status	N		n/a	GLA03
25	HS OS Performance Log Enable Flag	I	0x01; 0=Disabled, 1=Enabled	n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
25	HS OS Performance Log Item Count	N		n/a	GLA03
25	HS OS Performance Log Filter Start Address	N		n/a	GLA03
25	HS OS Performance Log Filter Mask	N		n/a	GLA03
25	Spares	N		n/a	GLA03
25	CS Status Flags	I	See Section A.12	n/a	GLA03
25	CS Code Segment Error Count	N		n/a	GLA03
25	CS EEPROM Segment Error Count	N		n/a	GLA03
25	CS Table Ram Segment Error Count	N		n/a	GLA03
25	CS Table ID of last Code Error	N		n/a	GLA03
25	CS Table ID of last EEPROM Error	N		n/a	GLA03
25	CS Table ID of last Table RAM Error	N		n/a	GLA03
25	CS Code Segment Master Check-sum	N		n/a	GLA03
25	CS Table RAM Master Checksum	N		n/a	GLA03
25	CS EEPROM Master Checksum	N		n/a	GLA03
25	CS Checksum of EEPROM Boot Memory	N		n/a	GLA03
25	CS Checksum of EEPROM Memory	N		n/a	GLA03
25	CS Checksum of PROM Memory	N		n/a	GLA03
25	CS Spare	N		n/a	GLA03
25	TC GLAS MET Upper 2 bytes	U	0xFF0000		GLA03
25	TC GLAS MET Lower 4 bytes	U	0x00FFFF		GLA03
25	TC Fire Command Time Increment Upper 2 bytes	U			GLA03
25	TC Fire Command Time Increment Lower 4 bytes	U			GLA03
25	TC GLAS MET Working Time sec-onds	U			GLA03
25	TC GLAS MET Working Time micro-seconds	U			GLA03
25	Spare	N		n/a	GLA03
25	SB Send Error Count	N		n/a	GLA03
25	SB Receive Error Count	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
25	SB OS Error Count	N		n/a	GLA03
25	SB Queue Full Error Count	N		n/a	GLA03
25	SB Buffer overrun Error Count	N		n/a	GLA03
25	SB last buffer overrun - Stream Id	N		n/a	GLA03
25	SB last buffer overrun - Pipeline Id	N		n/a	GLA03
25	SB last buffer overrun - Sender Task ID	N		n/a	GLA03
25	SB last queue full - Stream Id	N		n/a	GLA03
25	SB last queue full - Pipeline Id	N		n/a	GLA03
25	SB last queue full - Sender Task ID	N		n/a	GLA03
25	SB Spare	N		n/a	GLA03
25	SM number of remaining copies to be dumped	N		n/a	GLA03
25	SM table/memory dump in progress flag	I	0=False, 1=True	n/a	GLA03
25	SM table operations flag	I	See Section A.13	n/a	GLA03
25	SM table operations from image type	I	0=None, 1=EEPROM, 2=RAM, 3=NULL	n/a	GLA03
25	SM table id selected	N		n/a	GLA03
25	SM currently selected table size in words	N		n/a	GLA03
25	SM currently selected table check-sum	N		n/a	GLA03
25	SM table commit success count	N		n/a	GLA03
25	SM table commit failure count	N		n/a	GLA03
25	SM table num. of words loaded	N		n/a	GLA03
25	SM FSW build number	N		n/a	GLA03
25	SM FSW version number	N		n/a	GLA03
25	SM spares	N		n/a	GLA03
25	BCRT CONTROL REGISTER WORD	I	See Section A.14	n/a	GLA03
25	BCRT Status Register	I	0=RT Mode Disabled, 1=RT Mode Enabled	n/a	GLA03
25	BCRT INTERRUPT STATUS REG-ISTER	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
25	RT 1553 MESSAGE ERRORS	N		n/a	GLA03
25	RT 1553 RETRY COUNT	N		n/a	GLA03
25	RT 1553 INVALID COMMANDS	N		n/a	GLA03
25	RT 1553 INVALID BROADCAST CMDS	N		n/a	GLA03
25	RT MODE CODES RECEIVED	N		n/a	GLA03
25	SPARE	N		n/a	GLA03
25	RT PACKETS RECEIVED ON RCH1	N		n/a	GLA03
25	RT PACKETS Rejected ON RCH1	N		n/a	GLA03
25	RT PACKETS SENT ON XCH1	N		n/a	GLA03
25	RT PACKETS SENT ON XCH2	N		n/a	GLA03
25	RT Number of Command History Packets Sent	N		n/a	GLA03
25	RT Checksum Status	I	0=Cmd CS Disabled, 1=Cmd CS Enabled	n/a	GLA03
25	Spares	N		n/a	GLA03
25	MD Enable/Disable Flag	I	See Section A.22	n/a	GLA03
25	MD Table 1 Address Count	N		n/a	GLA03
25	MD Table 2 Address Count	N		n/a	GLA03
25	MD Table 1 Rate	P	0.0,0.125	sec-onds	GLA03
25	MD Table 2 Rate	P	0.0,0.125	sec-onds	GLA03
25	MD spare	N		n/a	GLA03
55	AD Software Error Count	N		n/a	GLA03
55	AD Hardware Error Count	N		n/a	GLA03
55	AD Shot Count Value	N		n/a	GLA03
55	AD Shot Count Skip Detected	I	0= no skip, 1=skip	n/a	GLA03
55	AD Synchronized Flag	I	0=not in sync, 1=in sync	n/a	GLA03
55	AD Spare	N		n/a	GLA03
55	AD DSP Laser Fire Count	N		n/a	GLA03
55	AD DSP Alive Count	N		n/a	GLA03
55	AD Ancillary Packets Sent	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
55	AD Engineering Packets Sent	N		n/a	GLA03
55	AD Science Small Packets Sent	N		n/a	GLA03
55	AD Science Large Packets Sent	N		n/a	GLA03
55	AD DSP Load Packets Processed Count	N		n/a	GLA03
55	AD DSP Memory Dump Packets Sent	N		n/a	GLA03
55	AD Memory Load Command Errors	N		n/a	GLA03
55	AD Memory Dump Command Errors	N		n/a	GLA03
55	AD DSP Checksum Rate	N		n/a	GLA03
55	AD DSP Checksum S/W Valid Status	I	0=Not Valid, 1=Valid	n/a	GLA03
55	AD DSP # of times all of memory has been checksummed	N		n/a	GLA03
55	AD DSP Bootstrap Checksum Lower 16 bits	N		n/a	GLA03
55	AD DSP EPROM Checksum Lower 16 bits	N		n/a	GLA03
55	AD DSP RAM Checksum Lower 16 bits	N		n/a	GLA03
55	AD DSP Bootstrap Checksum Upper 32 bits	N		n/a	GLA03
55	AD DSP EPROM Checksum Upper 32 bits	N		n/a	GLA03
55	AD DSP RAM Checksum Upper 32 bits	N		n/a	GLA03
55	AD DSP S/W Build Number	N		n/a	GLA03
55	AD DSP S/W Version Number	N		n/a	GLA03
55	AD GPS Range Window Packets received	N		n/a	GLA03
55	AS DSP Patch Checksum bits 15..0	N		n/a	GLA03
55	AS DSP Patch Checksum bits 47...16	N		n/a	GLA03
55	AD Auto Reset DSP Flag	I	0=False; 1=True	n/a	GLA03
55	AD Software Enable Flag	I	See Section A.26	n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
55	AD DSP Trouble Indicator Status Word	I	See Section A.27	n/a	GLA03
55	AD DSP Memory Table Load Error Counter	N		n/a	GLA03
55	AD Fixed Return Gain Setting	N		n/a	GLA03
55	AD Spares	N		n/a	GLA03
55	CD Software Error Count	N		n/a	GLA03
55	CD Shot Count	N		n/a	GLA03
55	CD Science Mode Packets Sent	N		n/a	GLA03
55	CD Engineering Mode Packets Sent	N		n/a	GLA03
55	CD Ancillary Packet Sent	N		n/a	GLA03
55	CD Range Gate Packets Received	N		n/a	GLA03
55	CD 40-bit Counter Packets Sent	N		n/a	GLA03
55	Spare	N		n/a	GLA03
55	CD Background #1 Delay	P	0.0,128.0	nano-sec-onds	GLA03
55	CD Background #2 Delay	P	0.0,128.0	nano-sec-onds	GLA03
55	CD Range Gate Delay	P	0.0,128.0	nano-sec-onds	GLA03
55	Spare	N		n/a	GLA03
55	CD Raw A/D Output Data	I	See Section A.15	n/a	GLA03
55	CD GPS 40 bit Latch Value 32 lsb	U			GLA03
55	CD Fire Acknowledge 40 bit Latch Value 32 lsb	U			GLA03
55	CD Fire Cmd 40 bit Latch Value 32 lsb	U			GLA03
55	Spare	N		n/a	GLA03
55	CD Fire Cmd 40 bit Latch Value 8 msb	U			GLA03
55	CD Fire Acknowledge 40 bit Latch Value 8 msb	U			GLA03
55	CD GPS 40 bit Latch Value 8 msb	U			GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
55	CD Data Ready Counter	I	CD Fire Acknowledge Counter mask 0x0000FF00; CD Data Ready Counter mask 0x000000FF	n/a	GLA03
55	CD Interrupt Status	I	See Section A.16	n/a	GLA03
55	Spare	N		n/a	GLA03
55	DC Software Fail Count	N		n/a	GLA03
55	DC Shot Count	N		n/a	GLA03
55	DC X Position	N		n/a	GLA03
55	DC Y Position	N		n/a	GLA03
55	DC LPA Packets Sent	N		n/a	GLA03
55	DC Test Mode Rate	N		n/a	GLA03
55	DC Packets Sent	N		n/a	GLA03
55	DC Bytes Sent	N		n/a	GLA03
55	DC Output bit rate in BPS	N		n/a	GLA03
55	DC Interrupt register	N		n/a	GLA03
55	DC Control latch register	N		n/a	GLA03
55	DC Interrupt Mask Register	I	See Section A.17	n/a	GLA03
55	DC fifo flags register	I	See Section A.18	n/a	GLA03
55	DC LPA gain register	I	See Section A.19	n/a	GLA03
55	DC LPA packet count register	I	See Section A.20	n/a	GLA03
55	DC Spares	N		n/a	GLA03
55	GP GPS 10 second Interrupt Count	N		n/a	GLA03
55	GP Number of Position Packets received	N		n/a	GLA03
55	GP Number of Housekeeping packets sent	N		n/a	GLA03
55	GP Number of Ancillary Packets sent	N		n/a	GLA03
55	GP GPS 10 second Pulse 40-Bit Counter Requests sent	N		n/a	GLA03
55	GP GPS 10 sec. Pulse 40-Bit Counter Packets Received	N		n/a	GLA03
55	GP Packets with bad X,Y,Z position data	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
55	GP Packets with X,Y,Z position data below tolerance	N		n/a	GLA03
55	GP Number of range packets sent	N		n/a	GLA03
55	GP Spares	N		n/a	GLA03
55	PC Software Error Count	N		n/a	GLA03
55	PC Shot Counter	N		n/a	GLA03
55	PC SCIENCE MODE PACKETS SENT	N		n/a	GLA03
55	PC ENGINEERING MODE PACKETS SENT	N		n/a	GLA03
55	PC ANCILLARY MODE PACKETS SENT	N		n/a	GLA03
55	PC RANGE GATE DELAY PACKETS RECEIVED	N		n/a	GLA03
55	PC SPCM Gate Delay	P	0.0,128.0	nanoseconds	GLA03
55	PC Background 1 Delay	P	0.0,128.0	nanoseconds	GLA03
55	PC Background 2 Delay	P	0.0,128.0	nanoseconds	GLA03
55	PC Range Gate Delay	P	0.0,128.0	nanoseconds	GLA03
55	PC Hardware Mode Status Word	I	See Section A.21	n/a	GLA03
55	PC SPCM STATUS	I	Bits indicate which SPCM are enabled; 0=Enabled, 1=Disabled.: SPCM 1: mask 0x00000100; SPCM 2: mask 0x00000200; SPCM 3: mask 0x00000400; SPCM 4: mask 0x00000800; SPCM 5: mask 0x00001000; SPCM 6: mask 0x00002000; SPCM 7: mask 0x00004000; SPCM 8: mask 0x00008000	n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
55	PC Data Ready Counter	I	PC Fire Acknowledge Counter: mask 0x00FF00 PC Data Ready Counter: mask 0x0000FF		GLA03
55	PC SPCM 1 THROUGH 4 RAW COUNTS	I	SPCM Raw Counts; SPCM 1: mask 0x000000FF SPCM 2: mask 0x0000FF00 SPCM 3: mask 0x00FF0000 SPCM 4: mask 0xFF000000	counts	GLA03
55	PC SPCM 5 THROUGH 8 RAW COUNTS	I	SPCM Raw Counts; SPCM 5: mask 0x000000FF SPCM 6: mask 0x0000FF00 SPCM 7: mask 0x00FF0000 SPCM 8: mask 0xFF000000	counts	GLA03
55	PC SPCM Duty Cycle	N			GLA03
55	PC Coarse Boresite Calibration X Start Pos	N			GLA03
55	PC Coarse Boresite Calibration Y Start Pos	N			GLA03
55	PC Fine Boresite Calibration X Start Pos	N			GLA03
55	PC Fine Boresite Calibration Y Start Pos	N			GLA03
55	PC Coarse Boresite Calibration X Increment	N			GLA03
55	PC Coarse Boresite Calibration Y Increment	N			GLA03
55	PC Fine Boresite Calibration X Increment	N			GLA03
55	PC Fine Boresite Calibration Y Increment	N			GLA03
55	PC Coarse Boresite Calibration Integration Seconds	N			GLA03
55	PC Fine Boresite Calibration Integration Seconds	N			GLA03
55	PC Boresite Calibration Best X Position	N			GLA03
55	PC Boresite Calibration Best Y Position	N			GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
55	PC Boresite Calibration Seconds Remaining	N			GLA03
55	Spares	N		n/a	GLA03
55	CT State Machine Current State	I	0=Unknown, 1=Reset, 2=Timeout, 3=Acquire Sync, 4=Wait for Muxes, 5=Process Telemetry, 6=Unknown	n/a	GLA03
55	CT COMMAND ECHO ERRORS	N		n/a	GLA03
55	CT LM BOARD CMDS RECEIVED	N		n/a	GLA03
55	CT TM BOARD CMDS RECEIVED	N		n/a	GLA03
55	CT MC BOARD CMDS RECEIVED	N		n/a	GLA03
55	CT HK BOARD CMDS RECEIVED	N		n/a	GLA03
55	CT HVPS Cmds Received	N		n/a	GLA03
55	CT PDU Cmds Received	N		n/a	GLA03
55	CT HW TLM 1 PACKETS SENT	N		n/a	GLA03
55	CT HW TLM 2 PACKETS SENT	N		n/a	GLA03
55	CT HW TLM 3 PACKETS SENT	N		n/a	GLA03
55	CT HW TLM 4 PACKETS SENT	N		n/a	GLA03
55	CT HW TLM 5 PACKETS SENT	N		n/a	GLA03
55	CT DWELL PACKETS SENT	N		n/a	GLA03
55	CT ANCILLARY PACKETS SENT	N		n/a	GLA03
55	CT TIMEOUT COUNT	N		n/a	GLA03
55	CT INTERRUPT COUNT	N		n/a	GLA03
55	CT Shot Counter Errors	N		n/a	GLA03
55	CT Dwell Mode	I	0=None, 1=LMB, 2=HK, 4=TCM, 8=MCS, 16=PDU, 32=HVPS	n/a	GLA03
55	CT Dwell Channel	N		n/a	GLA03
55	CT Laser Monitor Board Mux Error Counter	N		n/a	GLA03
55	CT Housekeeping Board Mux Error Counter	N		n/a	GLA03
55	CT Housekeeping Board Submux Error Counter	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
55	CT Temperature Controller Board Mux Error Counter	N		n/a	GLA03
55	CT Mechanism Controller Board Mux Error Counter	N		n/a	GLA03
55	CT High Voltage Power Supply Mux Error Counter	N		n/a	GLA03
55	CT Power Distribution Unit Mux Error Counter	N		n/a	GLA03
55	CT Command Echo Success Count	N		n/a	GLA03
55	CT Suppressed Event Message Error Flags	I	See Section A.23	n/a	GLA03
55	CT LHP1 Temperature Control State	I	See Section A.24	n/a	GLA03
55	CT LHP2 Temperature Control State	I	See Section A.24	n/a	GLA03
55	CT LHP1 Temperature Setpoint	N		n/a	GLA03
55	CT LHP2 Temperature Setpoint	N		n/a	GLA03
55	CT LHP1 Temperature Control Counter	N		n/a	GLA03
55	CT LHP2 Temperature Control Counter	N		n/a	GLA03
55	CT LHP1 Minimum Temperature	N		n/a	GLA03
55	CT LHP2 Minimum Temperature	N		n/a	GLA03
55	CT LHP1 Temperature Change	N		n/a	GLA03
55	CT LHP2 Temperature Change	N		n/a	GLA03
55	CT LHP1 Temperature Control Cycle Time	N		n/a	GLA03
55	CT LHP2 Temperature Control Cycle Time	N		n/a	GLA03
55	CT Misc Status Flags	I	0=HK SubMUX Paused 1=OK	n/a	GLA03
55	CT Spares	N		n/a	GLA03
31	Dump Packet CRC Error	I	0 = No Errors 1 = CRC Error Detected	n/a	*
31	Start address	N			*
31	Number of 48-bit words in packet	N		n/a	*
31	Type	I	0=data memory, 1=program memory	n/a	*

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
31	Data	I	100 48 bit-words. Every 2 consecutive 32-bit words contain a 48-bit word. The first 32-bit word contains the most significant 32 bits and the second contains the least significant 16-bits with the upper 16 bits zero filled.		*
32	Dump Packet CRC Error	I	0 = No Errors 1 = CRC Error Detected	n/a	*
32	Start address	N			*
32	Number of 32-bit words in packet	N	For Altimeter Digitizer one shot mode, multiply this number by 4 to get the number of waveform bins contained in the packet.	n/a	*
32	Type	I	0=data memory, 1=program memory	n/a	*
32	Data	N		n/a	*
33	C&T Board where telemetry point is being dwelled on	I	1= LMB, 2=HK, 4=TCM, 8=MCS, 16=PDU, 32=HVPS	n/a	*
33	Telemetry channel (or point) to dwell on	N		n/a	*
33	Data from 1st second (older)	N		n/a	*
33	Data from 2nd second	N		n/a	*
33	Data from 3rd second	N		n/a	*
33	Data from 4th second	N		n/a	*
27/28	The number of words currently used by Dwell Table 1 or 2	N		n/a	*
27/28	The dwell rate for Table 1 or 2	P	[(rate+1)*(1/8) sec], must be greater than 1/2 second, Polynomial coeff=(0.125, 0.125)		*
27 /28	The stored values sampled by Memory Dwell Table 1 or 2	N		n/a	*
27/28	Spare	N		n/a	*

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
34	Event Message Characters	N	66 bytes that contain a ASCII text message to be displayed on GLAS operator console (may have to be byte swapped)		*
35	Processor ID	N		n/a	*
35	Current Dump Copy Number	N		n/a	*
35	Memory Address of First Word in this Packet	N		n/a	*
35	Num. of Words Dumped in this Packet	N		n/a	*
35	Dumped Data Words	N		n/a	*
36	Table Id Number	N		n/a	*
36	Current Table Dump Copy Number	N		n/a	*
36	Table Offset	N		n/a	*
36	Num. of Words Dumped in this Packet	N		n/a	*
36	Table Source Type	I	1 = EEPROM; 2 = RAM; 4 = BUFFER	n/a	*
36	Dumped Table Data Words	N		n/a	*
48	Data Types Packet Fixed Pattern	N		n/a	*
12/13/14	Spare	N		n/a	*
12/13/14	Shot Counter	N		n/a	GLA01
12/13/14	Transmit Pulse Waveform	N		n/a	GLA01, GLA04
12/13/14	Transmit Pulse Waveform Peak Time	N		ns	GLA01, GLA04
12/13/14	Transmit Pulse Waveform Peak Threshold Flag	I	Bit 0: Software Error Bit 1: Search Failure (below threshold) Bit 2: Search Failure Latch. Value of 0 = False, 1 = True. Note: once set to true, Bit 2 can only be cleared by a DSP reset or by a ground command.	n/a	GLA01, GLA04

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
12/13/ 14	Starting Address of Transmit Pulse Sample	N		ns	GLA01, GLA04
12/13/ 14	Ending Address of Range Response Surface Echo Dump	N		ns	GLA01
12/13/ 14	Last Threshold Crossing Time(Trailing Edge)	N		ns	GLA01
12/13/ 14	Next to Last Threshold Crossing Time(Leading Edge)	N		ns	GLA01
12/13/ 14	4ns Filter Peak Value	N		counts	GLA01
12/13/ 14	8ns Filter Peak Value	N		counts	GLA01
12/13/ 14	Peak Value for the selected filter	N		counts	GLA01
12/13/ 14	Time of the Peak Value for the selected filter	N		ns	GLA01
12/13/ 14	Filter Selected	I	0 = 4 ns filter 1 = 8 ns filter 2 = 16 ns filter 3 = 32 ns filter 4 = 64 ns filter 5 = 128 ns filter	n/a	GLA01
12/13/ 14	Threshold Value	N		counts	GLA01
12/13/ 14	Background Noise Mean Value for 4 ns filter	N			GLA01
12/13/ 14	Background Noise Standard Deviation Value for the 4 ns filter	N			GLA01
12/13/ 14	Range Window Status Word	I	See Section A.29	n/a	GLA01
12/13/ 14	Calculated Weights for all Filters	U			GLA01
12/13/ 14	Altimeter Digitizer Gain Setting	U			GLA01
12/13/ 14	Surface Echo Sample Padding	N		n/a	GLA01
12/13/ 14	Surface Echo Compress Type	N	0=N, p & q 1=r	n/a	GLA01

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
12/13/ 14	Surface Echo Data Samples (may have been averaged)	N		counts	GLA01
15	Shot Counter	N			GLA02
15	-1 km to 10 km Data	N		n/a	GLA02
15	Background	N		n/a	GLA02
15	error flags	N		n/a	GLA02
15	spares	N		n/a	GLA02
15	10 km to 20 km data	N		n/a	GLA02
15	20 km to 40 km data	N		n/a	GLA02
16	Shot Counter	N		n/a	*
16	40 km to 20 km data	N		n/a	*
16	20 km to 10 km data	N		n/a	*
16	10 km to -1km data	N		n/a	*
17	Shot Counter	N		n/a	GLA02
17	-1 km to 10 km Data	N		n/a	GLA02
17	Background	N		n/a	GLA02
17	10 km to 20 km data	N		n/a	GLA02
18	Shot Counter	N		n/a	*
18	20 km to 10 km data	N		n/a	*
18	10 km to -1 km data	N		n/a	*
19	Shot counter	N		n/a	GLA03
19	Check-In Flags	I	1= tlm in ancillary packet, 0=tlm NOT in ancillary packet; AD Checkin Flag:Mask=0x01 PC Checkin Flag: Mask 0x02 CD Checkin Flag: Mask 0x04 GP Checkin Flag: Mask 0x08 CT Checkin Flag: Mask 0x10	n/a	GLA03
19	Shot Counter	N		n/a	GLA03
19	Altimeter Dig. Range Window Rmin	N		ns	GLA01
19	Altimeter Dig. Range Window Rmax	N		ns	GLA01
19	RMS Noise calculation start time off-set	N		ns	GLA01

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Filter Selection Mask	I	0=Filter Disabled, 1=Filter Enabled. 4 ns: Mask=0x0001 8 ns: Mask=0x0002 16 ns: Mask=0x0004 32 ns: Mask=0x0008 64 ns: Mask=0x0010 128 ns: Mask=0x0020	n/a	GLA01
19	Shot Counter for PDL waveform	N		n/a	GLA03
19	Post Delay Laser Pulse Response Start Address	N		ns	GLA03
19	Sampled Post Delay Pulse Wave-form	N		n/a	GLA03
19	OTS Laser Pulse Response Start Address	N		ns	GLA03
19	Shot Counter for OTS	N		n/a	GLA03
19	Sampled OTS Pulse Waveform	N		n/a	GLA03
19	Location of transmit pulse search window (start)	N		ns	GLA03
19	Number of No Threshold Crossing Shots for Error Condition	N		n/a	GLA03
19	Spare Telemetry Byte	N		n/a	GLA03
19	Surface Echo Land Type	I	0=sea, 1=land, 2=sea/ice, 3=land/ice	n/a	GLA01
19	Value of 'p' used for frame	N		n/a	GLA01
19	Value of 'q' used for frame	N		n/a	GLA01
19	Value of 'N' used for frame	N		n/a	GLA01
19	Value of 'r' used for frame	N		n/a	GLA01
19	Transmit Pulse Threshold Value	N		counts	GLA03
19	Filter Weight Param C0 for 4 ns filter	N		n/a	GLA03
19	Filter Weight Param C1 for 4 ns filter	N		n/a	GLA03
19	Filter Weight Param C2 for 4 ns filter	N		n/a	GLA03
19	Filter Weight Param C3 for 4 ns filter	N		n/a	GLA03
19	Filter Weight Param C0 for 8 ns filter	N		n/a	GLA03
19	Filter Weight Param C1 for 8 ns filter	N		n/a	GLA03
19	Filter Weight Param C2 for 8 ns filter	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Filter Weight Param C3 for 8 ns filter	N		n/a	GLA03
19	Filter Weight Param C0 for 16 ns filter	N		n/a	GLA03
19	Filter Weight Param C1 for 16 ns filter	N		n/a	GLA03
19	Filter Weight Param C2 for 16 ns filter	N		n/a	GLA03
19	Filter Weight Param C3 for 16 ns filter	N		n/a	GLA03
19	Filter Weight Param C0 for 32 ns filter	N		n/a	GLA03
19	Filter Weight Param C1 for 32 ns filter	N		n/a	GLA03
19	Filter Weight Param C2 for 32 ns filter	N		n/a	GLA03
19	Filter Weight Param C3 for 32 ns filter	N		n/a	GLA03
19	Filter Weight Param C0 for 64 ns filter	N		n/a	GLA03
19	Filter Weight Param C1 for 64 ns filter	N		n/a	GLA03
19	Filter Weight Param C2 for 64 ns filter	N		n/a	GLA03
19	Filter Weight Param C3 for 64 ns filter	N		n/a	GLA03
19	Filter Weight Param C0 for 128 ns filter	N		n/a	GLA03
19	Filter Weight Param C1 for 128 ns filter	N		n/a	GLA03
19	Filter Weight Param C2 for 128 ns filter	N		n/a	GLA03
19	Filter Weight Param C3 for 128 ns filter	N		n/a	GLA03
19	Background Noise A1 Coefficient for 4ns Filter	N		n/a	GLA03
19	Background Noise A2 Coefficient for 4ns Filter	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Background Noise A3 Coefficient for 4ns Filter	N		n/a	GLA03
19	Background Noise A1 Coefficient for 8ns Filter	N		n/a	GLA03
19	Background Noise A2 Coefficient for 8ns Filter	N		n/a	GLA03
19	Background Noise A3 Coefficient for 8ns Filter	N		n/a	GLA03
19	Background Noise A1 Coefficient for 16ns Filter	N		n/a	GLA03
19	Background Noise A2 Coefficient for 16ns Filter	N		n/a	GLA03
19	Background Noise A3 Coefficient for 16ns Filter	N		n/a	GLA03
19	Background Noise A1 Coefficient for 32ns Filter	N		n/a	GLA03
19	Background Noise A2 Coefficient for 32ns Filter	N		n/a	GLA03
19	Background Noise A3 Coefficient for 32ns Filter	N		n/a	GLA03
19	Background Noise A1 Coefficient for 64ns Filter	N		n/a	GLA03
19	Background Noise A2 Coefficient for 64ns Filter	N		n/a	GLA03
19	Background Noise A3 Coefficient for 64ns Filter	N		n/a	GLA03
19	Background Noise A1 Coefficient for 128ns Filter	N		n/a	GLA03
19	Background Noise A2 Coefficient for 128ns Filter	N		n/a	GLA03
19	Background Noise A3 Coefficient for 128ns Filter	N		n/a	GLA03
19	Spare Telemetry Bytes	N		n/a	GLA03
19	Enable/Disable Auto Gain Calculation	N	0 = fixed; 1 = Auto	n/a	GLA03
19	Enable/Disable Use of 8ns Filter for Auto Gain Calculation	N	0 = Selected Filter; 1 = 8 ns Filter	n/a	GLA03
19	Return Gain Value	N		n/a	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Auto Gain Calculation A1 Parameter	N		n/a	GLA03
19	Auto Gain Calculation A2 Parameter	N		n/a	GLA03
19	Auto Gain Calculation A3 Parameter	N		n/a	GLA03
19	Auto Gain Calculation A4 Parameter	N		n/a	GLA03
19	Auto Gain Calculation B1 Parameter	N		n/a	GLA03
19	Auto Gain Calculation B2 Parameter	N		n/a	GLA03
19	Auto Gain Calculation B3 Parameter	N		n/a	GLA03
19	Auto Gain Calculation B4 Parameter	N		n/a	GLA03
19	Auto Gain Calculation C0 parameter	N		n/a	GLA03
19	Auto Gain Calculation C1 parameter	N		n/a	GLA03
19	Auto Gain Calculation Vref Parameter	N		n/a	GLA03
19	Auto Gain Calculation Zmin Parameter	N		n/a	GLA03
19	Auto Gain Calculation Zmax Parameter	N		n/a	GLA03
19	Auto Gain Calculation Vmin Parameter	N		n/a	GLA03
19	Auto Gain Calculation Ginit Parameter	N		n/a	GLA03
19	Auto Gain Calculation Gmin Parameter	N		n/a	GLA03
19	Auto Gain Calculation Gmax Parameter	N		n/a	GLA03
19	Tolerance for Coincidence of Filters	N		ns	GLA03
19	Range Window Dump (waveform time) Offset for 4 ns filter	N		ns	GLA03
19	Range Window Dump (waveform time) Offset for 8 ns filter	N		ns	GLA03
19	Range Window Dump (waveform time) Offset for 16 ns filter	N		ns	GLA03
19	Range Window Dump (waveform time) Offset for 32 ns filter	N		ns	GLA03
19	Range Window Dump (waveform time) Offset for 64 ns filter	N		ns	GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Range Window Dump (waveform time) Offset for 128 ns filter	N		ns	GLA03
19	Surface (Pulse) Return Threshold Values for All Filters	N	2 spare bytes; 6 threshold values - one for each filter.	n/a	GLA03
19	FIR Filter Coefficients	N		n/a	GLA03
19	Filter Weight Min Standard Deviation	N		n/a	GLA03
19	Filter Noise Minimum thresholds for 4 ns filter	N		counts	GLA03
19	Filter Noise Minimum thresholds for 8 ns filter	N		counts	GLA03
19	Filter Noise Minimum thresholds for 16 ns filter	N		counts	GLA03
19	Filter Noise Minimum thresholds for 32 ns filter	N		counts	GLA03
19	Filter Noise Minimum thresholds for 64 ns filter	N		counts	GLA03
19	Filter Noise Minimum thresholds for 128 ns filter	N		counts	GLA03
19	Filter Reject Mask for Leading Edge Failures	N		counts	GLA03
19	Filter Reject Mask for Trailing Edge Failures	N		counts	GLA03
19	Spare Telemetry Bytes	N		n/a	GLA03
19	Spare	N		n/a	GLA03
19	SPCM 1-4 Raw Counts	N		counts	GLA02
19	SPCM 5-8 Raw Counts	N		counts	GLA02
19	SPCM Gate Delay and Background #1 Delay	N		counts	GLA02
19	Background #2 Delays and Range Gate Delay	N		counts	GLA02
19	SPCM status	N		counts	GLA02
19	Spare	N		counts	GLA02
19	A/D output and CD Amplifier Attenuation (gain) setting	N		counts	GLA02
19	Background #1 Delay	N		counts	GLA02
19	Background #2 and Range Gate Delay	N		counts	GLA02

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Detector status	N		counts	GLA02
19	Spare	N		n/a	GLA03
19	Shot Counter for start of Frame	N		n/a	GLA03
19	Shot Counter	N		counts	GLA03
19	Fire Acknowledge Time (from Freq and Time Bd)	M			GLA03
19	Fire Command Time (from Freq and Time Bd)	M	See Section A.32 for shot time tag specification. The raw value will be stored on GLA03. The shot times will be stored on GLA01 and GLA04		GLA03, GLA01, GLA04
19	Latitude	N		degree s	GLA03
19	Longitude	N		degree s	GLA03
19	Height (Hsat)	P	0.0, 1000.0	meters	GLA02, GLA03
19	Rsat	P	0.0, 1000.0	meters	GLA01
19	Rmin	P	0.0, 1000.0	meters	GLA01
19	Rmax	P	0.0, 1000.0	meters	GLA01
19	Wmin	P	0.0, 1000.0	meters	GLA01
19	Wmax	P	0.0, 1000.0	meters	GLA01
19	Hoffmin (DEM uncertainty + bias)	P	0.0, 1000.0	meters	GLA01, GLA02
19	Hoffmax (DEM uncertainty - bias)	P	0.0, 1000.0	meters	GLA01, GLA02
19	Rbmin	P	0.0, 1000.0	meters	GLA01
19	Rbmax	P	0.0, 1000.0	meters	GLA01
19	PC Range Bias	P	0.0, 1000.0	meters	GLA02
19	CD Range Bias	P	0.0, 1000.0	meters	GLA02
19	Surface Type	I	0=ocean & no ice 1=land & no ice 2=ocean & ice 3=land & ice	n/a	GLA01

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Position data valid flag	I	0 = no errors detected during position data processing otherwise non-zero.	n/a	GLA03
19	Spacecraft time & position packet data	N	Format is defined in space-craft ICD.	n/a	GLA03
19	Shot Count for 1553 Spacecraft Position and command packet.	N	Only lower 8 bits valid	n/a	GLA03
19	GLAS MET for 1553 Spacecraft Position and command packet.	U			GLA03
19	DEM minimum byte	I, P	See Section A.28	meters	GLA01, GLA02, GLA03
19	DEM maximum byte	I, P	See Section A.28	meters	GLA01, GLA02, GLA03
19	Range data source	I	0=s/c time & pos packet 1=uplinked DEM bytes 2=uplinked Rmin/Rmax	n/a	GLA01, GLA03
19	GPS 10 Sec Pulse 40 bit count value	N		n/a	GLA03
19	GLAS MET for GPS 0.1 Hz Pulse	N		n/a	GLA03
19	Spare Bytes	N		n/a	GLA03
19	Etalon Calibration - Current mode	I	0 = off, 1 = Acquire, 2 = Tracking	n/a	GLA03
19	Etalon State	I	0 = Idle, 1 = Init, 2 = Set Temperature, 3 = Settle, 4 = Average, 5 = Open Loop, 6 = Modified	n/a	GLA03
19	Etalon Temperature Settle Time	N		sec	GLA02, GLA03
19	Etalon Flags	I	See Section A.31	n/a	GLA02, GLA03
19	Etalon Averaged On-Axis Transmis-sion	N		n/a	GLA02, GLA03
19	Etalon Averaged Off-Axis Transmis-sion	N		n/a	GLA02, GLA03
19	Etalon Temperature Error	N		C	GLA02, GLA03

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
19	Etalon Tracking Loop Filter Output	N		n/a	GLA02, GLA03
19	Etalon Tracking Failure Average	N		n/a	GLA02, GLA03
19	Etalon Start Temperature for Acquire Command	N		C	GLA02, GLA03
19	Etalon Stop Temperature for Acquire Command	N		C	GLA02, GLA03
19	Etalon Temperature Step for Acquire Command	N		Deg C	GLA02, GLA03
19	Etalon Averaging Time for Acquire Command	N		sec	GLA02, GLA03
19	Etalon Temperature Settle Time for Acquire Command	N		sec	GLA02, GLA03
19	Etalon Averaging Update Counter	I	0=off, 1=on	n/a	GLA02, GLA03
19	Spare Bytes	N		n/a	GLA02, GLA03
19	Dual Pin A (Etalon Feedback Monitor Value)	N		n/a	GLA02, GLA03
19	Dual Pin B (Etalon Feedback Monitor Value)	N		n/a	GLA02, GLA03
19	Etalon 532 Energy	N		n/a	GLA02, GLA03
26	Spare	N		n/a	GLA03
26	Shot Counter	N		counts	GLA04
26	X Position of Box	N		pixel number	GLA04
26	Y Position of Box	N		pixel number	GLA04
26	LPA Data	N			GLA04
49	Valid Commands in Packet	N		counts	*
49	GLAS Time of Command	U			*
49	Command (first 20 bytes)	U			*
126	Shot Counter	N		n/a	*
126	LPA Data	N		n/a	*
38	Calibration Type	I	0 = Coarse, 1 = Fine	n/a	*

Table A-1 Conversion Description for GLAS Telemetry Data (Continued)

APID	Name	Conv. Type	Conversion Description	Units	L1A Product ID
38	X Position Of The Mirror	U			*
38	Y Position Of The Mirror	U			*
38	Integration Result	U			*

Table A-2, the terms TLM_raw and TLM_proc, refer to the raw telemetry data in counts and the processed telemetry data in engineering units respectively.

Table A-2 Pseudo-Telemetry Conversions

Eqn. No.	APID / Telemetry Data	Pseudo Equation
7	21 / Primary Monitor Calibration, Upper Byte; Primary Monitor Calibration, Lower Byte	SLOPE1 = 5.0 / (GPDMON1CALUB - GPDMON1CALLB) note: used in equations 8 - 19
8	21 / Primary Monitor Calibration, Upper Byte	INTERCEPT1 = 5.0 - (SLOPE1 * GPDMON1CALUB) note: used in equations 9 - 19
9	21 / +28V Bus A Instrument	TLM_proc = ((SLOPE1 * TLM_raw) + INTERCEPT1)* 9.22
10	21 / Hybrid Supplies	TLM_proc = ((SLOPE1*(TLM_raw - 10.0)) + INTERCEPT1) * 1.52
11	21 / HVPS Detector Supplies	TLM_proc = ((SLOPE1*(TLM_raw - 4.0)) + INTERCEPT1) * 0.408
12	21 / Operational Heaters	TLM_proc = ((SLOPE1*(TLM_raw - 2.0)) + INTERCEPT1) * 0.41
13	21 / Mechanical System	TLM_proc = ((SLOPE1*(TLM_raw - 3.0)) + INTERCEPT1) * 0.407
14	21 / +28V Bus B Laser 1	TLM_proc = ((SLOPE1 * TLM_raw) + INTERCEPT1) * 9.2
15	21 / +28V Bus B Laser 1	TLM_proc = ((SLOPE1 * (TLM_raw - 8.0)) + INTERCEPT1) * 1.25
16	21 / +28V Bus C Laser 2	TLM_proc = ((SLOPE1 * TLM_raw) + INTERCEPT1) * 9.25
17	21 / +28V Bus C Laser 2	TLM_proc = ((SLOPE1*(TLM_raw - 10.0)) + INTERCEPT1) * 1.25
18	21 / +28V Bus D Laser 3	TLM_proc = ((SLOPE1 * TLM_raw) + INTERCEPT1) * 9.25
19	21 / +28V Bus D Laser 3	TLM_proc = ((SLOPE1 * (TLM_raw - 13.0)) + INTERCEPT1) * 1.25

Table A-2 Pseudo-Telemetry Conversions (Continued)

Eqn. No.	APID / Telemetry Data	Pseudo Equation
20	21 / Secondary Monitor Calibration, Upper Byte; Secondary Monitor Calibration, Lower Byte	SLOPE2 = 5.0 / (GPDMON2CALUB - GPDMON2CALLB) note: used in equations 21 - 40
21	21 / Secondary Monitor Calibration, Upper Byte	INTERCEPT2 = 5.0 - (SLOPE2 * GPDMON2CALUB) note: used in equations 22 - 40
22	21 / + 5 V Hybrid # 1	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 1.514
23	21 / + 5 V Hybrid # 1	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 1.91
24	21 / +12 V Hybrid # 2	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 3.52
25	21 / + 12 V Hybrid # 2	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 0.66
26	21 / - 12 V Hybrid # 3	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * (-3.515)
27	21 / - 12 V Hybrid # 3	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 0.63
28	21 / + 5 V Hybrid # 4	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 1.515
29	21 / + 5 V Hybrid # 4	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 1.91
30	21 / - 5 V Hybrid # 5	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * (-1.532)
31	21 / - 5 V Hybrid # 5	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 1.49
32	21 / - 5 V Hybrid # 6	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * (-1.52)
33	21 / - 5 V Hybrid # 6	TLM_proc = ((SLOPE2 * (TLM_raw - 3.0))+ INTERCEPT2) * 2.05
34	21 / + 15 V Boost Post Reg	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * 4.05
35	21 / - 15 V Boost Post Reg	TLM_proc = ((SLOPE2 * TLM_raw) + INTERCEPT2) * (-4.078)
36	21 / +12 V Prim Osc Thermal Control	TLM_proc = ((SLOPE2 * (TLM_raw - 3.0)) + INTERCEPT2) * 0.054
37	21 / +12 V Sec Osc Thermal Control	TLM_proc = ((SLOPE2 * (TLM_raw - 7.0)) + INTERCEPT2) * 0.052
38	21 / -2 V Discrete Voltage	TLM_proc = (((SLOPE2 * TLM_raw) + INTERCEPT2) * 2.0) - 5.0
39	21 / Hybrid Heatsink Temperature	TLM_proc = (((SLOPE2 * TLM_raw) + INTERCEPT2) * 30.2) - 30.0
40	21 / FET Switch Bank Heatsink Temperature	TLM_proc = (((SLOPE2 * TLM_raw) + INTERCEPT2) * 30.2) - 30.0

A.3 Laser and OTS Enable readbacks

The interpretation of the Laser and OTS Readback telemetry word is in Table A-3 "Laser and OTS Readback Interpretation" on page -36.

Table A-3 Laser and OTS Readback Interpretation

Status	Mask	Possible Values
Laser 1 Enable/Disable Status	0x01	0=ENABLED, 1=DISABLED
Laser 2 Enable/Disable Status	0x02	0=ENABLED, 1=DISABLED
Laser 3 Enable/Disable Status	0x04	0=ENABLED, 1=DISABLED
OTS Enable/Disable Status	0x08	0=ENABLED, 1=DISABLED

A.4 FET Switch Bank

The interpretation of the FET Switch Bank telemetry word is in Table A-4 "FET Switch Bank Interpretation".

Table A-4 FET Switch Bank Interpretation

Flag	Mask	Possible Values
Primary Oscillator	0x01	0=off, 1=on
Secondary Oscillator	0x02	0=off, 1=on
Primary Altimeter Digitizer	0x10	0=off, 1=on
Secondary Altimeter Digitizer	0x20	0=off, 1=on

A.5 Optical Sensor Status

The interpretation of the Optical Sensor Status telemetry word is in Table A-5 "Optical Sensor Status Interpretation" on page -37.

A.6 Status Command Telemetry

The interpretation of the Status Command telemetry word is in Table A-6 "Command Status Interpretation".

A.7 CD Status Flags

The interpretation of the CD Status flag telemetry word is in Table A-7 "CD Status Flag Interpretation".

Table A-5 Optical Sensor Status Interpretation

Status	Mask	Possible Values
Primary Sensor Position Laser Select Mechanism 1, HOP-1	0x0C00	0=In-Deployment, 1=Unknown, 2=Deployed, 3=Stowed
Primary Sensor Position Laser Select Mechanism 2, HOP-2	0x0300	0=In-Deployment, 1=Unknown, 2=Deployed, 3=Stowed
Primary Sensor Position Altimeter Digitizer Detector Select Mechanism, HOP-3	0x00C0	0=In-Deployment, 1=Unknown, 2=Detector 2, 3=Detector 1
Secondary Sensor Position Laser Select Mechanism 1, HOP-1	0x0030	0=In-Deployment, 1=Unknown, 2=Deployed, 3=Stowed
Secondary Sensor Position Laser Select Mechanism 2, HOP-2	0x000C	0=In-Deployment, 1=Unknown, 2=Deployed, 3=Stowed
Secondary Sensor Position Altimeter Digitizer Detector Select Mechanism, HOP-3	0x0003	0=In-Deployment, 1=Unknown, 2=Detector 2, 3=Detector 1

Table A-6 Command Status Interpretation

Status	Mask	Possible Values
HOP Temperature Status	0x0800	0=In Tolerance, 1=Out of Tolerance
ADC Pulse Status	0x0400	0=Not Received, 1= Received
Deployed optic diodes power status	0x0200	0=ON, 1=OFF
Stowed optic diodes power status	0x0100	0=ON, 1=OFF
HOP LED Turn Off	0x0080	0=Armed, 1=Triggered
HOP Temp Turn Off	0x0040	0=Armed, 1=Triggered
HOP Timer Turn Off	0x0020	0=Armed, 1=Triggered
HOP Command Trigger Status	0x0010	0=Not Received, 1= Received
Reset Latch relay command status	0x0008	0=Not Received, 1= Received
Set latch relay command status	0x0004	0=Not Received, 1= Received

Table A-6 Command Status Interpretation (Continued)

Status	Mask	Possible Values
DAC Initial Conversion Signal Status	0x0002	0=Not Sent, 1=Sent
DAC Latch Data Signal Status	0x0001	0=Not Sent, 1=Sent

Table A-7 CD Status Flag Interpretation

Status	Mask	Possible Values
CD Timeout Occurred Flag	0x01	0 = no timeout 1 = timeout
CD Target Present Flag	0x02	0 = not configured 1 = configured
CD Event Messages Disable Flag	0x04	0=Enabled, 1=Disabled
CD Measurement Reference Source	0x08	0=Fire Acknowledge 1= Fire Command
CD 40Hz Interrupt	0x10	0=Enabled, 1=Disabled
CD AD Detector Selected	0x020	0= AD #1 Selected, 1=AD #2 Selected
CD Detector Selected	0x40	0= CD #1 Selected, 1=CD #2 Selected
CD AD Board Selected	0x80	0= AD #1 Selected, 1=AD #2 Selected
CD Hardware Mode	0x0F00	1=Idle, 2=Engineering, 4=Science, Other values invalid
CD Software Mode	0xF000	0=Idle, 1=Engineering, 2=Science, 3=Memory test, Other values invalid

A.8 DC Status Flags

The interpretation of the DC Status flag telemetry word is in Table A-8 "DC Status Flag Interpretation".

A.9 PC Status Flags

The interpretation of the PC Status flag telemetry word is in Table A-9 "PC Status Flag Interpretation".

Table A-8 DC Status Flag Interpretation

Status	Mask	Possible Values
DC TimeoutStatus	0x01	0 = no timeout 1 = timeout
DC Target Present Flag	0x02	0 = not present 1 = target present
DC Event Messages Disable Flag	0x04	0=Enabled, 1=Disabled
DC Software Mode	0xFF00	0=SSR, 1=SSR_LPA, 2=TEST

Table A-9 PC Status Flag Interpretation

Status	Mask	Possible Values
PC Timeout Status	0x01	0 = no timeout 1 = timeout
PC Target Present Flag	0x02	0 = not configured 1 = configured
PC Calibration Type	0x04	0=Coarse, 1=Fine
PC Event Messages Disable Flag	0x08	0=Enabled, 1=Disabled
PC Range Gate Dither Flag	0x10	0=Disabled, 1=Enabled
PC Measurement Reference Source	0x20	0=Fire Acknowledge 1= Fire Command
PC Hardware Mode	0x0F00	1=Idle, 2=Engineering, 4=Science, Other values invalid
PC Software Mode	0xF000	0=Idle, 1=Engineering, 2=Science, 3=Boresite Cal, 4=Memory test, Other values invalid

A.10 CT Task Mode

The interpretation of the CT Task Mode telemetry word is in Table A-10 "CT Task Mode Interpretation" on page -40.

Table A-10 CT Task Mode Interpretation

Status	Mask	Possible Values
CT Task Software Mode	0x0001	0=Manual, 1=Normal
CT Task C&T Control Hardware Mode Register bit	0x0002	0=Manual, 1=Normal
CT Task Startup Mode, Discrete cmd	0x0004	0=Manual, 1=Auto Power Up Osc/AD
CT Task Startup AD/OSC, Discrete cmd mask	0x0008	0=Primary, 1= Secondary
CT Etalon Mode	0x0070	0=Off, 1=Acquire, 2=Tracking, 4=Test, 5=Test/Acquire, 6=Test/Tracking
CT Etalon Tracking Active Flag	0x0080	0=Paused, 1=Active
CT Etalon Tracking Low Transmission Flag	0x0100	0=Good, 1=Low
CT Etalon Tracking Open-Loop Flag	0x0200	0=Normal, 1=Open-loop

A.11 Subsystem Present Flags

The interpretation of the Subsystem Present Flags is in Table A-11 "Subsystem Present Flag Interpretation" on page -40.

Table A-11 Subsystem Present Flag Interpretation

Flag	Mask	Possible Values
HS Subsystem Present Flag	0x0001	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
CS Subsystem Present Flag	0x0002	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
TC Subsystem Present Flag	0x0004	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
SB Subsystem Present Flag	0x0008	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
SM Subsystem Present Flag	0x0010	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
RT Subsystem Present Flag	0x0020	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
MD Subsystem Present Flag	0x0040	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
AD Subsystem Present Flag	0x0080	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets

Table A-11 Subsystem Present Flag Interpretation (Continued)

Flag	Mask	Possible Values
CD Subsystem Present Flag	0x0100	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
DC Subsystem Present Flag	0x0200	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
GP Subsystem Present Flag	0x0400	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
PC Subsystem Present Flag	0x0800	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets
CT Subsystem Present Flag	0x1000	0=No, 1=Yes Subsystem Telemetry is present in Small and Large Telemetry Packets

A.12 CS Status Flag

The interpretation of the CS Status Flag is in Table A-12 "CS Status Flag Interpretation".

Table A-12 CS Status Flag Interpretation

Flag	Mask	Possible Values
CS Enable/Disabled Flag	0x03	0=Disabled, 1=Enabled
CS Code Memory Checksum Status	0x0C	0=Disabled, 1=Enabled, 2=Disabled and Recomputing, 3=Enabled and Recomputing
CS Table Memory Checksum Status	0x30	0=Disabled, 1=Enabled, 2=Disabled and Recomputing, 3=Enabled and Recomputing
CS EEPROM Checksum status flag	0xC0	0=Disabled, 1=Enabled, 2=Disabled and Recomputing, 3=Enabled and Recomputing

A.13 SM Table Operations Flag

The interpretation of the SM Table Operations Flag is in Table A-13 "SM Table Operations Flag Interpretation".

A.14 BCRT Control Register Word

The interpretation of the BCRT Control Register word is in Table A-14 "BCRT Register Control Word Interpretation".

Table A-13 SM Table Operations Flag Interpretation

Flag	Mask	Possible Values
SM Table Session Type	0x3F	0=None, 5=DUMP_ONLY, 6=REP_EEPROM, 7=REP_RAM, 8=APPD_ACTV
SM Table Operations Flag	0x40	0=Inactive, 1=Active

Table A-14 BCRT Register Control Word Interpretation

Status	Mask	Possible Values
RT Channel A Select	0x0080	0=OFF, 1=ON
RT Channel B Select	0x0100	0=OFF, 1=ON

A.15 CD Raw A/D Output Data

The interpretation of the CD Raw A/D Output Data word is in Table A-15 "CD Raw A/D Output Data Interpretation".

Table A-15 CD Raw A/D Output Data Interpretation

Flag	Mask	Possible Values
CD Raw A/D Overflow Flag	0x0100	0=No overflow, 1=Overflow
CD Attenuation Settings	0x3E00	1=0.0, 2=1/1.77, 4=1/3.16, 8=1/5.6, 16=1/10

A.16 CD Interrupt Status

The interpretation of the CD Interrupt Status word is in Table A-16 "CD Interrupt Status Interpretation".

Table A-16 CD Interrupt Status Interpretation

Flag	Mask	Possible Values
CD Data Ready Interrupt	0x00000008	0=Enabled, 1=Disabled
CD Interrupt Source	0x00003000	1= Fire Command, 2= fire acknowledge

A.17 DC Interrupt Mask Register

The interpretation of the DC Interrupt Mask Register word is in Table A-17 "DC Interrupt Mask Register Interpretation".

Table A-17 DC Interrupt Mask Register Interpretation

Flag	Mask	Possible Values
DC Interrupt 1	0x00000001	0=Disabled, 1=Enabled
DC LPA Interrupt	0x00000002	0=Disabled, 1=Enabled
DC Output FIFO Full Interrupt	0x00000004	0=Disabled, 1=Enabled
DC Output FIFO Empty Interrupt	0x00000008	0=Disabled, 1=Enabled
DC RAM Busy Interrupt	0x00000010	0=Disabled, 1=Enabled
DC Interrupt 6	0x00000020	0=Disabled, 1=Enabled

A.18 DC FIFO Flags Register

The interpretation of the DC FIFO Flags Register is in Table A-18 "DC FIFO Flags Register Interpretation".

Table A-18 DC FIFO Flags Register Interpretation

Flag	Mask	Possible Values
DC FIFO Full	0x00000001	0=True, 1=False
DC FIFO Almost Full	0x00000004	0=True, 1=False
DC FIFO Almost Empty	0x00000002	0=True, 1=False
DC FIFO Empty	0x00000008	0=True, 1=False

A.19 DC LPA Gain Register

The interpretation of the DC LPA Gain Register is in Table A-19 "DC LPA Gain Register Interpretation" on page -43.

Table A-19 DC LPA Gain Register Interpretation

Flag	Mask	Possible Values
DC LPA Gain	0x00000007	0=4.00, 1=2.80, 2=2.15, 3=1.75, 4=1.47, 5=1.27, 6=1.12, 7=1.00
DC LPA Reset	0x00000008	0=In Reset, 1=Not in Reset

A.20 DC LPA Packet Count Register

The interpretation of the DC LPA Packet Count Register is in Table A-20 "DC LPA Packet Count Register Interpretation".

Table A-20 DC LPA Packet Count Register Interpretation

Flag	Mask	Possible Values
DC LPA Frame Byte Count	0x00003FFF	counter
DC LPA Packet (Frame) Count	0x00FF0000	counter

A.21 PC Hardware Mode Status

The interpretation of the PC Hardware Mode Status word is in Table A-21 "PC Hardware Mode Status Interpretation".

Table A-21 PC Hardware Mode Status Interpretation

Flag	Mask	Possible Values
PC Board Hardware Mode	0x00000007	1=Idle, 2=Engineering, 4=Science
PC Interrupt Source	0x00003000	1=Fire Command, 2=Fire Acknowledge
PC Measurement Source	0x00004000	0=Fire Acknowledge, 1=Fire Command

A.22 MD Enable / Disable Flag

The interpretation of the MD Enable/Disable Flag word is in Table A-22 "MD Enable /Disable Flag Interpretation".

Table A-22 MD Enable /Disable Flag Interpretation

Flag	Mask	Possible Values
MD Global Enable/Disable Flag	0x001	0=Disabled 1=Enabled
MD Table 1 Enable/Disable Flag	0x002	0=Disabled 1=Enabled
MD Table 2 Enable/Disable Flag	0x004	0=Disabled 1=Enabled

A.23 CT Suppressed Event Message Error Flag

The interpretation of the CT Suppressed Event Message Error Flag word is in Table A-23 "CT Suppressed Event Message Error Flag Interpretation".

Table A-23 CT Suppressed Event Message Error Flag Interpretation

Flag	Mask	Possible Values
CT Event Messages Enabled/ Disabled Flag	0x0001	0=All Enabled 1=Some Disabled
CT Shot Count Error Flag	0x0002	0=OK 1=Error
CT Laser Monitor Board Mux Error Flag	0x0004	0=OK 1=Error
CT Housekeeping Board Mux Error Flag	0x0008	0=OK 1=Error
CT Housekeeping Board Sub-mux Error Flag	0x0010	0=OK 1=Error
CT Temperature Controller Board Mux Error Flag	0x0020	0=OK 1=Error
CT Mechanism Controller Board Mux Error Flag	0x0040	0=OK 1=Error
CT Power Distribution Unit Mux Error Flag	0x0080	0=OK 1=Error

Table A-23 CT Suppressed Event Message Error Flag Interpretation (Continued)

Flag	Mask	Possible Values
CT High Voltage Power Supply Mux Error Flag	0x0100	0=OK 1=Error
CT Ancillary Packet Allocation Error FlagMD Global Enable/ Disable Flag	0x0200	0=OK 1=Error

A.24 CT Loop Heat Pipe Control State

The interpretation of the CT Loop Heat Pipe (LHP) Control State words for LHP 1 and LHP 2 is in Table A-24 "CT LHP Control State Interpretation".

Table A-24 CT LHP Control State Interpretation

Flag	Mask	Possible Values
CT LHP Temperature Control Enabled Flag	0x0001	0=Off 1=On
CT LHP Temperature Control Active Flag	0x0002	0=Idle 1=Active

A.25 GP Task Status Bits

The interpretation of the GP Task Status Bits word is in Table A-25 "GP Task Status Bits Interpretation".

Table A-25 GP Task Status Bits Interpretation

Flag	Mask	Possible Values
Position Data Source	0x0003	0= spacecraft 1=Ground Hmin/Hmax 2=Ground Rmin/Rmax
Position Data Status Flag	0x000C	0=OK 1=No data 2=Calculation Error
GPS Pulse Received Flag	0x0010	0=Not Receiving Pulse 1=Receiving Pulse
GPS Pulse Select	0x0020	0=GPS1 1=GPS2

A.26 AD Software Enable Flags

The interpretation of the AD Software Enable Flags is in Table A-26 "AD Software Enable Flag Interpretation".

Table A-26 AD Software Enable Flag Interpretation

Flag	Mask	Possible Values
AD Auto Reset DSP Flag	0x0001	0=False, 1=True
AD Auto Gain Use 8ns Filter Flag	0x0010	0=Disabled, 1=Enabled
AD Auto Gain Enable Flag	0x0020	0=Disabled, 1=Enabled
AD Hardware Error Events Flag	0x0040	0=Disabled, 1=Enabled
AD Software Error Events Flag	0x0080	0=Disabled, 1=Enabled

A.27 AD DSP Trouble Indicator Status Word

The interpretation of the AD DSP Trouble Indicator Status word is in Table A-27 "AD DSP Trouble Indicator Status Word Interpretation".

Table A-27 AD DSP Trouble Indicator Status Word Interpretation

Flag	Mask	Possible Values
Invalid Search	0x0001	0=No problem 1=Invalid search
Laser Failure	0x0002	0=No problem 1=Laser Failure
Multiple Interrupts	0x0004	0=No problem 1=Multiple Interrupts
Buffer Full	0x0008	0=No problem 1=Buffer Ful
Invalid Mode	0x0010	0=No problem 1=Invalid Mode
Infinite Loop	0x0020	0=No problem 1=Infinite Loop
Invalid Range Window	0x0040	0=No problem 1=Invalid Range Window
Invalid Tournament	0x0080	0=No problem 1=Invalid Tournament
Noise Region Outside Acq Memory	0x0100	0=No problem 1=Noise Region Outside Acq Memory
Invalid Sample Size for Noise region	0x0200	0=No problem 1=Invalid Sample Size for Noise region

A.28 DEM Minimum and Maximum Bytes

The DEM Minimum (Min) and Maximum (Max) bytes are converted to Hmin and Hmax in meters by masking off bit 7 and multiplying the result by 125. Bit 7 of the DEM Min and Max bytes is the DEM surface type indicator. Bit 7 of the DEM Min byte indicates the surface is land (=1) or sea (=0). Bit 7 of the DEM Max byte indicates the surface is ice (=1) or no ice (=0). Bit 7 is the most significant bit.

A.29 Range Window Status

The interpretation of the Range Window Status word is in Table A-28 "Range Window Status Interpretation" on page -48.

Table A-28 Range Window Status Interpretation

Flag	Mask	Possible Values
No first crossing (rising edge) found on 4ns filter	0x00000001	0=False, 1=True
No first crossing (rising edge) found on 8ns filter	0x00000002	0=False, 1=True
No first crossing (rising edge) found on 16ns filter	0x00000004	0=False, 1=True
No first crossing (rising edge) found on 32ns filter	0x00000008	0=False, 1=True
No first crossing (rising edge) found on 64ns filter	0x00000010	0=False, 1=True
No first crossing (rising edge) found on 128ns filter	0x00000020	0=False, 1=True
No second crossing (falling edge) found on 4ns filter	0x00000040	0=False, 1=True
No second crossing (falling edge) found on 8ns filter	0x00000080	0=False, 1=True
No second crossing (falling edge) found on 16ns filter	0x00000100	0=False, 1=True
No second crossing (falling edge) found on 32ns filter	0x00000200	0=False, 1=True
No second crossing (falling edge) found on 64ns filter	0x00000400	0=False, 1=True
No second crossing (falling edge) found on 128ns filter	0x00000800	0=False, 1=True
First sample in range >= threshold for 4ns filter	0x00001000	0=False, 1=True
First sample in range >= threshold for 8ns filter	0x00002000	0=False, 1=True
First sample in range >= threshold for 16ns filter	0x00004000	0=False, 1=True
First sample in range >= threshold for 32ns filter	0x00008000	0=False, 1=True
First sample in range >= threshold for 64ns filter	0x00010000	0=False, 1=True
First sample in range >= threshold for 128ns filter	0x00020000	0=False, 1=True
All filters were rejected flag. True if bits 0 - 5 are true.	0x00040000	0=False, 1=True
No filters were ever selected; all previous selections failed. (Happens on DSP reset.)	0x00080000	0=False, at least one previous selection succeeded, 1=True

Table A-28 Range Window Status Interpretation

Flag	Mask	Possible Values
4ns filter failed	0x00100000	0=False, 1=True
8ns filter failed	0x00200000	0=False, 1=True
16ns filter failed	0x00400000	0=False, 1=True
32ns filter failed	0x00800000	0=False, 1=True
64ns filter failed	0x01000000	0=False, 1=True
128ns filter failed	0x02000000	0=False, 1=True
Return range is invalid	0x40000000	0=Range OK, 1=Failure
Science processing is incomplete	0x80000000	0=Ready, 1=Failure

A.30 AD Target Status and Mode Flags

The interpretation of the AD Target Status and Mode Flag word is in Table A-29 "AD Target Status and Mode Flag Word Interpretation".

Table A-29 AD Target Status and Mode Flag Word Interpretation

Flag	Mask	Possible Values
AD Target Present Flag	0x80	0=Not Present, 1=Target Present
AD Target Timeout Flag	0x40	0=No Timeout, 1=Timeout
AD Mode of Operations	0x38	0=Idle, 1=Science, 2=OneShot, 3=Load, 4=Dump
AD DSP Software Mode	0x07	0=Science, 1=Idle, 2=Load, 3=Dump

A.31 Etalon Flags

The interpretation of the Etalon Status Flags word is in Table A-30 "Etalon Flags Word Interpretation".

Table A-30 Etalon Flags Word Interpretation

Flag	Mask	Possible Values
Etalon Tracking Low Transmission Flag	0x01	0=Good, 1=Low
Etalon Tracking Active Flag	0x02	0=Paused, 1=Active
Etalon Tracking Test Mode Flag	0x04	0=Normal, 1=Test
Etalon Tracking Openloop Mode Flag	0x08	0=Normal, 1=Openloop
Etalon Tracking Openloop Update Toggle	0x10	

A.32 Time Tagging Algorithm

A.32.1 Definitions

The GLAS time tag on all products is the time in seconds from noon January 1, 2000 in Universal Time Code reference frame (includes leap seconds).

The GPS time in the packets received from the Backjack GPS flight receiver is time in seconds from the start of GPS time (January 1980). GPS time is continuous and does not include leap seconds. GPS ticks are always on integer seconds.

The GPS to UTC offset is a constant that shall be defined as the GPS time of Noon January 1, 2000 (the UTC reference time). This constant will be negative because it used to remove from the laser shot GPS time the amount of GPS time occurring from the GPS time reference time (January 1, 1980) to the UTC reference time.

A.32.2 Basic Algorithm with GPS

1) Determine the current leapsecond correction to use from the GPS to UTC Leapseconds File.

2) Compute the laser shot time in UTC:

a) Find the largest GLAS GPS latch time (to the .1 Hz GPS pulse) from the frequency and time board (accounting for roll over) less then the first Fire Command Time of packet (note: both times are 40 bit counters found in GLAS APID 19).

b) Until the first Fire Command Time of the packet is greater than the next GLAS GPS latch time compute the laser shot time in GPS. There is a delay between the fire command time and the start of digitization. This delay must be applied to the fire command time to get the correct laser shot time. Also the time from the start of the digitization to the time of the transmit pulse peak must be included in the algorithm to get to the time of the laser shot. Since the 1 Gigahertz oscillator does not operate perfectly the oscillator frequency must be computed and applied to the 40 bit counter time. Compute the laser shot time in GPS units by the equation:

Laser Shot Time in GPS = {[(Fire Command Time – GLAS GPS latchtime) * freqbrdscale] + time of transmit pulse peak}*oscillator frequency + GPS time + digitizer delay

Where freqbrdscale is the oscillator frequency scale factor to convert counts to seconds. The GPS time in GPS seconds is contained in the spacecraft time and position packet which is downlinked in GLAS APID 19. The format of the spacecraft time and position packet is contained in Appendix C. The digitizer delay and oscillator frequency are provided by the GLAS instrument operations team. The time of the transmit peak is provided in the GLAS waveform data (APIDs 12 and 13).

[Note: any 40 bit counter time from the GLAS frequency and time board can be converted by using the largest GLAS GPS latch time less then the 40 bit counter by the following equation:

40 bit counter time in GPS = [(40 bit counter – GLAS GPS latch time) * freqbrdscale]*oscillator frequency} + GPS time

c) For each shot, determine the correct leapsecond correction to use from the GPS to UTC Leapsecond File. Compute the laser shot time in UTC by the following equation:

Laser Shot Time in UTC = Laser Shot Time in GPS + Leapseconds + GPStoUTCoffset

Where, Leapseconds is the correction from the GPS to UTC Leapseconds File and GPStoUTCoffset is the offset from the GPS reference time to the UTC reference time.

3) Convert spacecraft time (Bvtcw) to UTC:

a) Correct for the delay in the reported Bvtcw latched to the GPS .1 Hz pulse and the actual Bvtcw latched to the GPS .1 Hz pulse. The Bvtcw GPS latch time is reported in the spacecraft time and position packet contained in GLAS APID 19. To compute the corrected Bvtcw GPS latch time add a spacecraft time calibration offset (Btimeoffset):

Corrected Bvtcw GPS latch time = Bvtcw GPS latch time + Btimeoffset

b) The Corrected Bvtcw GPS latch time corresponds directly to the GPS time in UTC that is in the spacecraft time and position packet.

c) Any spacecraft time (Bvtcw) can be converted to UTC by using the largest Bvtcw GPS latch time less then the Bvtcw by the following equation:

Bvtcw in UTC = (Bvtcw - Corrected Bvtcw GPS latch time) * BvtcwScale + GPS time in UTC

where BvtcwScale is from the Bvtcw to UTC table.

4) Compute Laser Reference System (LRS) Time Tags:

a) Compute the estimated 10 Hz LRS time of the GLAS laser fire command in UTC using the LRS Bvtcw, the LRS increment time tag, and the GPS time. The LRS increment time tag is latched upon the detection of a GLAS fire command signal and provides the precise timing of the LRS data. The LRS Bvtcw and increment time tag are in the spacecraft's Position, Rate, and Attitude Packet (PRAP). The equation is:

estimated LRS fire command time tag in UTC = (LRS Bvtcw – Corrected Bvtcw GPS latch time)*BvtcwScale + GPS time in UTC + LRS increment time tag

b) Apply the delay from the recording of the time of the LRS 10 Hz data to the actual time of the 10 Hz data to get the corrected LRS fire command time. The delay (Lrs_bvtcw_delay) is constant. The equation is:

corrected LRS fire command time in UTC =
estimated LRS fire command time in UTC + Lrs_bvtcw_delay

c) Compute the actual 10 Hz LRS time of the GLAS laser fire command time. Find the nearest (within 12.5 millisecond) actual laser fire command time to the corrected LRS fire command time tag. The time of the LRS 10 Hz sample is the laser fire command time and the LRS Center of Integration (COI) time. The LRS COI time is found in the spacecraft's Position, Rate, and Attitude Packet (PRAP). The equation is:

LRS sample time in UTC = actual laser fire command time + LRS COI time

d) Determine the corresponding GLAS laser shots for the LRS 10Hz data. Find the Laser Shot Time in UTC that is within 12.5 milliseconds of the LRS sample time in UTC for each LRS sample. Assign the LRS sample this shot number and time. Keep all times with the record.

e) The LRS health data shall be assigned the shot and time of the first 10 Hz sample.

f) The LRS star, laser, and Collimated Reference Source (CRS) images correspond to the shot and time for matching frame numbers of the LRS data samples.

5) Convert Instrument Star Tracker (IST) time tags to UTC:

a) Compute the estimated 10 Hz IST time of the GLAS laser fire command in UTC using the IST Bvtcw, the IST increment time tag, and the GPS time. The IST increment time tag is latched upon the detection of a GLAS fire command signal and provides the precise timing of the IST data. The IST Bvtcw and increment time tag are in the spacecraft's Position, Rate, and Attitude Packet (PRAP). The equation is:

estimated IST fire command time tag in UTC = (IST Bvtcw –
Corrected Bvtcw GPS latch time) * BvtcwScale + GPS time in UTC +
IST increment time tag*IST time scale

b) Apply the delay from the recording of the time of the IST 10 Hz data to the actual time of the 10 Hz data to get the corrected IST fire command time. The delay (Ist_bvtcw_delay) is constant. The equation is:

corrected IST fire command time in UTC =
estimated IST fire command time in UTC + Ist_bvtcw_delay

c) Compute the actual 10 Hz IST time of the GLAS laser fire command time. Find the nearest (within 12.5 millisecond) actual laser fire command time to the corrected IST fire command time tag. The time of the IST 10 Hz sample is the laser fire command time and the IST Center of Integration (COI) time. The IST COI time is found in the spacecraft's Position, Rate, and Attitude Packet (PRAP). The equation is:

IST sample time in UTC = actual laser fire command time + IST COI time

d) Determine the corresponding GLAS laser shots for the IST 10Hz data. Find the Laser Shot Time in UTC that is within 12.5 milliseconds of the IST sample time in UTC for each IST sample. Assign the IST sample this shot number and time. Keep all times with the record.

6) Convert the 10 Hz IRU time tags to UTC by the method in step 3 above. The IRU Bvtcw is in the spacecraft's PRAP. Additionally, the IRU BVTCW needs to be adjusted by the delay from the recording of the time of the IRU 10 Hz data to the actual time of the 10 Hz data. The delay (G_bvtcw_delay) is constant. The equation is:

IRU Bvtcw in UTC = (IRU Bvtcw – Corrected Bvtcw GPS latch time) * BvtcwScale + G_bvtcw_delay + GPS time in UTC

7) Convert the Ball Star Tracker (BST) time tags to UTC by the method in step 3 above. There are two BSTs on the ICESat spacecraft. The BST1 and BST2 Bvtcw are in the spacecraft's PRAP. Additionally, the BST BVTCW needs to be adjusted by the delay from the recording of the time of the BST 10 Hz data to the actual time of the 10 Hz data. Each BST has its own delay (B_bvtcw_delay) and the delays are constant. The equation is:

BST Bvtcw in UTC = (BST Bvtcw – Corrected Bvtcw GPS latch time) * BvtcwScale + B_bvtcw_delay + GPS time in UTC

8) Convert the spacecraft quaternion data time tags to UTC by the method in step 3 above. The quaternion data is time tagged by the ADCS Bvtcw found in the PRAP. The ADCS Bvtcw needs to be adjusted by the delay from the recording of the time of the PRAP to the actual time of the quaternion data. The delay (Q_bvtcw_delay) is constant. The equation is:

Quaternion Data Bvtcw in UTC = (ADCS Bvtcw – Corrected Bvtcw GPS latch time)*BvtcwScale + Q_bvtcw_delay + GPS time in UTC

9) The IRU and BST data will not be shot aligned to the GLAS data. Assign to the IRU and BST data the first laser shot time in UTC from the GLAS APID 19 that corresponds to that data.

10) If the GLAS APID 19 is missing, estimate the shot time for events by using the secondary header time from the Altimeter Digitizer science packet (GLAS APID 12 or 13 depending on the surface type). The secondary header time must be corrected such that it corresponds to the time of the first laser shot in the packet. For most of the GLAS packets, the secondary header time corresponds to the last shot in the packet. The nominal time between shots is 25 milliseconds. Use the following equation to estimate the time of a shot:

Estimated Laser Shot Time in UTC =
(estimated shot number -1)*25 ms*freqbrdscale +
Secondary header time corresponding to the first shot in the packet

A.32.3 Basic Algorithm without GPS

1) Compute the LRS 10Hz sample time tags.

a) Compute the time of each 10hz LRS Data pulse in UTC. The LRS data is contained in the spacecraft's PRAP. Convert the LRS Bvtcw (VTCW echo) to UTC using the Bvtcw to UTC table. The LRS Bvtcw must be corrected by the increment (LRS increment time tag) to the GLAS 10 Hz pulse to get the correct time of the latch. Additionally, the LRS BVTCW needs to be adjusted by the delay from the recording of the time of the LRS 10 Hz data to the actual time of the 10 Hz data. The delay (Lrs_bvtcw_delay) is constant. The equation is for each pulse:

LRS data pulse time in UTC = (LRS Bvtcw – Bvtcw from table)*BvtcwScale
+ Bvtcw from table in UTC + LRS increment time tag*LRS Time scale
+ Lrs_bvtcw_delay

Where 'Bvtcw from table' is the largest Bvtcw in the Bvtcw to UTC table just less than the Bvtcw being converted and BvtcwScale is from the Bvtcw to UTC table.

b) The time of the LRS 10 Hz sample is the sum of the LRS data pulse time tag and the LRS Center of Integration (COI) time. The LRS COI time is found in the spacecraft's Position, Rate, and Attitude Packet (PRAP). The equation is:

LRS sample time in UTC = LRS data pulse time in UTC + LRS COI time

2) Convert GLAS Mission Elapsed Time (MET) of spacecraft time and position packet (position and command packet) to UTC using the GLAS MET to UTC conversion table. The GLAS MET of the spacecraft time and position packet is in GLAS APID 19.

3) Compute the estimated fire command time in UTC for 40 shots. Use the fire command time (40 bit counter) of the shot corresponding to the spacecraft time and position packet as the reference point. Since the 1 Gigahertz oscillator is not perfect, the oscillator frequency must be computed and applied to the 40 bit counter data. For each shot the equation is:

Estimated fire command time of shot in UTC = [(fire command time of shot - fire command time of time and position packet)*freqbrdscale] *
oscillator frequency + GLAS MET of time and position packet in UTC

Where freqbrdscale is the oscillator frequency scale factor the converts the counts to seconds. The oscillator frequency is provided by the GLAS instrument operations team.

[Note: Must take care of rollover of shot and fire command time counters]

4) Time align fire command times in UTC to LRS 10 Hz Data pulse times (prior to LRS COI time being applied).

a) Compare estimated fire command times in UTC to the LRS data pulse time in UTC for each pulse. Align a laser shot to an LRS sample when the difference between the times are within a predetermined range of milliseconds. To start the range will be -9 to 24 milliseconds.

b) Check that the shot numbers corresponding to the LRS samples increment by 4 and the LRS data pulse time in UTC increments by about 100 ms. Set error flag if these conditions are not met.

5) Compute the estimated laser shot time in UTC by referencing to the closest matched laser shot/LRS sample pair. The digitizer delay (delay between the fire command time and the start of digitization) and the time from the start of digitization to the transmit pulse peak must be applied. the digitizer delay is provided by the GLAS Instrument Operations team and the time of the transmit pulse peak is contained in the GLAS Altimeter Digitizer packets. The oscillator frequency must also be applied. For each shot:

Corrected laser shot time in UTC = {[(fire command time of shot – fire command time of first match)*freqbrdscale] + transmit pulse peak} * oscillator frequency + LRS data pulse time in UTC of match + digitizer delay

[Note: Must take care of rollover of shot and fire command time counters.]

6) Determine the corresponding GLAS laser shots for the LRS 10 Hz data and LRS star, laser, and CRS images by the same method used in “Basic Algorithm with GPS”, Appendix A.32.2 steps 4.d, 4.e, and 4.f.

7) Compute the 10 Hz IST Data sample times in UTC. The IST data is contained in the spacecraft’s PRAP.

a) Convert the IST Bvtcw (VTCW echo) to UTC using the Bvtcw to UTC table. The IST Bvtcw must be corrected by the increment (IST increment time tag) to the GLAS 10 Hz pulse to get the correct time of the sample. Additionally, the IST BVTCW needs to be adjusted by the delay from the recording of the time of the IST 10 Hz data to the actual time of the 10 Hz data and the IST Center of Integration (COI) time. The delay (Ist_bvtcw_delay) is constant. The IST COI time is found in the spacecraft’s Position, Rate, and Attitude Packet (PRAP). The equation is for each sample:

   IST data sample times in UTC = (IST Bvtcw – Bvtcw from table)*BvtcwScale+ Bvtcw from table in UTC + IST time tag*IST time scale + Ist_bvtcw_delay + IST COI time

   Where Bvtcw from table is the largest Bvtcw in the Bvtcw to UTC table just less than the Bvtcw being converted and BvtcwScale is from the Bvtcw to UTC table.

b) Determine the corresponding GLAS laser shots for the IST 10 Hz data by the same method used in “Basic Algorithm with GPS”, Appendix A.32.2 step 5.d.

8) Convert IRU Bvtcw to UTC using the Bvtcw to UTC table. Additionally, the IRU BVTCW needs to be adjusted by the delay from the recording of the time of the IRU 10 Hz data to the actual time of the 10 Hz data. The delay (G_bvtcw_delay) is constant. The equation is:

IRU Bvtcw in UTC = (IRU Bvtcw – Bvtcw from table)*BvtcwScale + G_bvtcw_delay + Bvtcw from table in UTC

Where Bvtcw from table is the largest Bvtcw in the Bvtcw to UTC table just less than the Bvtcw being converted and BvtcwScale is from the Bvtcw to UTC table.

9) Convert BST Bvtcw to UTC using the Bvtcw to UTC table. Additionally, the BST BVTCW needs to be adjusted by the delay from the recording of the time of the BST 10 Hz data to the actual time of the 10 Hz data. Each BST has its own delay (B_bvtcw_delay) and the delays are constant.:

BST Bvtcw in UTC = (BST Bvtcw – Bvtcw from table)*BvtcwScale + B_bvtcw_delay + Bvtcw from table in UTC

Where Bvtcw from table is the largest Bvtcw in the Bvtcw to UTC table just less than the Bvtcw being converted and BvtcwScale is from the Bvtcw to UTC table.

10) Convert spacecraft's quaternion data Bvtcw to UTC using the Bvtcw to UTC table. The quaternion data is time tagged by the Bvtcw from the spacecraft's PRAP secondary header. Additionally, the PRAP secondary header time (Bvtcw) needs to be adjusted by the delay from the recording of the time of the PRAP to the actual time of the quaternion data. The delay (Q_bvtcw_delay) is constant. The equation is:

Quaternion Data Bvtcw in UTC = (PRAP Bvtcw – Bvtcw from table) * BvtcwScale + Q_bvtcw_delay + Bvtcw from table in UTC

Where Bvtcw from table is the largest Bvtcw in the Bvtcw to UTC table just less than the Bvtcw being converted and BvtcwScale is from the Bvtcw to UTC table.

11) The IRU and BST data will not be shot aligned to the GLAS data. Assign to the IRU and BST data the first laser shot time in UTC from the GLAS APID 19 that corresponds to that data.

12) If the GLAS APID 19 is missing, compute the estimated laser shot time in UTC by the same method used in "Basic Algorithm with GPS", Appendix A.32.2 step 10.

Appendix B
GLAS Telemetry Description

The format of the GLAS telemetry files are documented on the GLAS WFF web site.

To reach the GLAS telemetry files via the internet, use the URL:

http://glas.wff.nasa.gov/index.php?module=documents&JAS_DocumentManager_op=categories&category=11

Summary pages listing the telemetry packets are included in this appendix.

Rev B

GLAS Science Telemetry Packets

Pkt Name	App id	Size	Pkt Freq.	Pkt Interval	Rate	Output to			Confidence	CCSDS Primary
		in bytes	in Hertz	in seconds	bps	SSR	1553 Bus		In contents	Header
	decimal						HK	Diag	H, M, L	hex
Altimeter Digitizer Data-Large	12	6856	4	0.25	219392.0	Yes	No	No	High	#NAME?
Altimeter Digitizer Data-Small	13	3416	4	0.25	109312.0	Yes	No	No	High	#NAME?
AD Eng Mode - One Shot	14	700	1	1		Yes	No	No	High	#NAME?
Photon Counter (PC) Science Pkt	15	8112	1	1	64896.0	Yes	No	No	High	#NAME?
PC Eng Pkt	16	8236	1	1		Yes	No	No	High	#NAME?
Cloud Digitizer (CD) Science Pkt	17	7576	1	1	60608.0	Yes	No	No	High	#NAME?
CD Eng Pkt	18	5616	1	1		Yes	No	No	High	#NAME?
Ancilary Science Pkt	19	1368	1	1	10944.0	Yes	No	No	High	#NAME?
LPA Data Pkt	26	4056	4	0.25	129792.0	Yes	No	No	High	#NAME?
Command History Packet	49	296	Async			Yes	No	No		#NAME?
Spare	40									
LPA 80x80 Test Data Pkt	126	6416	Async			Yes	No	No	High	#NAME?
Boresite Calibration Results Pkt	38	1816	Async			Yes	No	No	High	#NAME?
				Total Rate*	436096.0	**bps**				

*** This total assumes a 55%-45% distribution betwee Alt. Digitizer Large and Small Data Packets and does NOT include 1553, Asynchronous Data Packets, Gyro or LRS Data**

Notes:
1- The size of all packets going to the SSR must be a multiple of 4, This is because the FIFO width is 32 bits
2- Max Packet Size to SSR is 16 Kbytes. This is the size of the FIFO
3- LPA 80x80Test Packet is not use during Flight, but only for integration

1- Mnemonics use only 'G' as prefix to indicate GLAS(instead of the GL)
2- Mnemonics for the CCSDS header are not in spreadsheet.

Suggested Mnemoncic names are	Bits	Word	Mask
GPxxxPVNO	0..2	1st	0xE000
GPxxxPCKT	3	1st	0x1000
GPxxxSHDF	4	1st	0x0800
GPxxxID	5..15	1st	0x07FF
GPxxxSEGF	0..1	2nd	0xC000
GPxxxSCNT	2..15	2nd	0x3000
GPxxxPLEN	0..15	3rd	0xFFFF
GPxxxSTIME		4th..7th	

where xxx is the app id in hex
3- The shot counter is only a 8 bit counter. Where it is depicted as a two or four octet entity it contains padding in the upper bytes.

Filename: GLAS-582-SPEC-002-B7.xls Page 1 of 1 Worksheet: Summary

Rev A

GLAS Housekeeping and Diagnostic Telemetry Packets

Pkt Name	App id	Size in bytes (max)	Pkt Freq. in Hertz	Pkt Interval in seconds	Rate bps	Output to SSR	Output to 1553 Bus HK	Output to 1553 Bus Diag	Confidence In contents H, M, L	CCSDS Primary Header hex	Data uses SA Range	Output by Task
CT HW Tlm#1	20	56	0.25	4	112	Yes	Yes	No	High	#NAME?	1	CT
CT HW Tlm#2	21	56	0.25	4	112	Yes	Yes	No	High	#NAME?	1	CT
CT HW Tlm#3	22	56	0.0625	16	28	Yes	Yes	No	High	#NAME?	1	CT
CT HW Tlm#4	23	56	0.0625	16	28	Yes	Yes	No	High	#NAME?	1	CT
CT HW Tlm#5	50	56	0.03125	32	14	Yes	Yes	No	High	#NAME?	1	CT
Small Software #1 Tlm	24	56	0.25	4	112	Yes	Yes	No	High	#NAME?	1	HS
Large Software Tlm #1	25	300	0.25	4	600	Yes	No	Yes	High	#NAME?	3..10	HS
Large Software Tlm #2	55	376	0.25	4	752	Yes	No	Yes	High	#NAME?	3..10	HS
DSP Code Memory Dump	31	828	Async[1]			Yes	No	No	High	#NAME?	3..10	AD
DSP Data Memory Dump	32	828	Async[1]			Yes	No	No	High	#NAME?	3..10	AD
C&T Dwell Packet	33	336	Async[2]			Yes	No	Yes	High	#NAME?	3..10	CT
Memory Dwell Packet #1	27	276	Async[3]			Yes	No	Yes	Low	#NAME?	3..10	MD
Memory Dwell Packet #2	28	276	Async[3]			Yes	No	Yes	Low	#NAME?	3..10	MD
Event Message	34	80	Async			Yes	No	Yes	High	#NAME?	3..10	HS
Memory Dump	35	224	Async[4]			Yes	No	Yes	High	#NAME?	3..10	SM
Table Dump	36	224	Async[4]			Yes	No	Yes	High	#NAME?	3..10	SM
Etalon Calibration	37	492	Async[5]			Yes	No	No	Low	#NAME?	3..10	CT
GLAS Data Types Packet	48	72	Async			Yes	No	No	High	#NAME?	3..10	DC
	Synchronous HK 1553 Bus Data Rate				**406**	**bps**			**Max HK Bandwitdh**	**448**	**bps**	
	Synchronous DIAG 1553 Bus Data Rate				**1352**	**bps**			**Max DIAG Bandwidth**	**11,808**	**bps**	

(1) - These Packets are produced at a 4 pkts per second rate when AD is in Idle mode
(2) - This packet will be output at a 4 second interval when one of the C&T Boards is in dwell mode.
(3) - During a Memory Dwell the rate for these packets is commandable from 0.5 sec packet interval to 32 secs. MD is NOT in Build 3.0
(4) - During memory or table dumps these packets will be output at a max 1 packets per second rate
(5) - This packet is not currently in use, but might be so in Build 3.1

GLAS Housekeeping and Diagnostic Telemetry Packets

NOTES:

1- The size of all packets must be a multiple of 4, This is because the SSR FIFO width is 32 bits and all packets go to the SSR

2- Max Packet Size to SSR is 16 Kbytes. This is the size of the SSR interface FIFO

3- 1553 Diag channel packets will be output to 1553 Bus interface and continually read by the Bus Controller, but only in GLAS Diagnostics mode (16 kbps) will they be telemetered to the Ground

4- Mnemonics use only 'G' as prefix to indicate GLAS(instead of the GL)

5- Mnemonics for the CCSDS header are not in spreadsheet, but

Suggested Mnemoncic names are:	Bits	Word	Mask
GPxxxPVNO	0..2	1st	0xE000
GPxxxPCKT	3	1st	0x1000
GPxxxSHDF	4	1st	0x0800
GPxxxID	5..15	1st	0x07FF
GPxxxSEGF	0..1	2nd	0xC000
GPxxxSCNT	2..15	2nd	0x3000
GPxxxPLEN	0..15	3rd	0xFFFF
GPxxxSTIME		4th..7th	

where xxx is the app id in hex zero padded

6-Telemetry Points which are at the same offset and have a mask associated with them indicate that the telemetry point consists of only the bits in the mask

7- The Shot Counter is always a 8 bit counter, where depicted as an 2 or 4 byte entity there is padding in the upper bytes

Appendix C

Background Information for Time Tagging Algorithm

C.1 Information

1) There are 2 data types or streams downlinked from the GLAS instrument: science and engineering. The science data contain the science measurements recorded by GLAS and the parameters calculated by the flight software algorithm. Also, included in the science data are commanded flight software parameters. The GPS packet and the spacecraft Position, Rate, and Attitude Packet (PRAP) are science data collected and downlinked directly by the spacecraft. The engineering data contain the instrument health and status data including temperatures, currents, and software status indicators. There are several types of packets within each data type. These packets are defined by their APID (Application ID). The raw ICESat telemetry dumps are processed by EDOS to remove redundant packets and create data files on even 6 hour boundaries for each APID. Table C-1 "APIDs used by Normal I-SIPS Processing" lists the science and engineering data that is normally ingested by the I-SIPS to perform the GLAS data processing. As shown in the table, the Altimeter Digitizer has two different APIDs (12 and 13) but during any one second only one APID will exist.

Table C-1 APIDs used by Normal I-SIPS Processing

APID	Packet Name	Data Type	Frequency (/ = per)	Secondary Header Time
19	Ancillary Science	Science	1 per second	MET
12	Altimeter Digitizer (AD)-Large	Science	4 per second	MET
13	Altimeter Digitizer-Small	Science	4 per second	MET
14	AD Engineering	Science	1 per second*	MET
15	Photon Counter (PC) Science	Science	1 per second	MET
16	PC Engineering	Science	1 per second*	MET
17	Cloud Digitizer (CD) Science	Science	1 per second	MET
18	CD Engineering	Science	1 per second*	MET
26	LPA Data	Science	4 per second	MET
1088	GPS	Science	1 per 10 seconds	BVTCW
1984	PRAP	Science	1 per second	BVTCW
20	CT HW 1	Engineering	1 per 4 seconds	MET
21	CT HW 2	Engineering	1 per 4 seconds	MET

Table C-1 APIDs used by Normal I-SIPS Processing (Continued)

APID	Packet Name	Data Type	Frequency (/ = per)	Secondary Header Time
22	CT HW 3	Engineering	1 per16 seconds	MET
23	CT HW 4	Engineering	1 per16 seconds	MET
24	Small Software	Engineering	1 per 4 seconds	MET
25	Large Software 1	Engineering	1 per 4 seconds	MET
50	CT HW 5	Engineering	1per 32 seconds	MET
55	Large Software 2	Engineering	1 per 4 seconds	MET
* When particular board is commanded to engineering mode				

2) The Ancillary Science packet is always output from GLAS, but for AD, CD, and PC either science or engineering exists but not both. However at any time any packet may be lost from the telemetry stream during data transmission.

3) A number of diagnostic packets from the engineering data stream will need to be accommodated. The diagnostic packets are sent upon request and will not appear regularly in the stream.

4) GLAS packets contain the GLAS Mission Elapsed Time (MET) in their secondary header. GLAS science packets are synchronized.

5) As part of the initial telemetry data processing (GL0P - GLAS Level 0 Processing) by the I-SIPS, an index number is assigned for each received ancillary science packet. All other GLAS APIDs that correspond time-wise (using the secondary header) to that ancillary science packet will be assigned the same index number. Subsequent processing can align the data by the index number.

6) GLAS science packets also contain the shot counter in order to exactly align the data, however this counter rolls over every 5 seconds (200 shots) so the secondary header time must be used for initial alignment.

7) GLAS engineering packets occur at various rates as shown in Table C-1. These are considered asynchronous to the science packets but are output on fixed shot counts. The initial telemetry processing assigns to the GLAS engineering data the index number of the GLAS APID 19 record that has a MET that is greater than the MET of the engineering data (less than 1, 4, 16, or 32 seconds before).

8) GPS and PRAP packets are asynchronous.

9) The latched BVTCW at GPS time and the GPS time are provided in the PRAP (Position, Rate, and Attitude Packet) and in the spacecraft time and

position packet which is contained in the GLAS APID 19 (Ancillary science).

10) In addition to secondary header time, GLAS APID 19 contains: shot counter, Fire command time and fire acknowledge time (40 bit counters), GPS time, GLAS frequency and time board time latched to GPS time (40 bit counter), BVTCW at GPS time, BVTCW of spacecraft position and time packet, GLAS MET near spacecraft position and time packet, and shot near spacecraft position and time packet.

11) In the spacecraft position and time packet (contained in GLAS APID 19) the GPS time and Bvtcw at GPS time pair are repeated for about 10 packets (~10 seconds). The other position packet parameters (Bvtcw for the position packet, GLAS MET and shot number near the position packet) update each second. The Bvtcw of the position packet has a small delay offset. The GLAS MET and shot number near the position packet are not absolute; these values are the latest available when the packet is received.

12) The GLAS frequency and time board time latched to GPS time appears in the GLAS APID 19 after the GPS pulse. It will be repeated for about 10 times (~10 seconds). This time must be matched to the correct GPS time of the pulse in order to convert the 40 bit counter to UTC.

13) The correct GPS time (and its latched Bvtcw) will appear in the position and time packet, contained in GLAS APID 19, approximately 10 seconds after the pulse (the Bvtcw of the position and time packet is about 10 seconds past Bvtcw latched to the GPS time).

14) The GPS/DEM information contained in GLAS APID19 is used for data collection in the next frame. Therefore, the time of this data is one second later than the time of the altimeter digitizer task data contained in GLAS APID19. See Appendix D for packet timing details.

15) The LRS and IST receive a 10 hz signal from the GLAS that requires alignment to the exact laser shot. The LRS And IST are contained in the spacecraft's PRAP. The time of the PRAP is not synchronized to the 1/second GLAS data. The index number assigned to the PRAP during initial telemetry processing provides alignment to GLAS APID 19 within two (three?) records (seconds).

16) The ISF will maintain the GLAS MET close to the spacecraft time (Bvtcw).

17) The Bvtcw will be maintained by the ICESat Mission Operations Center (MOC) to be close to continuous during the mission. MOC will reset Bvtcw after power off and for drift to maintain spacecraft time to about 3 milliseconds.

C.2 Problems to Consider:

1) For a second, some packet types may be missing when others are available.

2) At the start of a PDS or EDS any packet type may be the earliest UTC and the 4hz AD science packet set may be separated (1,2, or 3 packets at the beginning or end).
3) After time gap of all packets, any packet type may be present first.
4) ISF provides the correction table for GLAS MET. MET is a software counter therefore it increments the exact number of counts for each laser shot for a perfect 40 hz timing. It therefore will not be true time that accounts for any oscillator drift. The correction table will account for MET losses during:

- GLAS processor resets - The MET will lose some “ticks” during a reset.
- GLAS warm reboots - the MET counter attempts to keep the time (counter) but will lose a few pulse interrupts (ticks) so will “miss” time (for example if two pulses are missed the time will increment by 25 msec but really 75 ms will have really elapsed).

5) Since GLAS engineering packets occur asynchronously to the science packets are their any issues with assigning the index number to the engineering packets? (Need to determine if any smoothing needed on engineering).

C.3 Telemetry Definitions

For the GLAS Science Telemetry Definition and GLAS Engineering Telemetry Definition, see Appendix B. A high level description of the spacecraft’s Position, Rate, and Attitude Packet is contained in Table C-2 "Format of PRAP". The detailed description of the PRAP is contained in the Details of the PRAP contents are defined in the *Data Interface Control Document between the ICESat Spacecraft and the EOS Ground System (EGS)*, listed in Section 5. The format of the spacecraft’s position and time packet is shown in Table C-3 "Time and Position Message Packet Description" on page C-5.

Table C-2 Format of PRAP

Item	Size (Bytes)	Samples/ Sec	# Bytes	Cumulative Bytes
VTCW	6	1	6	6
VTCW IRU Time Tag	6	10	60	66
IRU Data	14	10	140	206
VTCW BST1 Time Tag	6	10	60	266
BST1 Data	60	10	600	866
VTCW BST2 Time Tag	6	10	60	926
BST2 Data	60	10	600	1526
IST VTCW Echo	6	10	60	1586
IST Data	64	10	640	2226

Table C-2 Format of PRAP (Continued)

Item	Size (Bytes)	Samples/ Sec	# Bytes	Cumulative Bytes
IST Health	10	10	100	2326
LRS VTCW Echo	6	10	60	2386
LRS Data	64	10	640	3026
LRS Health	4	1	4	3030
LRS Star Image	512	5	2560	5590
LRS Laser Image	512	4	2048	7638
LRS CRS Image	512	1	512	8150
Estimated Quaternion	8	1	8	8158
Estimated Position (x,y,z) - 4xf32	6	1	6	8164
Estimated Rate (x,y,z) - 3xf32	6	1	6	8170
Solar Array Position - 2xf32	4	1	4	8174
GPS Receiver Time	4	1	4	8178
VTCW latched to GPS	6	1	6	8184

Table C-3 Time and Position Message Packet Description

Description	Word
CCSDS Header (hex value = 180F)	0
CCSDS Header (hex value = C000)	1
CCSDS Header (hex value = 002B)	2
CCSDS Header (hex value = 0A00)	3
BVTCW - Most Significant Word (us)	4
BVTCW - Mid Significant Word (us)	5
BVTCW - Least Significant Word (us)	6
ECEF Position (Km) – Vector 1 –X - double	7
ECEF Position (Km) – Vector 1–X – double	8
ECEF Position (Km) – Vector 1–X – double	9
ECEF Position (Km) – Vector 1–X – double	10
ECEF Position (Km) – Vector 2–Y - double	11

Table C-3 Time and Position Message Packet Description (Continued)

Description	Word
ECEF Position (Km) – Vector 2–Y – double	12
ECEF Position (Km) – Vector 2–Y – double	13
ECEF Position (Km) – Vector 2–Y – double	14
ECEF Position (Km) – Vector 3–Z - double	15
ECEF Position (Km) – Vector 3–Z – double	16
ECEF Position (Km) – Vector 3–Z – double	17
ECEF Position (Km) – Vector 3–Z - double	18
GPS Rcvr Time (Seconds) - unsigned long int	19
GPS Rcvr Time (Seconds) – unsigned long int	20
BVTCW@ 0.1 Hz pulse - Most Significant Word (us)	21
BVTCW@ 0.1 Hz pulse - Mid Significant Word (us)	22
BVTCW@ 0.1 Hz pulse - Least Significant Word (us)	23
Note1: This message is time-tagged when sent, which is within 300 msec of when the position data is valid. Note2: The position message in GLAS APID 19 does not include the CCSDS header.	

Appendix D

GLAS Science Packets Synchronization and Alignment Information

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER

ICESAT GLAS Flight Software

GLAS Science Packets Synchronization and Alignment

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Overview

This document describes when and how often Science and Ancillary data is collected and how this data correlates with each other. For more information regarding the contents of each packet see the GLAS SCIENCE TELEMETRY PACKETS DEFINITION DOCUMENT (GLAS-582-SPEC-002).

GLAS Science Packets

The following Science packets are generated by the GLAS flight software.

Photon Counter Science Packet

The Photon Counter task generates 1 Photon Counter Science Packet per second while the task is in Science Mode. This packet contains 40 shots of data. The Science packet is time stamped when the packet is sent; on the 40^{th} shot. The shot counter is recorded on the first shot of the frame.

Photon Counter Engineering Packet

The Photon Counter task generates 1 Photon Counter Engineering Packet per second while the task is in Engineering Mode. This packet contains 15 shots of data. The Engineering packet is time stamped when the packet is sent; on the 40^{th} shot. The shot counter is recorded on the first shot of the frame.

Cloud Digitizer Science Packet

The Cloud Digitizer task generates 1 Cloud Digitizer Science Packet per second while the task is in Science Mode. This packet contains 40 shots of data. The Science packet is time stamped when the packet is sent; on the 40^{th} shot. The shot counter is recorded on the first shot of the frame.

Cloud Digitizer Engineering Packet

The Cloud Digitizer task generates 1 Cloud Digitizer Engineering Packet per second while the task is in Engineering Mode. This packet contains 20 shots of data. The Engineering packet is time stamped when the packet is sent; on the 40^{th} shot. The shot counter is recorded on the first shot of the frame.

Altimeter Digitizer Science Packet

The Altimeter Digitizer task generates four Altimeter Digitizer Science packets per second while the task is in Science mode. Each science packet contains 10 shots of science data. Each shot of science data contains the shot counter value indicating the shot in which the data was sampled. The Altimeter Digitizer science packets are time stamped when the packet is sent; on the 10^{th}, 20^{th}, 30^{th}, and 40^{th} shots.

LPA Data Packet

The DC&H task generates four LPA Data packets per second while the task is in SSR_LPA mode. The LPA packet is time stamped when the packet is sent; on the 10^{th}, 20^{th}, 30^{th}, and 40^{th} shots. There are ten shots of LPA data per packet and the shot count is recorded separately for each shot in the packet.

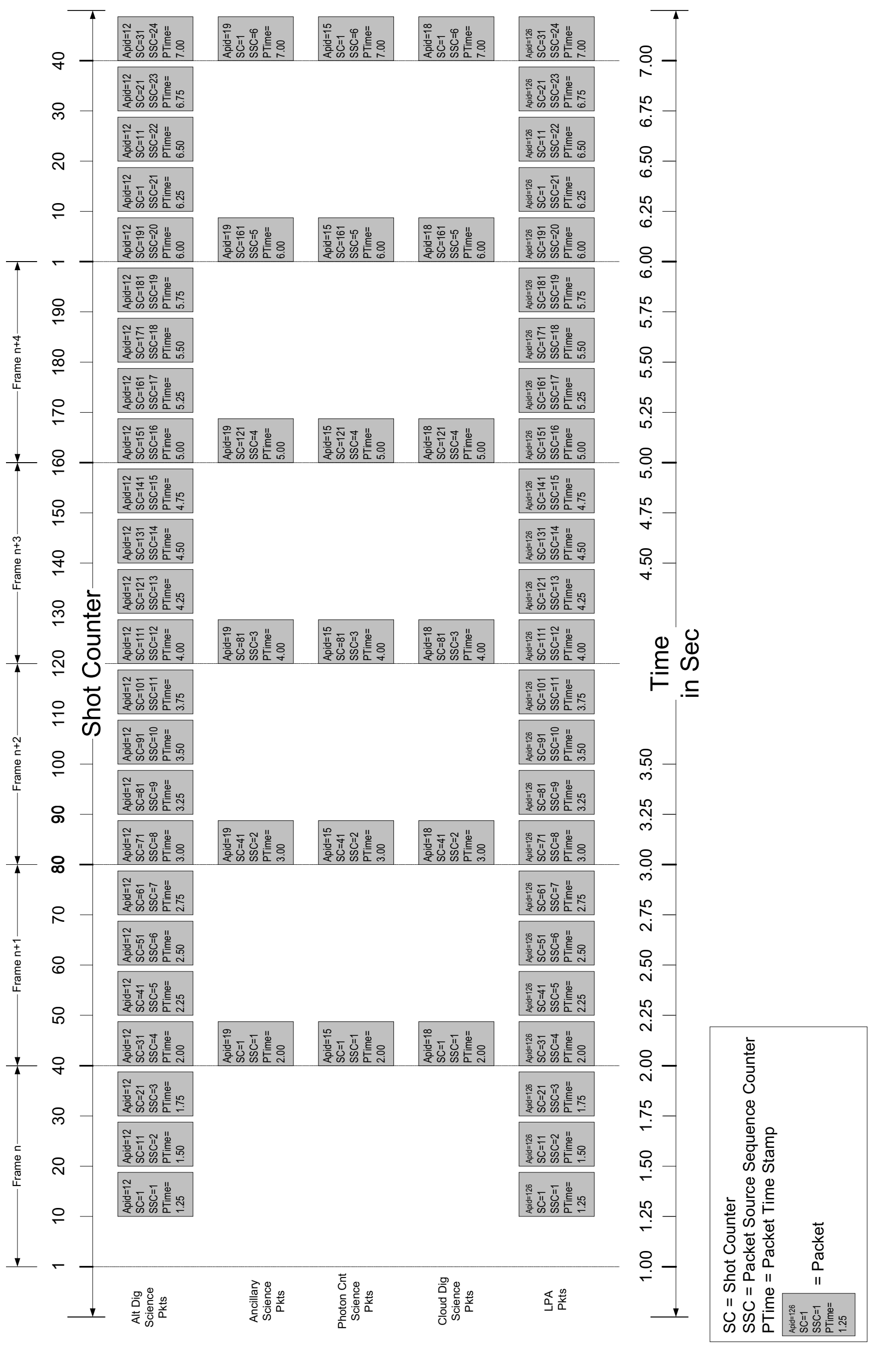
Ancillary Data Packet

The Ancillary packet is generated once per second by the CT Task while the task is in NORMAL mode. The Ancillary packet is time stamped when it is sent; on the 40th shot. The Ancillary packet is a combination of data collected by various tasks. Each task that contributes to the ancillary packet will send it's portion of the ancillary data to the CT task every second. The CT task will then collect the various pieces of ancillary data and combine them together into one packet. Not all tasks will provide ancillary data all the time. That will depend on the current mode of the task. A flag in the ancillary packet indicates which tasks have contributed data to the current combined ancillary packet. The following table describes in what mode each task generates ancillary telemetry.

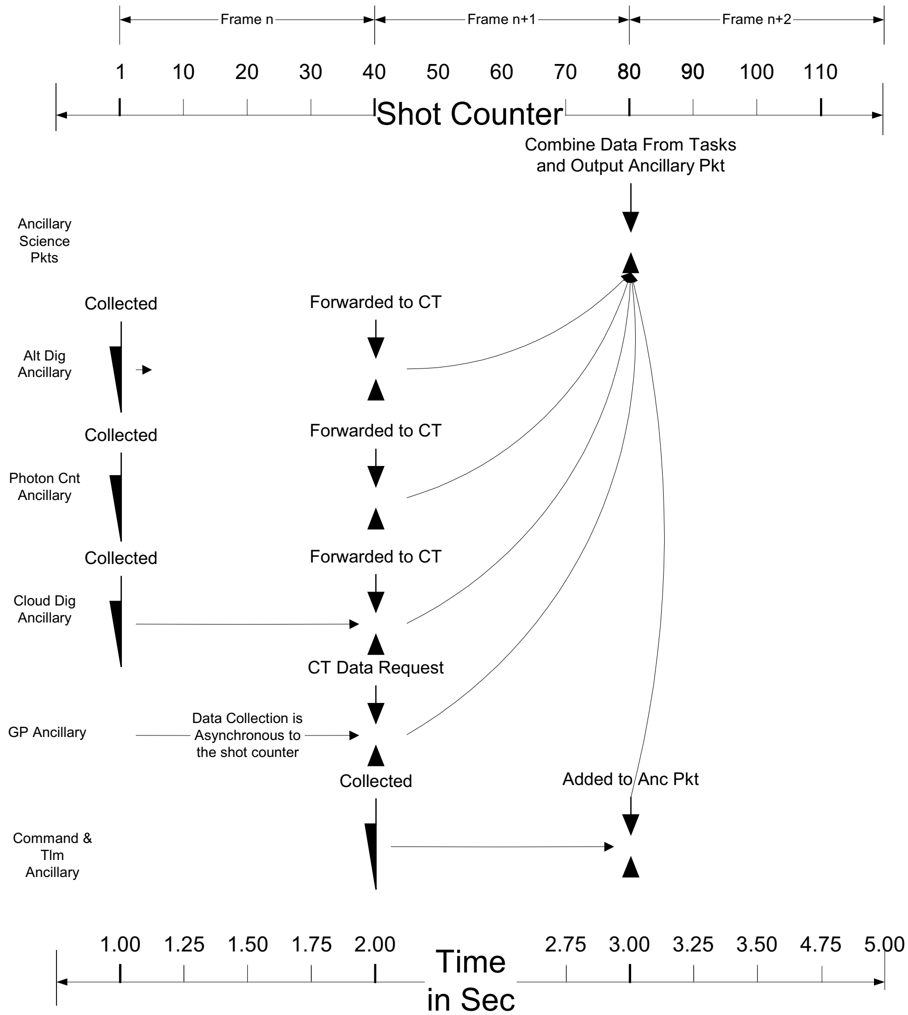
Task	Mode	Generates Ancillary Data
Photon Counter	Idle	No
	Science	Yes
	Engineering	Yes
	Boresite Cal	No
	Memory Test	No
Altimeter Digitizer	Idle	No
	Science	Yes
	1-Shot	Yes (Only 1 packet)
	Load	No
	Dump	No
Cloud Digitizer	Idle	Yes
	Science	Yes
	Engineering	Yes
	Memory Test	No
DC&H	SSR	No
	SSR_LPA	No
	Test	No
CT	Manual	No
	Normal	Yes
GP	N/A	Always sends when requested by CT

Timing Relationship Between Different Science Packets

The diagram below shows graphically the relationship between when each science packet is generated.



Synchronizing the Ancillary packet with it's corresponding Science packets can be confusing because Science Data is collected at different rates and the Ancillary Packet is output at a different time than it's corresponding Science Packets. The diagram below shows graphically when each task collects it's portion of the ancillary in relation to when the ancillary packet is output by the CT task.



Notes:
Altimeter Digitizer Ancillary:

- Ancillary telemetry is collected during the first 4 shots of the frame.
- Ancillary telemetry is stamped with the shot count value for the first shot in the frame where the data is collected.
- Ancillary telemetry is collected during the first shot of the frame in 1-Shot mode.
- Only one ancillary telemetry packet is generated in 1-Shot mode.
- Ancillary data is forwarded to CT on the 40th shot.

Photon Counter Ancillary:

- Collected on shot 1 in Science and Engineering modes.
- Ancillary telemetry is stamped with the shot count value for the first shot in the frame where the data is collected.
- Ancillary data is forwarded to CT on the 40th shot.

Cloud Digitizer Ancillary:

- Fire Cmd, Fire Ack, and GPS 10 Second Pulse forty bit counters are collected on every shot in all modes.
- The rest of the CD ancillary data is collected on shot 1 in Science and Engineering modes.
- Ancillary telemetry is stamped with the shot count value for the first shot in the frame where the data is collected.
- Ancillary data is forwarded to CT on the 40th shot.

GP Ancillary:

- GPS collects the GPS 40 bit counter from the CD task every 10 seconds upon the receipt of the GPS 10 second pulse. This 40 bit counter corresponds to the last 10 second GPS pulse and is included as part of GP's ancillary telemetry.
- Position/Range data is also part of GP's ancillary telemetry and is updated every second.
- GP will only send ancillary data to the CT task when it receives a ancillary telemetry request packet from CT.

CT Ancillary:

- Etalon status information is collected on shot 1.
- Dual pin A, B and 532 energy data is collected on every shot.
- CT requests ancillary data from the GP task on the 40th shot. All other tasks automatically forward the data to CT on the 40th shot.
- CT adds the new ancillary data from the other tasks to the combined ancillary packet on the 20th shot.
- CT adds it's own piece of the ancillary data to the combined ancillary packet on the 40th shot.
- Since CT is the sender of the ancillary packet it's own ancillary data is collected on the current frame where the other tasks data is collected on the previous frame.

DC&H does not contribute to the ancillary telemetry

Abbreviations & Acronyms

APID	Application Process Identifier. CCSDS Packets identify the APID as supplied by the Spacecraft Instrument; EDOS identifies the APID as a concatenation of Spacecraft Identification (SCID) and the APID.
CCSDS	Consultative Committee for Space Data Systems
EDOS	EOS Data and Operations System
EOS	NASA Earth Observing System Mission Program
EOSDIS	Earth Observing System Data and Information System
GLAS	Geoscience Laser Altimeter System instrument or investigation
GPS	Global Positioning System
GSFC	NASA Goddard Space Flight Center at Greenbelt, Maryland
GSFC/WFF	NASA Goddard Space Flight Center/Wallops Flight Facility at Wallops Island, Virginia
HK	Housekeeping
ID	Identification
LASER	Light Amplification by Stimulated Emission of Radiation
LIDAR	Light Detection and Ranging
LPA	LASER Profiler Array
N/A	Not (/) Applicable
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
PDS	Production Data Sets
PDU	
POD	Precision Orbit Determination
PROD ID	Data Product Identification
SCF	GLAS investigation Science Computing Facility and workstation(s)
SRS	Stellar Reference System
TBD	to be determined, to be done, or to be developed
TLM	Telemetry
UNIX	the operating system jointly developed by the AT&T Bell Laboratories and the University of California-Berkeley System Division

Glossary

Level 0	The level designation applied to an EOS data product that consists of raw instrument data, recorded at the original resolution, in time order, with any duplicate or redundant data packets removed.
Level 1A	The level designation applied to an EOS data product that consists of reconstructed, unprocessed Level 0 instrument data, recorded at the full resolution with time referenced data records, in time order. The data are annotated with ancillary information including radiometric and geometric calibration coefficients, and georeferencing parameter data (i.e., ephemeris data). The included, computed coefficients and parameter data have not however been applied to correct the Level 0 instrument data contents.
Level 1B	The level designation applied to an EOS data product that consists of Level 1A data that have been radiometrically corrected, processed from raw data into sensor data units, and have been geolocated according to applied georeferencing data.
Level 2	The level designation applied to an EOS data product that consists of derived geophysical data values, recorded at the same resolution, time order, and georeference location as the Level 1A or Level 1B data.
Level 3	The level designation applied to an EOS data product that consists of geophysical data values derived from Level 1 or Level 2 data, recorded at a temporally or spatially resampled resolution.
Level 4	The level designation applied to an EOS data product that consists of data from modeled output or resultant analysis of lower level data that are not directly derived by the GLAS instrument and supplemental sensors.
product	Specifically, the Data Product or the EOS Data Product. This is implicitly the labeled data product or the data product as produced by software on the SDPS or SCF. A GLAS data product refers to the data file or record collection either prefaced with a product label or standard formatted data label or linked to a product label or standard formatted data label file. Loosely used, it may indicate a single pass file aggregation, or the entire set of product files contained in a data repository.
record	A specific organization or aggregate of data items. It represents the collection of EOS Data Parameters within a given time interval, such as a one-second data record. It is the first level decomposition of a product file.