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Algorithm Theoretical Basis Document (ATBD) For ATLAS Level 1A Processing

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Abstract

This document describes the theoretical basis of the Level 1A processing algorithms and the L1A product that is produced by the ICESat-2 mission. It includes descriptions of the parameters that are provided and the derivation of these ICESat-2 parameters.

CM Foreword

This document is an Ice, Cloud, and Land Elevation (ICESat-2) Project Science Office controlled document. Changes to this document require prior approval of the Science Development Team ATBD Lead or designee. Proposed changes shall be submitted in the ICESat-II Management Information System (MIS) via a Signature Controlled Request (SCoRe), along with supportive material justifying the proposed change.

In this document, a requirement is identified by “shall,” a good practice by “should,” permission by “may” or “can,” expectation by “will,” and descriptive material by “is.”

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Preface

This document is the Algorithm Theoretical Basis Document for the ATLAS Level 1A processing to be implemented at the ICESat-2 Science Investigator-led Processing System (SIPS). The SIPS supports the ATLAS (Advance Topographic Laser Altimeter System) instrument on the ICESat-2 Spacecraft and encompasses the ATLAS Science Algorithm Software (ASAS) and the Scheduling and Data Management System (SDMS). The science algorithm software will produce Level 1 through Level 3 standard data products as well as the associated product quality assessments and metadata information.

The ICESat-2 Science Development Team, in support of the ICESat-2 Project Science Office (PSO), assumes responsibility for this document and updates it, as required, to meet the needs of the ICESat-2 SIPS. Reviews of this document are performed when appropriate and as needed updates to this document are made. Changes to this document will be made by complete revision.

Changes to this document require approval of the Change Authority listed on the signature page. Proposed changes shall be submitted to the ICESat-2 PSO, along with supportive material justifying the proposed change. The PSO will submit the ATBD to the ICESat-2 MIS as a SCoRe.

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Change History Log

Revision Level	DESCRIPTION OF CHANGE	SCoRe No.	Date Approved
1.0	Initial Release		
2.0	Updated November 2017. Changes reflect as build code and shown as tracked changes with in the text.		

List of TBDs/TBRs

Item No.	Location	Summary	Ind./Org.	Due Date

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1.0 INTRODUCTION

This Algorithm Theoretical Basis Document (ATBD) describes the processing to create the Decommutated Telemetry Level 1A (L1A) data product (ATL01) from the ATLAS Level 0 (L0) data (ATL00) received from EOS Data and Operations System (EDOS) and include the spacecraft ancillary science data packets. The ICESat-2 ATL01 product output by this process is an HDF5 formatted version of all of the ICESat-2 Level 0 data and will be used as input for higher-level science data processing.

Section 2 provides an overview of the decommutation process and more detail on the parameters that reside in the product.

Section 3 provides a more in-depth description of the algorithms used in the derivation of the L1A product.

Section 4 describes the specific implementations of the algorithms that are relevant to the development of the processing code. Included here are inputs, outputs and algorithmic details.

Section 5 provides the processing requirements for data quality monitoring and control. There are quality assessments of the key parameters to provide criteria for automatic quality control to facilitate timely distribution of the product to the higher level processing and users. Summary statistics or images that allow users to easily evaluate (or Browse) whether the data would be useful and of quality for their research. Also the summaries aid in the quick approval or disapproval of data products to public distribution.

Section 6 describes the testing and validation procedures that are planned.

2.0 OVERVIEW AND BACKGROUND INFORMATION

The initial process in the conversion of raw telemetry data to science enabling products is the Level 1A conversion described herein. The process takes the science (X-band telemetry from the spacecraft) downlinked Application Packet IDs (APIDs) from the EDOS Level Zero Processing Facility (LZPF), decompresses, time aligns, and reformats the data to HDF5 and creates the Level 1A ICESat-2 ATL01 product. The APIDs include all the ATLAS Science data (including laser Reference System, LRS) and the Spacecraft science ancillary data. The ATL01 product is intended for input to the Level 1B processing and for use by researchers who want access to the Level 0 telemetry. It gives access to all of the pertinent information from the ATLAS altimetry, atmosphere, laser reference system, housekeeping data and calibration mode data and the spacecraft ancillary science data (GPSR, ACS, IMU and location) in a bit-decompressed time-aligned HDF5 formatted data product.

2.1 Background

There are a number of APIDs for the ATLAS, the LRS, and the spacecraft. Each APID is a specific defined collection of data parameters normally in raw counts and compressed into as few bits as possible to reduce the downlink bandwidth. EDOS collects all the telemetry packets for each specific APID into a single file that is time ordered with any duplications removed. A specific time period of such data is collected into a Production Data Set (PDS) for delivery to SIPS. ICESat-2 expects the normal PDS to cover two hours of data. EDOS can also create Expedited Data Sets (EDS), which are similar to the PDS but are created from data as soon as available for some requested time and not for specific elapsed time period. EDS may contain duplicate data packets.

The ATLAS altimeter data will consist of a number of APID packets. Unique APID dataset packets will be at a fixed rate. The Altimeter Science Packet is a 50 Hz packet that contains the 200 transmit times of each pulse and receive times of each photon in a ground track (one strong beam and one weak beam). Since it is unknown how many photons will be received it uses the continuation ability to downlink as little or much as needed. The time of day correlation to the transmit time and GPS time are in another APID with packets at 1 Hz. The atmosphere histograms for each track will have their unique APID provided at 25 Hz.

The spacecraft data has four downlinked packet types (APIDs). Each APID will contain the sub packet data related to specific subsystems like GPS, IMU or ACS.

The L1A processing will decompress all parameters only for specificselected packets that are needed by the science processing and engineering monitoring that were packed in order to conserve space in the downlinked telemetry. All data will be and placed them into standard HDF variable types. Each parameter will be time aligned within an HDF group that represents the APID and placed on a granule for specific time periods. For example if EDOS makes a PDS (file) for each APID that covers two hours there could be as many as 50 files delivered each with different start/stop times. The HDF L1A product will be sorted out into time-aligned packets on the HDF L1A product. Examples of packets that will not be decompressed are the flight software diagnostic and memory dump packets that are not use in the processing to create the ATL02 (L1B) product. The L1A processing would merge all the data from the 50 APID files for some period like 10 minutes into one file that contains the information for that period and the parameters will be in a decompressed form ready for easy processing when used as input to the unit conversion and calibration Science Unit Converted Telemetry (L1B) processing.

Some parameters will be converted to engineering units to perform time alignment, data quality and for higher level processing and will be on the L1A product. The product will also still contain their decompressed unconverted value.

2.2 Reformatted Telemetry (ATL01/L1A)

The ATL01/L1A Reformatted Telemetry product contains all the ICESat-2 science data that was downlinked by the X-band telemetry stream. This stream contains ATLAS data, including LRS and Spacecraft Science data as well as engineering data. The data parameters will be decompressed so each value is stored in a standard HDF data type. The L1A data granules (files) will contain all the telemetry parameters for a fixed time period.

The UTC time and time offsets must be maintained and all associated data from the GPS timing information included in the ATLAS telemetry to allow exact UTC time to be computed by the L1B algorithms for each laser shot.

The primary ATLAS packets (APIDs) are:

SM_HK Packet (A_SIM_HK apid 1026)

Altimeter Science Packet for each Photon Counting Electronics (PCE) card (PCEx_ALT_SCI_TLM_MID apid 1254, 1264, 1274)

Algorithm Science Packet for each PCE (A_PCEx_PMF.ALGORITHM_SCIENCE apid 1162, 1164, 1166)

1 Pulse Per Second (PPS) Major Frame Time At Tone Packet for each PCE (APID 1139, 1140, 1141)

Atmospheric Histogram Science Packets for each PCE (PCEx_SAM_SCI_TLM_MID apid 1255, 1265, 1275)

ATLAS housekeeping Packet E (A_HKT_E apid 1063)

The primary LRS packets (APIDs) are:

LRS Stellar Centroid Data (A_LRS_SCENT apid 1124)

LRS Laser Centroid Data (A_LRS_LCENT apid 1123)

LRS Housekeeping (A_LRS_HK apid 1120)

The primary Spacecraft sub-packets are:

IMU data at 50 HZ (inside spacecraft packet 1 apid 5)

Star Tracker Data 10hz (inside spacecraft packet 2 apid 6)

GPS data at 1 hz (inside spacecraft packet 3 and 4 apid 7 and 8)

ACS data at 1 hz (inside spacecraft packet 1 apid 5)

SADA Position data at 1 hz (inside spacecraft packet 1 apid 5)

2.3 References

ICESat-2-ATSYS-HDBK-3886	ATLAS Command & Telemetry Handbooks, Version 15, June 1, 2015
ICESat-2-IT-RPT-4005	ATLAS Telemetry and Commands rec files & Products for inclusion in the Project Database, Ver 18, September 1, 2017
ICESat-2-LRS-IFACE-1794	Laser Reference System (LRS) Command and Data Interface Control Document (ICD), Revision B, November 16 2016
DN-ICESat2-SYS-024	Ancillary Telemetry Packet Description, Rev C, June 22 2015
ICESat-2-MEB-SPEC-0875	Main Electronics Box (MEB) Photon Counting Electronics (PCE) Data Flow Controller (DFC) Field Programmable Gate Array (FPGA) Specification, Revision I, February 5 2016.
ICESat-2-ATSYS-TN-0910	ATLAS Spots, Channels and Redundancy Assignments, Revision D, September 22 2015.
ICESat-2-SCSYS-CDRL-1258	[CDRL SE-9A] 1553 Interface Control Document (ICD), Revision G, September 03 2015

ICESat-2-SIPS-SPEC-4256	ATLAS Science Algorithm Standard Data Product (SDP) – Volume 1 (ATL01)

3.0 ATL01 PRODUCT DESCRIPTION

The ATL01 structure is designed to preserve the level 0 APID knowledge. The top-level structure is a group for each downlinked APID. In the non-diagnostic packet the parameters are fully broken down and in cases may have subgroups to aid easy data access to time series data like the received photon events.

3.1 ATL01 Time of Day

The ATLAS HDF Standard Data Products (SDP) contain a number of groups where each group can be at different data rates. To aid the alignment of the data each group will contain a delta time generated by the SIPS processing. This delta time is defined as Number of GPS seconds since the ATLAS SDP epoch. The ATLAS Standard Data Products (SDP) epoch is 2018-01-01T00:00:00 [TBD]. The value is contained in the ancillary data group as the a;tas_sdp_gps_epoch. The delta time will be consistent across all products as a continuous counting from this epoch. Generally a UTC time can be computed by computing the number of seconds from the first data point (earliest time of data) and adding it to the data_start_utc in ancillary_data.

For the L1A data product each delta_time is computed by using the CCSDS header time of the packet. Data within a packet that are provided multiple times per packet are either placed in a dimensioned array by the times it reoccurs (e.g. number of laser centroids (6)) or in a time series where the delta_time is repeated and a counter is added for each event (e.g. for the received photon events).

3.2 ATLAS Telemetry

The ATLAS telemetry is defined in the ATLAS documents in the section 2.3 references. Mainly ATLAS Command & Telemetry Handbooks and Main Electronics Box (MEB) Photon Counting Electronics (PCE) Data Flow Controller (DFC) Field Programmable Gate Array (FPGA) Specification. The latest approved version is found in the ICESat-2 MIS. Some packets are defined in detail and others reference ATLAS documents in MIS for the detailed information. Important science packets are described below. Many other packet types can be downlinked by ground command.

3.2.1 SM-HK data Packet

This packet contains the important time latches to both the GPS/spacecraft 1 PPS and the ATLAS internal 1 PPS. This packet provides the references between the GPS time of the GPS/spacecraft 1 PPS and the ATLAS time (AMET). It also provides the computed GPS time for the ATLAS internal 1 PPS.

3.2.2 PCE Altimetry Science Data Packet

The telemetry for each Altimetry Science Data APID is formed by a specific PCE and contains the data for one track pair (a strong and weak beam) consisting of 2 channels for the transmit pulse, 16 channels of the strong beam and 4 channels of the weak beam for the received photons plus 2 channels for calibration. The strong and weak beam received photons also contain information that reports if it is rising or falling edge detection. The data are grouped in major frames at 50 Hz. The downlink band is reported once per major frame. Each PCE major frame contains two measurements for each of the 200 transmit pulses and a time for each received photon. Details of these are defined in ICESat-2-MEB-SPEC-0875 ATLAS MEB Photon Counting Electronics (PCE) Data Flow Controller (DFC) Field Programmable Gate Array Specification.

On ATL03 there is a set of parameters that are once per major frame in one group. This group has the parameters like the PCE calibration and the 50 shot photon sums over the range window. The transmit pulse and received photon data are each in their own times series group.

3.2.2.1 Transmit Start Time Measurements

Start time measurements from four threshold crossings on the start pulse are carried forward on this product for L1B processing. The data consists of six parameters per shot. Three pairs of measurements (one from each PCE) of the transmit leading edge detection and one each to either the leading upper, trailing upper or trailing lower detection.

3.2.2.2 Received Photon Time Measurements

Measured time of receipt of each photon per channel per shot per PCE are in this product. Each received photon will be given a unique photon ID by the L1A processing that will allow its association across the ICESat-2 standard data products as needed.

3.2.3 PCE Algorithm Science Packet

An Algorithm Science Packet is reported for each PCE that contains the major frame information like the range to the top of the altimeter window and its width. The data is reported at 50 Hz. They are defined in ICESat-2-ATSYS-HDBK-3886 ATLAS Command & Telemetry Handbooks

3.2.4 PCE 1 PPS time at the tone Packet

A 1 PPS Time at the Tone packet (TAT) is reported for each PCE. It contains the major frame information to properly tag each laser pulse with the time of day. The rate is 50 Hz. They are defined in ICESat-2-ATSYS-HDBK-3886 ATLAS Command & Telemetry Handbooks

3.2.5 PCE Atmospheric Histogram Packet

Each Atmospheric Histogram APID contains histograms for a strong or weak beam that spans 14km in 30m resolution bins (-1 to 13km). The range to the top of the histogram is provided. The histograms are provided at 25 Hz. They are defined in ICESat-2-ATSYS-HDBK-3886 ATLAS Command & Telemetry Handbooks

3.3 LRS Telemetry

The LRS is considered part of ATLAS. Its telemetry is defined in detail in ICSat-2-LRS-IFACE-1794 the ATLAS LRS Command and Data ICD (see sections 9 and 10). The latest approved version is found in the ICESat-2 MIS.

The LRS normal mode is the Application Mode and three packet types are normally downlinked (Housekeeping, Laser Centroid Data and Stellar Centroid Data). Ten other packet types can be downlinked by ground command. The LRS Failsafe Mode has 1 packet type that is normally downlinked and 2 packet types that are downlinked by ground command.

All LRS data packets will be placed on the output product in their own groups.

3.4 Spacecraft Telemetry

The spacecraft telemetry is defined in detail in the Ancillary Telemetry Packet Description - DN-ICESat2-SYS-024. The latest approved version is found on the Orbit_ATK sharepoint.

The ancillary telemetry (Spacecraft data) is provided in four packet types at 1 Hz each. Each packet contains data from several subsystems and their own packet within the packet. Figure 3-1 displays a top-level summary of the data (including correlation accuracies to GPS Time). The ATL01 has each subsystem data in its own data group.

< 50 µsec wrt GPST

- **IMU data @ 50Hz**
  - Sync Pulse timestamp (in SC clock time format)
  - IMU sync event and data timestamps
  - Mode/validity status and Integrated Angle Counters
- **GPS data @ 1Hz**
  - Time Correlation Data Record (GPST, UTC, GPSR Oscillator Time)
  - Channel Status Data Record
  - Noise Histogram Data Record
  - Housekeeping Parameter Report
  - Navigation Solution Data Record
  - Carrier Amplitude Data Record
  - Carrier and Code Phase Data Records
    - Contains carrier cycle counter and delta range
    - Contains GPS chip count
- **ACS SW-filtered Inertial-to-LRS frame quaternions, SC body rates and position/velocity data @ 1Hz**
  - Including calculation time tags
  - Same data that is provided to ATLAS in RT
- **ACS SW Mode @ 1Hz**

< 60 µsec wrt GPST

- **Star Tracker data @ 10Hz**
  - ETR timestamp (in SC clock time format)
  - SW Mode and OH sequencing status
  - Quaternions & quality indices (OH1 and OH2) and Measurement Time
  - Number of coherent stars

< 100 msec wrt GPST

- **SADA Position Telemetry @ 1Hz**
  - Measured Az/El from potentiometer
  - Estimated Az/El position from ACS SW (based on commanded counts)

< 1 sec wrt GPST

- **SC & ATLAS temperatures @ 1Hz**
  - Solar Array temps, SC-to-ATLAS I/F flexure temps, SC-monitored ATLAS temps
- **SC & ATLAS voltage/currents @ 1Hz**
  - SC bus voltage and SC PDU-measured ATLAS currents
- **OBS Configuration Telemetry @ 1Hz**
  - SC PDU switch status of ATLAS services

Figure 3-1 Top-level Summary of the Spacecraft Data

3.5 Other inputs

- A GPS leap second table that allows the conversion of GPS time to a Julian data time.
- The ATL01 Granule start and stop times based on predicted orbits

4.0 ALGORITHM THEORY

The Level 1A product is a reformatted version of the level 0 data, therefore no science algorithms are required to process the data. The processing is solely to decompress and time-align data from the APIDs, then place the data for a defined time period into a single ATL01 HDF product containing all parameters for higher level processing.

4.1 ATLAS Telemetry

The ATLAS telemetry consists of the ATLAS instrument and the LRS instrument data.

4.1.1 ATLAS Instrument

The exact decoding of each ATLAS data packets and parameters are defined in ICESat-2-ATSYS-HDBK-3886, ICESat-2-MEB-SPEC-0875 (section 5.12 and 5.13) and ICESat-2-IT-RPT-4005

The science and instrument monitoring required packets received in the ATL00 will be unpacked as specified in the ATLAS reference documents. The flight software diagnostic packets will be maintained in near downlink format for easy use by the instrument team. Most packet types will be placed in their own group that maintains parameter names that are close to its ATL00 mnemonic as an unpacked parameter on the ATL01. There are some parameters like the received photon times that will be in a group that allows them to be simple single dimension parameters. The time for each packet is decoded from the CCSDS header Shdays and Shmsec. These are Days since epoch where epoch is defined by the ICESat-2 Mission as 6-Jan-1980 00:00:00

4.1.2 LRS Instrument

The exact decoding of each LRS data packet and its parameters are defined in ICESat-2-LRS_IFACE_1974 sections 9 and 10.

4.1.3 LRS Application Mode

Housekeeping, Laser Centroid Data, and Stellar Centroid Data are the packets normally downlinked to the ground when the LRS is in Application Mode. SSR Memory Dump, Real Time Memory Dump, TAMS Window Data, Laser Window Data, Stellar Window Data, Laser Image Data, Stellar Image Data, and Timing Data and Configuration Data are only downlinked by ground command.

Most LRS packets received in the ATL00 will be unpacked as specified in the LRS ICD. Some packets will be maintained in near downlink format for easy use by the instrument team. Each packet type will be its own group that maintains close parameter name to its ATL00 mnemonic as an unpacked parameter on the ATL01. The time for the packet is decoded from the Shdays and Shmsec in the CCSDS header. These are Days since epoch where epoch is defined by the ICESat-2 Mission as 6-Jan-1980 00:00:00.

4.1.3.1 LRS Failsafe Mode

Housekeeping is the only packet normally downlinked to the ground when the LRS is in Failsafe Mode. SSR Memory Dump and Real Time Memory Dump are only downlinked by ground command. The housekeeping packet received in the ATL00 will be unpacked as specified in the LRS ICD.

4.2 Spacecraft

The exact decoding of each Ancillary Science data packets and their parameters are defined in DN-ICESat-2-SYS-024.

Within the Spacecraft Ancillary Science Data packets there are a number of internal sub packets that contain the different component's data. The data in these ATL00 packets will be unpacked as specified in the Ancillary Telemetry Packet Description Design Note. Each component's data will be its own group that has unpacked parameters on the ATL01 for each ATL00 parameter. The time for the packet is decoded from the Shdays and Shmsec. These are Days since epoch where epoch is defined by the ICESat-2 Mission as 6-Jan-1980 00:00:00.

5.0 ALGORITHM IMPLEMENTATION

This section describes the specific implementation of the algorithm for program development.

5.1 Outline of Procedure

The APID files will be read for all data within a specific processing time for an output file. All data within the time span will be placed on one ATL01 output file having defined groups of parameters. A delta time for each group or parameter will be created from the time field in the CCSDS header. Most packets contain a checksum that the ATL01 processing will verify. Each input parameter will be extracted for its telemetry packed field and placed in a byte structure that contains only that parameter. Some parameters will concatenate bits from multiple bytes to form a single output parameter. A count of packets processed in the time span will be computed that can be used with the expected number of packets as part of the product quality assurance. (Table 5-1)

5.1.1 Input Variables

5.1.2 Parameters Required from ICESat-2 Telemetry

The ATLAS packets are described in table 5-1. Most parameters for output will be derived directly from data that will come from ICESat-2 telemetry. The ATL01 parameters are provided in its Data Dictionary available separately. (ICESat-2-SIPS-SPEC-4256)

ATLAS instrument

The ATLAS APIDs listed in tables above are all input to the Level 1A processing algorithm. The breakdown of the packets is described in the referenced ICESat-2 MIS documents and will not be repeated within this ATBD.

Table 5-1 ATAS Altimeter packets that are decommutated

Decimal	Hex	Label	Rate
1026	0x402	A_SIM_HK	1
1032	0x408	A_SLA_HK	1
1033	0x409	A_SXP_HK	1
1057	0x421	A_MCE_POS	200
1059	0x423	A_HKT_A	1
1060	0x424	A_HKT_B	1
1061	0x425	A_HKT_C	1
1062	0x426	A_HKT_D	1
1063	0x427	A_HKT_E	1
1065	0x429	A_HKT_STATUS	1

1072	0x430	A_DFC1_HK	50
1085	0x43D	A_PCE1_PMF_SCIENCE_MODE_HK	1
1088	0x440	A_DFC2_HK	50
1101	0x44D	A_PCE2_PMF_SCIENCE_MODE_HK	1
1104	0x450	A_DFC3_HK	50
1117	0x45D	A_PCE3_PMF_SCIENCE_MODE_HK	1
1136	0x470	A_SC_TAT	1
1137	0x471	A_SC_POS	1
1138	0x472	A_SC_PON	1
1139	0x473	PCE1_PMF_TIMEKEEPING	0
1140	0x474	PCE2_PMF_TIMEKEEPING	0
1141	0x475	PCE3_PMF_TIMEKEEPING	0
1152	0x480	SXP_SSR_PCE1_XP_DATA_STRONG_MID	0
1153	0x481	SXP_SSR_PCE1_XP_DATA_WEAK_MID	0
1154	0x482	SXP_SSR_PCE2_XP_DATA_STRONG_MID	0
1155	0x483	SXP_SSR_PCE2_XP_DATA_WEAK_MID	0
1156	0x484	SXP_SSR_PCE3_XP_DATA_STRONG_MID	0
1157	0x485	SXP_SSR_PCE3_XP_DATA_WEAK_MID	0
1161	0x489	A_PCE1_PMF_ALGORITHM_DIAGNOSTIC	1
1162	0x48A	PCE1_ALG_SCI_TLM_MID	0
1163	0x48B	A_PCE2_PMF_ALGORITHM_DIAGNOSTIC	1
1164	0x48C	PCE2_ALG_SCI_TLM_MID	0
1165	0x48D	A_PCE3_PMF_ALGORITHM_DIAGNOSTIC	1
1166	0x48E	PCE3_ALG_SCI_TLM_MID	0
1250	0x4E2	PCE1_SAL_DIAG_HIST_TLM_MID	0
1251	0x4E3	PCE1_WAL_DIAG_HIST_TLM_MID	0
1252	0x4E4	PCE1_SAM_DIAG_HIST_TLM_MID	50
1253	0x4E5	PCE1_WAM_DIAG_HIST_TLM_MID	50
1254	0x4E6	PCE1_ALT_SCI_TLM_MID	50
1255	0x4E7	PCE1_SAM_SCI_TLM_MID	25
1256	0x4E8	PCE1_PHS_HDW_DIAG_TLM_MID	0
1259	0x4EB	PCE1_WAM_SCI_TLM_MID	25
1260	0x4EC	PCE2_SAL_DIAG_HIST_TLM_MID	0
1261	0x4ED	PCE2_WAL_DIAG_HIST_TLM_MID	0
1262	0x4EE	PCE2_SAM_DIAG_HIST_TLM_MID	50
1263	0x4EF	PCE2_WAM_DIAG_HIST_TLM_MID	50
1264	0x4F0	PCE2_ALT_SCI_TLM_MID	50
1265	0x4F1	PCE2_SAM_SCI_TLM_MID	25
1269	0x4F5	PCE2_WAM_SCI_TLM_MID	25

1270	0x4F6	PCE3_SAL_DIAG_HIST_TLM_MID	0
1271	0x4F7	PCE3_WAL_DIAG_HIST_TLM_MID	0
1272	0x4F8	PCE3_SAM_DIAG_HIST_TLM_MID	50
1273	0x4F9	PCE3_WAM_DIAG_HIST_TLM_MID	50
1274	0x4FA	PCE3_ALT_SCI_TLM_MID	50
1275	0x4FB	PCE3_SAM_SCI_TLM_MID	25
1279	0x4FF	PCE3_WAM_SCI_TLM_MID	25

Table 5-1 ATAS Altimeter packets that are left in telemetry byte order

Decimal	Hex	Label	Rate
1025	0x401	A_SRT_HK	1
1027	0x403	A_SBC_FM_HK	1
1028	0x404	A_SBC_HS_HK	1
1029	0x405	A_SDI_HK	1
1030	0x406	A_SBS_HK	1
1031	0x407	A_STH_HK	1
1034	0x40A	A_SMT_HK	1
1035	0x40B	A_SRT_SA	1
1036	0x40C	A_SIM_SPW_STAT	1
1037	0x40D	A_SBC_FM_PDU	0
1038	0x40E	A_SBC_FM_STAT	0
1039	0x40F	A_SBC_FM_LIST	0
1040	0x410	A_SBC_FM_EEFS_STAT	0
1041	0x411	A_SBC_HS_HDW_DIAG	0
1042	0x412	A_SBC_HS_RT_STATS	0
1043	0x413	A_SBC_HS_DT	0
1044	0x414	A_SBC_HS_DIAG_LOG	0
1045	0x415	A_SBC_HS_TASKS_DIAG	0
1046	0x416	A_SBC_HS_RT_FILTER	0
1047	0x417	SDI_1553_DIAG_TLM_MID	1
1048	0x418	A_SBS_AMCS_MCE_POS_CMDS	1
1049	0x419	A_SBS_AMCS_DIAG	1
1050	0x41A	A_STH_BB	1
1051	0x41B	A_STH_PWM	1
1052	0x41C	A_SLA_DIAG	1
1053	0x41D	A_SLA_LSR_ASYNC_RESP	0
1054	0x41E	A_SMT_DIAG	1
1055	0x41F	A_ASC_RMAP	1

1056	0x420	A_MCE_HK	1
1058	0x422	A_MCE_RMAP	1
1064	0x428	A_HKT_RMAP	1
1066	0x42A	HKT_OFA_TRANS_TLM_MID	0
1067	0x42B	A_SIM_PCE1	0.30
1068	0x42C	A_SIM_PCE2	0.30
1069	0x42D	A_SIM_PCE3	0.30
1070	0x42E	A_SBC_FW_CMD_ECHO	0
1071	0x42F	SDI_SPW_DIAG_TLM_MID	1
1073	0x431	A_PCE1_PMF_HK	1
1074	0x432	PCE1_PMG_HK_TLM_MID	1
1075	0x433	A_PCE1_PSW_HK	1
1076	0x434	A_PCE1_FM_HK	1
1077	0x435	A_PCE1_FM_PDU	1
1078	0x436	A_PCE1_FM_STAT	1
1079	0x437	A_PCE1_FM_LIST	1
1080	0x438	A_PCE1_FM_EEFS_STAT	1
1081	0x439	A_PCE1_HS_HK	1
1082	0x43A	A_PCE1_HS_DT	1
1083	0x43B	A_PCE1_HS_DIAG_LOG	1
1084	0x43C	A_PCE1_HS_RT_FILTER	1
1086	0x43E	A_PCE1_PMF_MANUAL_MODE_HK	1
1089	0x441	A_PCE2_PMF_HK	1
1090	0x442	PCE2_PMG_HK_TLM_MID	1
1091	0x443	A_PCE2_PSW_HK	1
1092	0x444	A_PCE2_FM_HK	1
1093	0x445	A_PCE2_FM_PDU	1
1094	0x446	A_PCE2_FM_STAT	1
1095	0x447	A_PCE2_FM_LIST	1
1096	0x448	A_PCE2_FM_EEFS_STAT	1
1097	0x449	A_PCE2_HS_HK	1
1098	0x44A	A_PCE2_HS_DT	1
1099	0x44B	A_PCE2_HS_DIAG_LOG	1
1100	0x44C	A_PCE2_HS_RT_FILTER	1
1102	0x44E	A_PCE2_PMF_MANUAL_MODE_HK	1
1105	0x451	A_PCE3_PMF_HK	1
1106	0x452	PCE3_PMG_HK_TLM_MID	1
1107	0x453	A_PCE3_PSW_HK	1
1108	0x454	A_PCE3_FM_HK	1

1109	0x455	A_PCE3_FM_PDU	1
1110	0x456	A_PCE3_FM_STAT	1
1111	0x457	A_PCE3_FM_LIST	1
1112	0x458	A_PCE3_FM_EEFS_STAT	1
1113	0x459	A_PCE3_HS_HK	1
1114	0x45A	A_PCE3_HS_DT	1
1115	0x45B	A_PCE3_HS_DIAG_LOG	1
1116	0x45C	A_PCE3_HS_RT_FILTER	1
1118	0x45E	A_PCE3_PMF_MANUAL_MODE_HK	1
1142	0x476	SXP_PCE1_XP_DATA_STRONG_MID	2
1143	0x477	SXP_PCE1_XP_DATA_WEAK_MID	2
1144	0x478	SXP_PCE2_XP_DATA_STRONG_MID	2
1145	0x479	SXP_PCE2_XP_DATA_WEAK_MID	2
1146	0x47A	SXP_PCE3_XP_DATA_STRONG_MID	2
1147	0x47B	SXP_PCE3_XP_DATA_WEAK_MID	2
1148	0x47C	PCE1_TAT_TLM_MID	0
1149	0x47D	PCE2_TAT_TLM_MID	0
1150	0x47E	PCE3_TAT_TLM_MID	0
1257	0x4E9	PCE1_PHS_RT_STATS_TLM_MID	0
1258	0x4EA	PCE1_PHS_TASKS_DIAG_TLM_MID	0
1266	0x4F2	PCE2_PHS_HDW_DIAG_TLM_MID	0
1267	0x4F3	PCE2_PHS_RT_STATS_TLM_MID	0
1268	0x4F4	PCE2_PHS_TASKS_DIAG_TLM_MID	0
1276	0x4FC	PCE3_PHS_HDW_DIAG_TLM_MID	0
1277	0x4FD	PCE3_PHS_RT_STATS_TLM_MID	0
1278	0x4FE	PCE3_PHS_TASKS_DIAG_TLM_MID	0

LRS instrument

The LRS APIDs listed in table above are all input to the Level 1A processing algorithm. The breakdown of the packets is described in in ICESat-2-LRS_IFACE_1974 sections 9 and 10.

Table 5-3 ATAS LRS packets that are decommutated

Decimal	Hex	Label	Rate
1120	0x460	LRStmHK	1
1121	0x461	LRStmSSRDP	1
1122	0x462	LRStmRTDP	1

1123	0x463	LRStmLCENT	50
1124	0x464	LRStmSCENT	10
1125	0x465	LRStmTWIN	1
1126	0x466	LRStmLWIN	1
1127	0x467	LRStmSWIN	1
1128	0x468	LRStmLIMG	1
1129	0x469	LRStmSIMG	1
1130	0x46A	LRStmTIMING	1
1131	0x46B	LRStmCONFIG	1
1133	0x46D	LRSfstmHK	0
1134	0x46E	LRSfstmSSRDP	0
1135	0x46F	LRSfstmRTDP	0

Spacecraft Ancillary Science Data

The spacecraft packets are nominally once per second. There are four different packets. Their APIDs are 5, 6, 7 and 8. The breakdown of the components within the packet (sub packets) are shown in Table 5-2. The breakdown of the packet is described in the DN-ICESat2-SYS-024 rev B Ancillary Telemetry Packet Description and are not be repeated within this ATBD.

Table 5-5 ICESat-2 spacecraft packets that are decommutated

Decimal	Hex	Label	Rate
5	0x005	SC1	1
6	0x006	SC2	1
7	0x007	SC3	1
8	0x008	SC4	1
772	0x304	GPSR1_HK	1
774	0x306	GPSR1_SCI_POD	1
777	0x309	GPSR1_MEM	1
779	0x30B	GPSR1_SCI_S1	1
780	0x30C	GPSR1_SCI_SP	1
781	0x30D	GPSR1_SCI_EVENT	1
788	0x314	GPSR2_HK	1
790	0x316	GPSR2_SCI_POD	1
793	0x319	GPSR2_MEM	1
795	0x31B	GPSR2_SCI_S1	1

796	0x31C	GPSR2_SCI_SP	1
797	0x31D	GPSR2_SCI_EVENT	1

Table 5-1 Ancillary Packet Size (Spacecraft Packet 1)

Space Packet 1 Size			
Data Source	**Bits**	**Bytes**	
ACS Software	880	110	
GPS Receiver	0	0	
Star Trackers	0	0	
Inertial Measurement Unit	5600	700	
Integrated Electronics Module	1824	228	
Power Distribution Unit	288	36	
Space Packet Data Field TOTAL	**8592**	**1074**	**# Packets**
Space Packet Headers	48	6	
Space Packets TOTAL	**8640**	**1080**	**1**
M_PDU Fill to Complete Packet	**112**	**14**	**-**
ASM and M_PDU Overhead	**48**	**6**	**-**
Full Packets to SSR TOTAL	**8800**	**1100**	**1**

Table 5-2 Ancillary Packet Size (Spacecraft Packet 2)

Space Packet 2 Size			
Data Source	**Bits**	**Bytes**	
ACS Software	0	0	
GPS Receiver	0	0	
Star Trackers	8320	1040	
Inertial Measurement Unit	0	0	
Integrated Electronics Module	192	24	
Power Distribution Unit	0	0	
Space Packet Data Field TOTAL	**8512**	**1064**	**# Packets**
Space Packet Headers	48	6	
Space Packets TOTAL	**8560**	**1070**	**1**
M_PDU Fill to Complete Packet	**192**	**24**	**-**
ASM and M_PDU Overhead	**48**	**6**	**-**
Full Packets to SSR TOTAL	**8800**	**1100**	**1**

Table 5-3 Ancillary Packet Size (Spacecraft Packet 3)

Space Packet 3 Size			
Data Source	**Bits**	**Bytes**	
ACS Software	0	0	
GPS Receiver	8320	1040	
Star Trackers	0	0	
Inertial Measurement Unit	0	0	
Integrated Electronics Module	192	24	
Power Distribution Unit	0	0	
Space Packet Data Field TOTAL	**8512**	**1064**	**# Packets**
Space Packet Headers	48	6	
Space Packets TOTAL	**8560**	**1070**	**1**
M_PDU Fill to Complete Packet	**192**	**24**	**-**
ASM and M_PDU Overhead	**48**	**6**	**-**
Full Packets to SSR TOTAL	**8800**	**1100**	**1**

Table 5-4 Ancillary Packet Size (Spacecraft Packet 4)

Space Packet 4 Size			
Data Source	**Bits**	**Bytes**	
ACS Software	0	0	
GPS Receiver	3522	444	
Star Trackers	0	0	
Inertial Measurement Unit	0	0	
Integrated Electronics Module	192	24	
Power Distribution Unit	0	0	
Space Packet Data Field TOTAL	**3744**	**468**	**# Packets**
Space Packet Headers	48	6	
Space Packets TOTAL	**3792**	**474**	**1**
M_PDU Fill to Complete Packet	**4960**	**620**	**-**
ASM and M_PDU Overhead	**48**	**6**	**-**
Full Packets to SSR TOTAL	**8800**	**1100**	**1**

5.1.2.1 Parameters Required from Ancillary Sources

The GPS to UTC time leap second table is needed as an input.

5.1.2.2 Output Parameters

There are too many L1A output parameters to list within this document. A separate L1A data dictionary will be supplied. Most groups contain a delta_time that is computed based on the packet generation time in the CCSDS header as the Elapsed seconds since first data point in the granule.

5.1.3 Processing Procedures

5.1.3.1 L1A Geolocation processing

In order to have geolocation data with the L1A the group below will be on the L1A once per second.

/ATLAS/geolocation

The below will be provided as inputs by the processing

orbit_number

rgt – reference ground track

cycle

The below will be determined from the spacecraft GPSR telemetry in the SC4 (APID 8) packet

latitude – Navigation solution Latitude. This is provided once per second.

longitude – Navigation solution Longitude. This is provided once per second. A standard transform will be used work to move from s/c to each ATLAS beam pair.

h_ell- Navigation solution height above the reference ellipsoid (WGS84)

5.1.3.2 ATLAS Instrument processing

5.1.3.2.1 L1A processing algorithms

When the same packet format is used for several APIDs that produce unique output groups this ATBD defines a generic one such as PCEx for PCE1, PCE2 and PCE3.

There are a number of ATLAS flight software packets. Many of these do not need to be commutated and many will never be seen on the ground. A large of number of these are just put on the L1A product with a byte by byte copy of the packet data section. The CCSDS header is in their own group. There are APIDs assigned to ATLAS that are not defined or believed to be only transferred within the MEB (main electronics box). There is no requirement to address the undefined and internal ATLAS packets for L1A.

The Altimeter Science Packet processing needs to handle truncation tag (meaning all the Tx and RX were not downlinked). This is indicated in the altimeter science packets by the channel number being 0x1c = channel 28. The L1A processing also must keep the received and transmit time tag components in such a way they can be properly aligned for ATL02 progressing.

A. Time of day

ATLAS telemetry will report a number of time of day offsets relative to events. The details for computation of exact ATLAS time stamps are in the L1B ATBD. The decommutation of the ATLAS ATL00 packets to the ATL01 groups is defined in the references. Time of day for L1A computation is based on the CCSDS header times (see section 3.1).

The L1A processing does not provide a time of day for each transmit pulse or received photon. The downlink telemetry has the data that allows the L1B processing to compute per transmit pulse time of day. In the group that contains the received photon events the delta time changes only once per 200 laser pulses. A counter increments for each laser pulse and another counter increments for each received photon (see Photon ID Algorithm below). There are transmit laser pulse that will have no received photons. An indicator will identify transmit pulses that do not have received photons. For those laser pulses the received event parameters are set to 0.

The structure of the photon events is to keep the transmit and receive event time tags together in an easy form to be used in the L1B processing. Therefore they are kept in a single group. This means that when there are multiple receive events (photons) for the same transmit in one PCE (track pair) the transmit data are repeated. Users should make use of the laser pulse counter to select the first occurrence. Likewise if a PCE (track pair) has no received events (photons) for a transmit then the received event data values are set to zero and the photon counter has the value zero.

B. Photon ID

The **Photon ID Algorithm** is:

- Major Frame counter (in telemetry and said to count for 10 years)
- Laser_Pl_counter (there are 200 per major frame) this counts each transmit time tag and resets on major frame
- Channel_num - Channel numbers are 1 to 120. There are 20 on each PCE. For each there is a detection on the rise edge of a signal and on the fall edge of a signal to allow a detection in each channel about every 3 nanoseconds. We need to allow for a different calibration for the rise and fall photon detection for each channel. PCE1 – are channel_num 1 to 40, where 1 to 20 are the rise and 21 to 40 are the fall. PCE1 – are channel_num 41 to 80, where 41 to 60 are the rise and 61 to 80 are the fall. PCE1 – are channel_num 81 to 120, where 81 to 100 are the rise and 101 to 120 are the fall.
- Ph_counter - The photon_counter is a counter for each channel from 1 to N, with a reset to 1 for each laser pulse. (about 3 photons per GT per transmit).

Note : Never split a major frame data set across an ATL01.

In addition:

- A photonid needs to be related to the Atmosphere profile by using the count value of the first altimeter Transmit pulse within the profile time span (400 shots).
- A photonid needs to be related to the atlas background data (bgr). Use the same concept as for atmosphere. The value of the first altimeter Transmit pulse within the bgr time span (50 shots).

5.1.3.2.2 L1A user guide notes

A. Atmosphere Science histograms- ATLAS forms the histograms at every 200 shots then sums two histograms to produce the 400 shot downlinked histogram. Within ATLAS before downlink the histograms are shifted to account for differences in the range window starts between the two histograms. The flight software algorithm is:

   a. The flight software adds the histograms from two consecutive Major Frames to generate a 400 shot histogram. The calculation is done every 200 shots, for both the strong and the weak spots. Both the strong and weak spot histograms are used by the flight software to determine the presence of thick cloud.

   b. A 400 shot histogram is calculated at every major frame for both the weak and strong beam using the current 200 shot histogram and the previous one. These are used by the flight software presence of thick cloud detection algorithm. However only every other 400 shot atmospheric histogram from the strong spot is normally downlinked. So the packet sequence count will increment by 2 for each packet as well as the major frame count.

   c. If the start of the atmospheric histogram (Mrw) changes from one major frame (200 shots) to the next, one of the 200 shot histograms is shifted before it can be added to the other. Changes to the histogram start are always done in 200 ns (~30 m) increments so that the histogram bins can always be aligned. The atmospheric histogram with bins closest to the surface are retained, while the bins highest in the atmosphere, that do not overlap between histograms, should be discarded.

   d. The histogram with the smaller range window start is shifted before adding. This means after adding there will be bins at the start and end of the histogram that do not overlap and will contain the original 200 shot values. The flight software discards the bins at the start of the histogram that do not overlap and will NOT discard the bins at the end of the histogram that do not overlap. Since the non overlapping bins at the start of the histogram are discarded the total length of the histogram (including the non overlapping bins at the end) will not change, so there will still be 467 bins. To determine how many bins at the end of the histogram do not overlap and contain the original 200 shot values take the shift amount (in clock cycles) and divide it by 20 (20 clock cycles per bin) to get the number of bins.

B. In order to compute the received event photon time (distance) it is required to know the downlink band associated with the received photon. To know which beam the downlink band 1 ,2 ,3 or 4 relate to we use channel mask. The channel mask Bits 0-15 refer to strong channels 1-16, Bits 16-19 refer to weak channels 1-4. Value 0 means the channel is used and value 1 means it is not used. In normal operation for strong bands the weak channels will be disabled (i.e. 0xF0000) and for the weak bands the strong channels will be disabled (i.e. 0x0FFFF). However if a channel becomes bad for either weak or strong it may be masked so some of the 0's may take on a value. The check has to be made on the mask, meaning the downlink band is weak if any of the bits 16 to 19 are zero and the downlink band is strong is any of the bits 16-19 are zero. This allows the test data that has only one band to be used for both weak and strong.

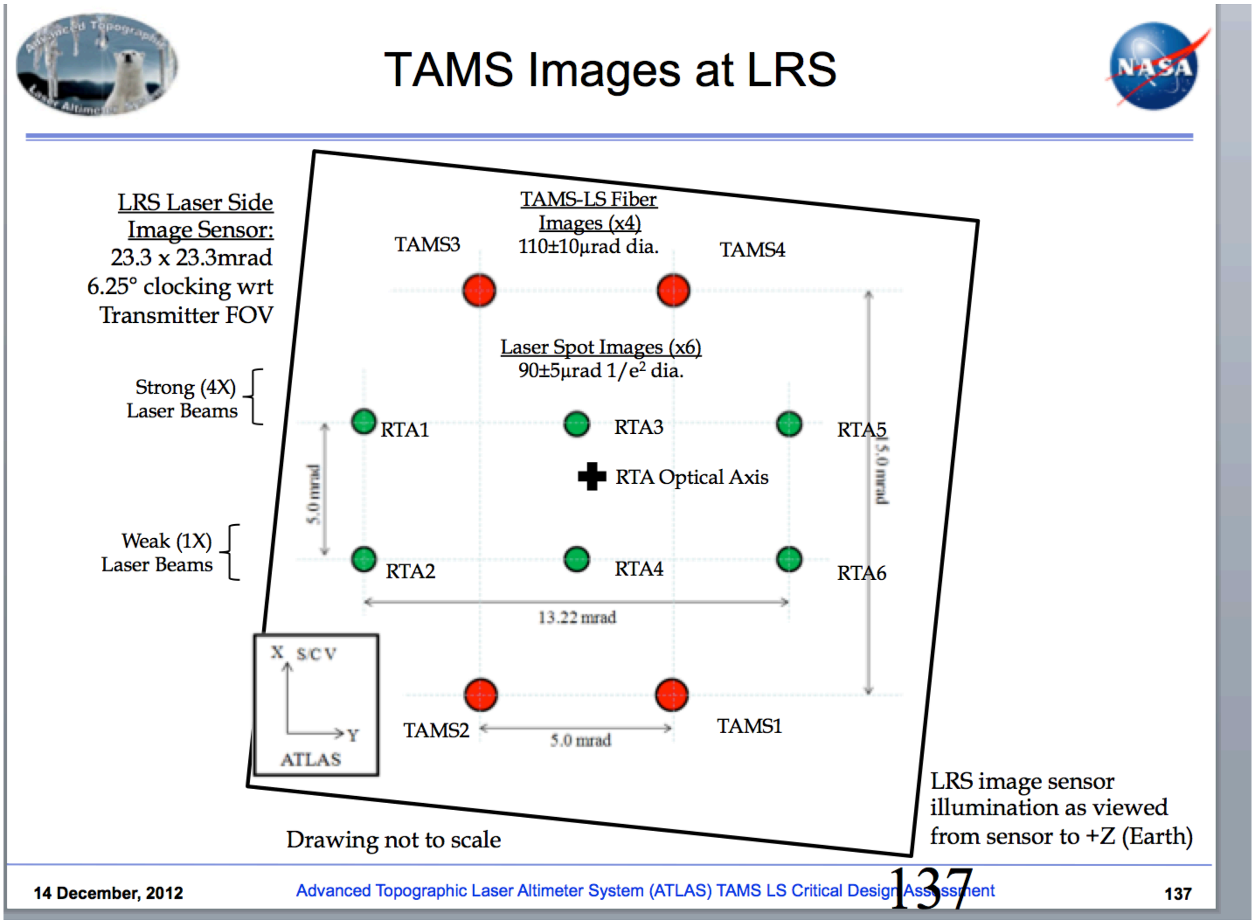
5.1.3.3 LRS Instrument processing

LRS telemetry will be reported on fixed offsets from the internal Operating Cycle, and at a frequency that is a sub-multiple of the Operating Cycle. The details of the LRS time stamps are in the LRS ICD. The decommutation of the ATL00 packets to the ATL01 groups is defined in the LRS ICD sections 8, 9 and 10.

All LRS packets have a checksum that needs to be verified in the processing of each packet. The 16-bit summation of all packet words, including the checksum should always result in 0 (x0000). A flag, checksumflg, is set based on if the summation is 0 or not.

A. The LRS SCENT is a variable length packet based on the number of stars detected. For L1A the SCENT data group always contains 30 stars (the maximum). N_stars is computed value in the SCENT data group that is the actual number of stars for which data was downlinked. N-Stars = (packet length – x)/y where X is the starting byte for the star centroid data (centmagtime) nominally 26 and Y is the number of bytes per star nominally 8.

B. Within the LRS LCENT data packet there is no guarantee of any one-to-one mapping between the order in the array and the physical location in the beam pattern (see figure 5-1). All the LRS guarantees is that any TAMS centroids will appear in the first 4 indices, and any Transmit centroids will appear in the last 6 indices, assuming that the laser-side optical inputs meet the ICD in terms of brightness, divergence, wavelength, etc. Then, the order of the flag bits in the “TrackStat” field and the “Quality” field matches the order of the centroids reported in the array. So any determination of which centroid is RTA1, which centroid is RTA2, and so forth, would have to be performed by the various users of the data.



5-1

5.1.3.4 Spacecraft Data processing

The details of the Ancillary Data Timestamps are included in the Ancillary Telemetry Packet Description DN-ICESat2-SYS-024. The decommutation of the APID 5, 6, 7 and 8 to the ATL01 groups is defined in the Ancillary Telemetry Packet Description Design note Appendix A

The GPSR data has a Packet Error Control (PEC) in a number of the sub packets. This is a checksum that is computed by the method defined in appendix D of DN-ICESat2-SYS-024. A checksum is to be determined and compared with the PECs. Based on this method a checksum flag (checksumflg) is set for data that fails the checksum.

(Note checksumflg parameters needs to be added to these s/c groups on ATL01.)

5.2 Variance or Uncertainty of Estimates

Not applicable

5.3 Numerical Computation Considerations

The precision of all data in downlink telemetry must be maintained.

5.3.1 Programmer/Procedural Considerations

TBD Code will be run in a production environment there all error condition will be trapped and reported as processing failures with normal execution termination.

5.3.2 Calibration and Validation

Calibrations are not applied in L1A processing. Validation will be done by comparisons with ATLAS performance analysis software as applicable.

5.3.3 Quality Control and Diagnostics

See section 6

6.0 DATA QUALITY AND BROWSE

6.1 Data Quality

All values below for quality checks are suggested default values that will need to be adjusted once operations are established.

6.1.1 Packet checksum

6.1.1.1 Processing

For all packets that contain a checksum the ground processing will compute the checksum and set a flag indicating the packet passed or failed its validation. For each packet type the sum of the passed and failed checksums will be reported.

6.1.1.2 Quality Criteria

Fail – if more than 20% of any packet type are marked as failed the processing will return a fail status.

> -If the number marked as failed for either the ATLAS Algorithm Science, Altimeter science, 1pps Major Frame time at tone, Atmosphere histogram science packets, sm_hk, ATLAS housekeeping packet E, the LRS LCENT, LRS SCENT, LRS HK packets or Spacecraft packets is more than 5% of its packets then the processing will return a fail status.

Warning– if more than 5% but less than 20% of any packet type are failed the processing will return a warning status.

Pass – if all packet types have less than 5% of any packet type are failed the processing will return a pass status.

6.1.2 *.* Packet count

6.1.2.1 Processing

For all normal packets the number of expected packets will be compared to the actual number of packets that have passed the checksum validity. The number of expected packets will be the computed based on the start and stop time requested and the packet nominal data rate. Packets that are downlinked by command only will not be checked.

6.1.2.2 Quality Criteria

Fail – if less than 80% of any expected packet type is available (either failed checksum or missing) then the processing will return a fail status.

Warning– if more than 80% but less than 95% of any packet type is available then the processing will return a warning status.

Pass – if each packet type has more than 95% of its expected packet type then the processing will return a pass status.

6.1.3 Received Photons

6.1.3.1 Processing

For each Ground Track (or track pair) the number of received photons will be counted and be compared to an expected return rate for that ground track.

6.1.3.2 Quality Criteria

Fail **–** if the actual return rate is less than 50% of the expected for any ground track the processing will return a fail status.

Warning– if the actual return rate is more than 50% but less than 70% of the expected for any ground track the processing will return a warning status.

Pass **–** if the actual return rate for each ground track has greater than 70% of expected returns the processing will return a pass status.

6.2 Browse

Browse will report along track statistics of packet counts and received photons for specified time intervals, plus the actual summary statistics for the entire granule.

6.2.1.1 Received Photons

At a specific time interval compute the number of received photons and number of shots and produce a scatter plot of shots verses received photons.

6.2.1.2 Reference Track

A ground track plot based on downlink lat/lon (ATLAS or s/c ACS location data).

7.0 TEST DATA AND RESULTS

7.1 Test Data 1

7.1.1 Source

TBD

7.1.2 Results

TBD

7.2 Test Data 2

7.2.1 Source

TBD

7.2.2 Results

TBD

8.0 CONSRAINTS, LIMITATIONS, AND ASSUMPTIONS

Processing exceptions

1. If SHDR times are zero the data are not processed. Packets are dropped

2. If there are ALT_SCI packets that do not have the starting major frame packet then the data are not processed. Packets are dropped

9.0 GLOSSARY/ACRONYMS

ACS	Attitude Control System
APIDs	Application Packet IDs
ASAS	ATLAS Science Algorithm Software
ATBD	Algorithm Theoretical Basis Document
ATLAS	ATLAS Advance Topographic Laser Altimeter System
EDOS	EOS Data and Operations System
EDS	Expedited Data Sets
EOS	Earth Orbiting Satellite
GSFC	Goddard Space Flight Center
GPS	Global Positioning System
GPSR	Global Positioning Satellite Receiver
HDF	Hard Data Format
ICESat-2	Ice, Cloud, Land Elevation Satelite-2
ICESat-2 MIS	ICESat-2 Management Information System
IMU	
LRS	Laser Reference System
LZPF	Level Zero Processing Facility
MIS	Management Information System
PCE	Photon Counting Electronics
	PDS Production Data Set
PEC	Packet Error Control
PSO	ICESat-2 Project Support Office
SIPS	ICESat-2 Science Investigator-led Processing System
TAT	Time At Tone
TBD	To Be Determined
UTC	Coordinated Time Universal