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Section 1 Introduction

This Data Format Control Book (DFCB) provides a detailed description of the mission data that the Ground Network Element (GNE) generates for the Landsat Data Continuity Mission (LDCM). Mission data consists of GNE collected and/or created data files. This DFCB describes the format and data content of each file for all collections received from the GNE. This information includes all data collected from the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). This document does not describe or define the format for any derived OLI and TIRS data products.

1.1 Document Organization

This document contains the following sections:

- Section 1 provides an introduction
- Section 2 describes the general contents of the files and how the data are logically arranged
- Section 3 describes characteristics of the OLI and TIRS instruments
- Section 4 describes each file in detail
- Appendix A lists example Interval Definition Files (IDFs)
- Appendix B lists example Message-Digest algorithm 5 (MD5) checksum files
- Appendix C lists glossary terms
- The References section contains a list of reference documents

Section 2 Mission Data Content Overview

The Collection Activity Planning Element (CAPE) and the Mission Operations Element (MOE) schedule collection intervals. The CAPE schedules earth imaging intervals and the MOE schedules all other types of intervals. The term "interval" refers to the period of time scheduled and any data the spacecraft recorded during that time. The spacecraft is capable of recording OLI, TIRS, or both during an interval collection. Each mission data interval contains the following data:

- OLI instrument data collected during the interval
- TIRS instrument data collected during the interval
- Ancillary data that the spacecraft collected during the interval
- Metadata that GNE collected and/or generated in the course of planning, receiving, and packaging the mission data for the interval

Mission data consists of data from any type of interval. Each interval consists of only one type. For example, a single interval does not contain both earth image data and shutter calibration data. Table 2-1 lists the types of intervals, along with a single-letter abbreviation used to refer to these interval types. These abbreviations are referenced at locations within this document.

Category	Interval Type	ID	Frequency
Primary	Earth Imaging	I	As scheduled by CAPE, typically every orbit
Calibration	Stellar	T	One to two times during commissioning
	Lunar	U	One complete set every 28 days
	Side Slither	Y	Once per month
	OLI Lamp	L	Once per day
	OLI Solar	O	Once every eight days
	OLI Shutter	S	Before and after other intervals as required
	OLI Shutter Integration Time Sweep	H	Once before and after every Z interval
	OLI Solar Integration Time Sweep	Z	Once every 16 days
	TIRS Blackbody	B	Before and after other intervals as required
	TIRS Deep Space	D	Before and after other intervals as required
	TIRS Integration Time Sweep	G	Once every 16 days
Test	OLI Test Patterns	E	Observatory Integration and Test (I&T) only
	Solid State Recorder (SSR) Pseudo-Noise (PN) Test Sequence	P	Observatory I&T only
	TIRS Test Patterns	Q	Observatory I&T only

Table 2-1. Interval Types and Abbreviations

2.1 File Structure

Mission data consists of GNE-collected files and GNE-created files. International Cooperators (ICs) may also collect the mission data files or create the IDF. Only GNE generates the checksum file.

GNE- or IC-collected files:

- **Mission Data Files.** All instrument and ancillary data are stored in one or more mission data files. A mission data file may contain either OLI or TIRS data, but never both. The files are referred to as OLI mission data files and TIRS mission data files. These files contain all instrument data and ancillary data interleaved in a time-ordered fashion. Each mission data file is less than 1.0 Gigabyte (GB) in size.

GNE- or IC-created file:

- **Interval Definition File (IDF).** The IDF provides information about the interval, including the list of files and their respective sizes. The IDF includes the list of scenes and a priority flag for each interval. (See Appendix A for example IDFs.)

GNE-created file:

- **Checksum File.** The checksum file lists each file in the mission data interval directory (excluding the checksum file) and the calculated MD5 checksum. The purpose of the checksum file is to ensure that downstream processing systems can verify that all files are present and received without corruption.

The following sections discuss each file in more detail.

2.2 File Name Format

GNE renames the GNE-collected mission data files using the Solid State Recorder (SSR) root file directory / sub-file name that the data was stored to and the date / time the data was downlinked. The GNE-collected data files are named in accordance to subsection 2.2.1. The GNE-generated IDF and checksum file names are based on the Landsat Interval Identifier (ID). The form of the Landsat Interval ID depends on the type of collection. Earth viewing intervals have a Landsat Interval ID that includes the World Reference System-2 (WRS-2) path and row information for the interval. Calibration intervals, which do not collect data corresponding to the WRS-2 grid, have a Landsat Interval ID that indicates the collection type and time of day for the collection. The detail for mission data files, both types of Landsat Interval IDs, and example file names are given in the following subsections.

2.2.1 GNE-Collected Files

GNE-collected mission data files are named according to the following format:

RRR.ZZZ.YYYYdoyHHMMSSsss.XXX

Parameter Description	Filename Position	Values
The root file directory number on the SSR where the data was stored.	RRR	001–511
The sequence (or sub-file) of this file within the root file.	ZZZ	000–127
The year the data was received.	YYYY	2012–2999
The number of the day within the year the data was received.	doy	001–366 (366 only valid for leap years)
Hour of the day the data was received.	HH	00–23
Minute of the hour the data was received.	MM	00–59
Second of the minute the data was received.	SS	00–60 (60 only valid when a leap second is added)
Fraction of the second the data was received.	sss	000–999
Ground Station Identifier (GSI) where the data was received.	XXX	Any valid three letter GSI. Example: LGS

Table 2-2. Mission Data File Name Convention

2.2.2 GNE-Created Files

The IDF and checksum file names are based on the Landsat Interval ID and their contents:

<Landsat Interval ID>_<File Contents>.<File Extension>

Table 2-3 lists the file contents and file name extensions.

File Type	File Contents	File Extension
Interval Definition File	IDF	xml
Checksum File	MD5	txt

Table 2-3. File Contents and Extension Fields in File Name Format

The Landsat Interval ID differs slightly for earth image and calibration collections. The file name formats and examples are described in the following subsections.

2.2.2.1 Earth Image Intervals

The Landsat Interval ID naming convention for earth image LDCM collections is VINpppRRRrrrYYYYdddGSIvv. Table 2-4 describes the components of the filename format. The grayed parameters highlight intervals that are not used in calibration collections.

Parameter Description	Filename Position	Values
<Vehicle>	V	L = Landsat
<Instrument>	I	O = Operational Land Imager T = Thermal Infrared Sensor C = Combined (both OLI and TIRS)
<Vehicle Number>	N	8 = Landsat 8
<WRS-2 Path>	ppp	1–233 (starting path)
<WRS-2 Start Row>	RRR	1–248
<WRS-2 End Row>	rrr	1–248
<Year>	YYYY	Four digit acquisition starting year
<Day>	ddd	Three digit acquisition starting day of year
<Ground Station>	GSI	Ground Station Identifier
<version>	vv	Version (vv = 00–99)

Table 2-4. Landsat Interval ID Convention for Earth Image Intervals

2.2.2.1.1 Example Earth Image File Names

The following example displays five OLI mission data files and two TIRS mission data files. The files are for an OLI and TIRS LDCM image, which collects over path 222, rows 001–012 on day 286 of 2014, and are received at Ground Stations within the Landsat Ground Network (LGN).

```
267.000.2014286134235476.LGS
267.001.2014286134452345.LGS
267.002.2014286134723213.GLC
267.003.2014286134854745.GLC
267.004.2014286134928645.LGS
442.000.2014286135234165.LGS
442.001.2014286135332675.LGS
LC82220010122014286LGN00_IDF.xml
LC82220010122014286LGN00_MD5.txt
```

The following example displays three OLI mission data files. The files are for an OLI-only LDCM image, which collects over path 187, rows 001–005 on day 341 of 2014, and are received at the Alice Springs, Australia (ASA) Ground Station.

```
124.000.2014341185434398.ASA
124.001.2014341185512511.ASA
124.002.2014341185558031.ASA
LO81870010052014341ASA00_IDF.xml
LO81870010052014341ASA00_MD5.txt
```

2.2.2.2 Calibration and Test Intervals

For calibration intervals, the path and row information (pppRRRrrr) is replaced with collection type and collection Universal Time Code (UTC) start time (00DHHMMSS). Table 2-5 describes these components.

Parameter Description	Filename Position	Values
<Vehicle>	V	L = Landsat
<Instrument>	I	O = Operational Land Imager
		T = Thermal Infrared Sensor
		C = Combined (both OLI and TIRS)
<Vehicle Number>	N	8 = Landsat 8
<filler>	00	00
<Collect Type>	D	Any of the one-letter abbreviations in Table 2-1 except I
<Hour>	HH	0–23 (UTC)
<Minute>	MM	0–59 (UTC)
<Second>	SS	0–60 (allows leap second) (UTC)
<Year>	YYYY	Four digit acquisition starting year
<Day>	ddd	Three digit acquisition starting day-of-year
<Ground Station>	GSI	Ground Station Identifier
<version>	vv	Version (vv = 00–99)

Table 2-5. Landsat Interval ID Convention for Calibration Intervals

2.2.2.2.1 Example Calibration File Names

The files created for an LDCM OLI shutter calibration collect data on day 265 of 2014 at 12:34:56 UTC and are received at the Landsat Ground System (LGS) Ground Station, which is part of the LGN. The number of mission data files depends on the data volume. The files are named as follows:

```
267.000.2014265152532476.LGS
LO800S1234562014265LGN00_IDF.xml
LO800S1234562014265LGN00_MD5.txt
```

Section 3 Instrument Characteristics

Several characteristics of the OLI and TIRS instruments affect the mission data format.

3.1 OLI

3.1.1 OLI Bands

The OLI instrument outputs thirteen band packets covering nine spectral ranges, eight Multispectral (MS) bands, a Panchromatic (PAN) band made up of four individual band packets, and a single blind band. The MS and blind bands occupy one band packet each. Because the PAN band has twice as many detectors and is sampled twice as often as the MS bands, OLI outputs it as four band packets with a resolution that is two times that of the other bands. Each OLI band has a spatial resolution of 30 meters (m) with the exception of the PAN band, which has a 15m resolution. The Blind band contains detectors from three of the spectral ranges. The Blind band is not used to image the Earth, but is used for calibration and its detectors are mechanically covered to keep any light from entering.

3.1.2 Organization of Detectors

Positioned within the focal plane are 14 Sensor Chip Assemblies (SCAs). Each SCA contains an array of detectors for every band. The 14 SCAs are identical with respect to electronic configuration and detector layout. As shown in Figure 3-1, the 14 SCAs are arranged in a staggered fashion to ensure complete viewing coverage of the field. As depicted in Figure 3-2, adjacent SCAs are rotated 180 degrees with respect to each other. Therefore, the PAN band detectors are closest to the axis of the focal plane for all SCAs.

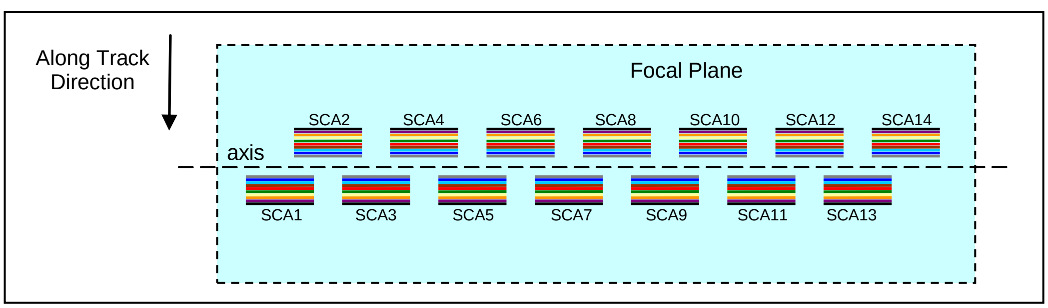

Figure 3-1. SCA Placement in the Focal Plane

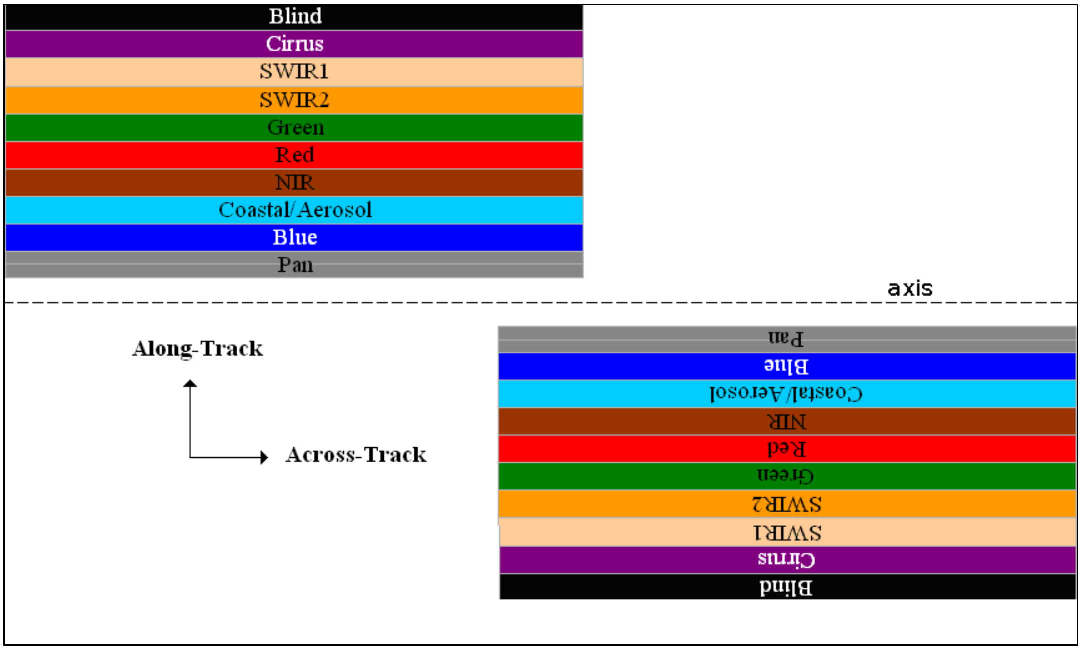

Figure 3-2. Detector Placement on Adjacent SCAs

Each detector array consists of imaging detectors and Video Reference Pixels (VRPs). The VRPs are located on either side of the imaging detectors. The detector arrays for the 8 MS bands have 6 VRPs, followed by 494 imaging detectors, followed by 6 VRPs. The PAN band has 12 VRPs, followed by 988 imaging detectors, followed by 12 VRPs.

The instrument and the spacecraft treat the VRPs the same way as pixels are treated from the imaging detectors. The pixels for a given band (both VRPs and imaged pixels) are read and transmitted.

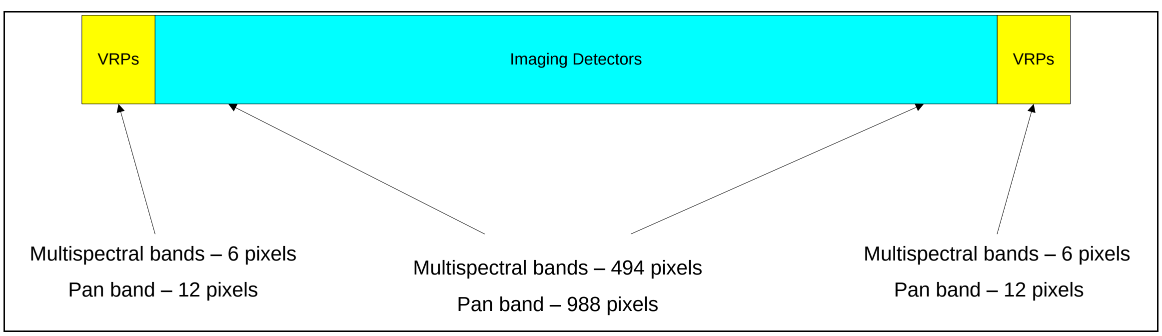

Figure 3-3. VRP Detector Placement

3.1.3 Blind Band

The Blind band is the same width (506 pixels per SCA) as the MS bands. However, the Blind band consists of 13 sets of Short Wavelength Infrared 2 (SWIR2) / SWIR1 / Cirrus pixel groups containing 5 VRPs and 8 image pixels in each band per group. With a total of 39 pixels per group (15 VRPs and 24 images), the total number of pixels is 507; the last Cirrus set has only seven image pixels instead of eight, which makes the total pixel count match the other bands. This calculation yields 65 VRPs for each band, 104 image pixels for both SWIR1 and SWIR2, and 103 image pixels for Cirrus.

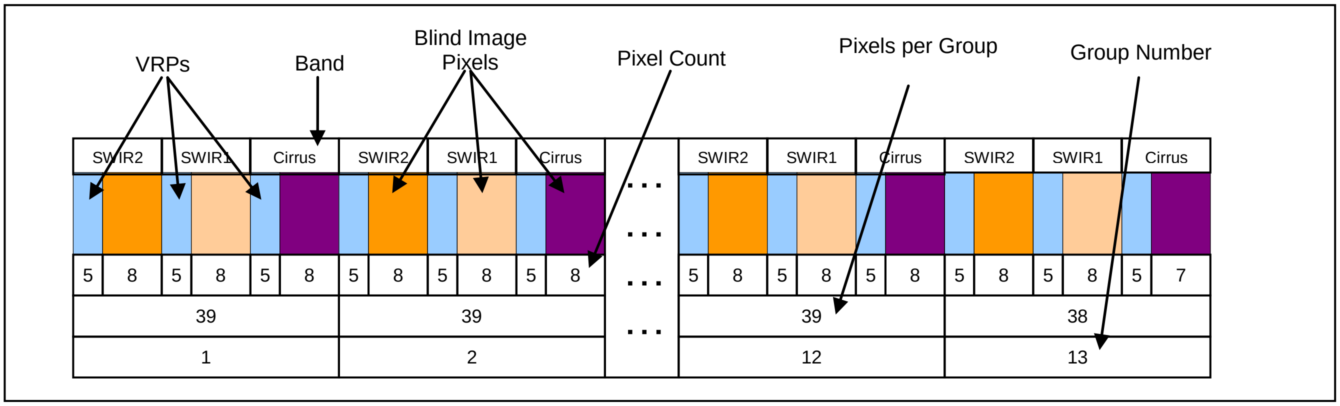

Figure 3-4. Blind Band Pixel Arrangement

3.1.4   14-bit Detectors / 12-bit Samples

The detectors used in OLI yield a 14-bit Digital Number (DN). However, only 12 bits are recorded to the SSR and transmitted to ground by the satellite. Specifically, the 12 Most Significant Bits (MSBs) of data are recorded, while the satellite bus ignores the lower two Least Significant Bits (LSBs). For certain collection types, the OLI automatically shifts image pixel values up two bits before outputting those values to the satellite bus. Pixels shifted in this manner have 12 LSBs recorded to the SSR rather than 12 MSBs. The top bits are truncated and possible data loss may occur. Shifting pixels in this manner preserves the resolution of the pixel DNs that require a less dynamic range. For pixels that require the full dynamic range of the detectors, the resolution must be sacrificed.

To accommodate this operation, the OLI employs two operating modes: Standard Imaging mode and Dim / Dark Scene Imaging mode. In either operating mode, the VRPs, the Blind band pixels, and the pixels from shutter data are always shifted up two bits. The pixels from all other bands are shifted only when operating in the Dim / Dark Scene Imaging mode. See References for more detailed information on the Dim / Dark Scene Imaging mode.

Stimulation lamp calibration intervals are sometimes collected in Standard Imaging mode and sometimes in Dim / Dark Scene Imaging mode. The detectors for some bands have a very low response and require full resolution for accurate calibration, while other detectors have a very high response and require the full dynamic range of detectors. Figure 3-5 illustrates the detector response to the stimulation lamp source as reported in the OLI Critical Design Review (CDR). When operating in Dim / Dark Scene Imaging mode, the SWIR1, SWIR2, and Cirrus bands are truncated. The loss of resolution when operating in Standard Imaging mode reduces the precision of the measurements for the remaining bands.

The imaging mode is contained in the Image Header in the Image Data Truncation Setting**.**

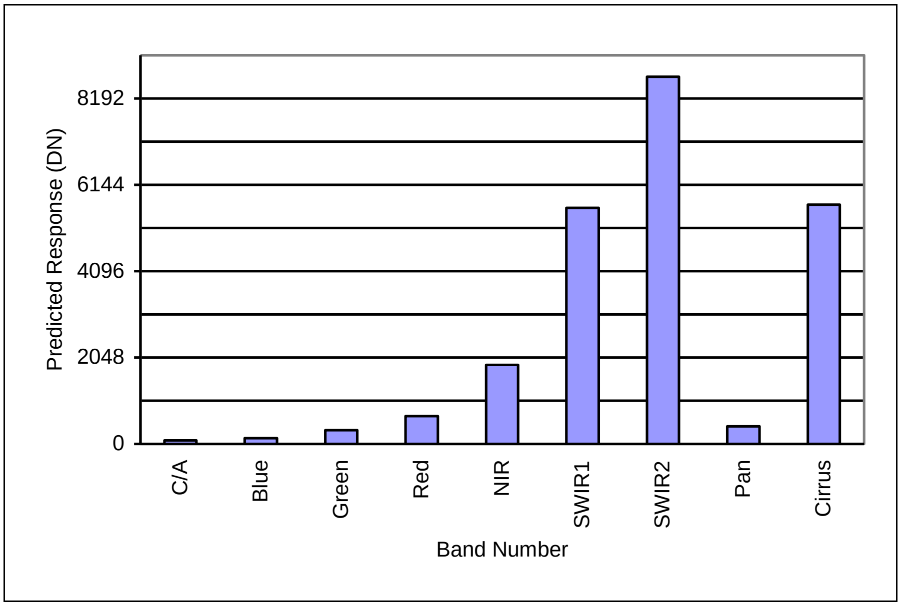

Figure 3-5. OLI Response to Stimulation Lamp Source

3.1.5 Pixel Readout

The PAN band is transmitted in the same format as the other OLI bands. Due to its increased resolution, the PAN band is treated as four separate bands at this point. This method makes the samples per band the same as the other bands. A detector order divides the PAN samples into separate bands; the even detectors and the odd detectors are split into separate bands. One band contains data from the even-numbered detectors. A second band contains data for the odd-numbered detectors. These bands are called Pan 1 Even, Pan 1 Odd, Pan 2 Even, and Pan 2 Odd. The method of splitting the detectors into individual bands yield bands with 506 pixels, and yields 6 VRPs, followed by 494 imaged pixels, followed by 6 VRPs. The first detector is numbered 1, which means the detector is placed into one of the odd bands.

OLI outputs all image data for a single frame at one time. OLI outputs the data for each band in the order shown in Figure 3-6, with Pan 1 Odd as the first output. Every band contains 14 SCAs * 506 samples per SCA = 7084 samples * 1.5 = 10,626 bytes of output data. The 7084 samples equal 92092 12-bit DNs, resulting in 138138 bytes of image data. An entire frame of OLI data is 138,264 bytes which includes the frame header at the beginning of the frame, padding at the end of every band, and the CRC at the end of the frame.

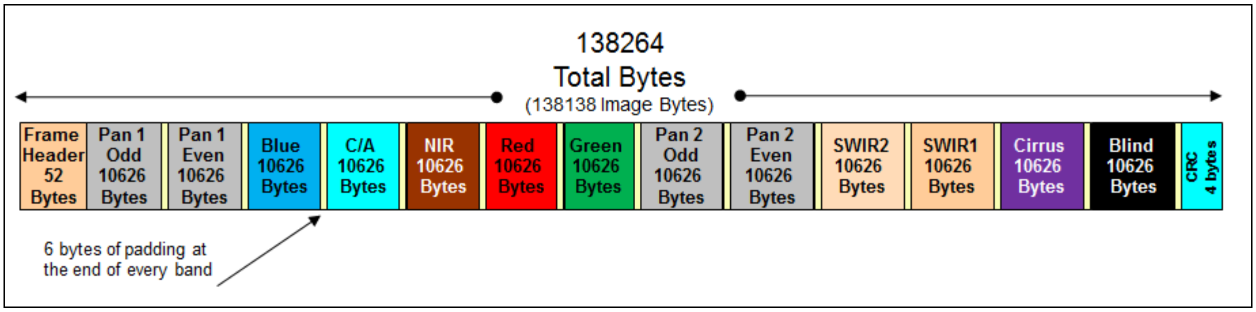

Figure 3-6. OLI Band Output Order

The data are interleaved by SCA within each band. The first 14 sample outputs come from the first detector in each of the SCAs – SCA 1 first, followed by SCA 2, and so on. The next 14 samples come from the second detector in each SCA. This pattern repeats through detector 506.

Each of the 14 SCAs are identical with respect to electronic configuration. Because adjacent SCAs are rotated 180 degrees with respect to each other, the detectors for every other SCA are read in the opposite direction. Figure 3-7 shows the detector order for each SCA. The arrows in Figure 3-7 indicate the detector order.

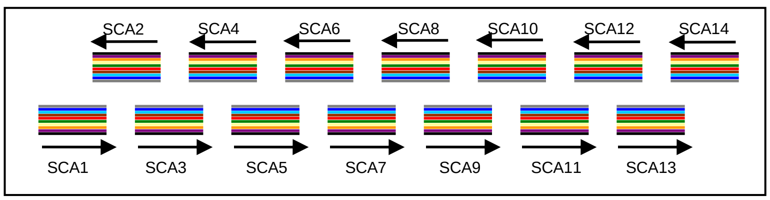

Figure 3-7. OLI SCA Readout Directions

3.1.6 OLI Interval Structure

The OLI generates an image header each time it receives an “Image Acquire” command. Only one image header is present for each mission data collection. Except in the case of data loss, a mission data collection never contains partial frames.

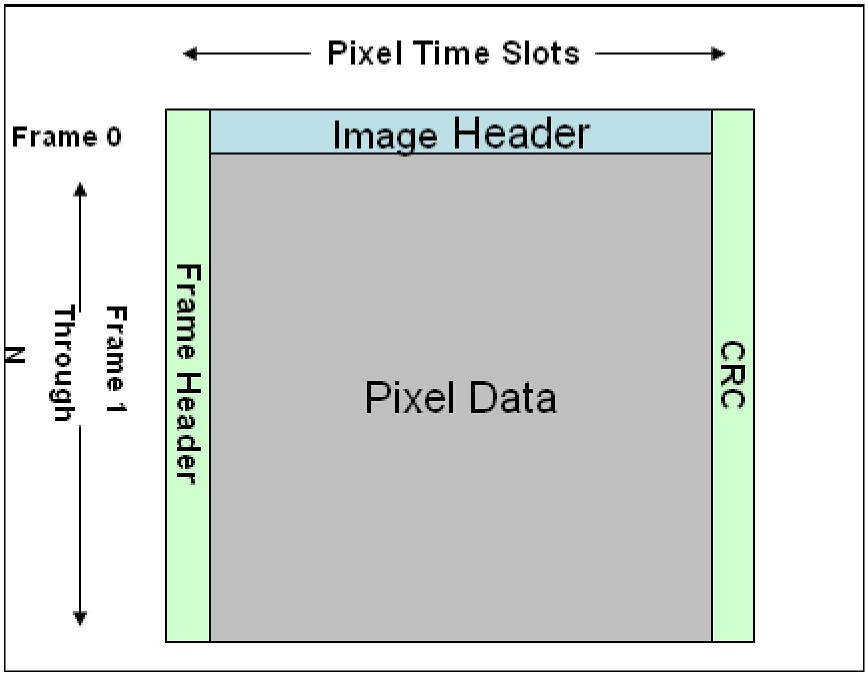

Figure 3-8. OLI Interval Overview

Figure 3-8 displays the interval structure. The beginning of the interval is called the image header and is treated as a frame, specifically frame zero. All frames that follow are image frames. These image frames are numbered 1 through N. At the beginning of every frame, including the image header frame, is a frame header. At the end of every frame is a Cyclic Redundancy Check (CRC). The CRC validates that the data within the frame has not been corrupted. The contents and structure of the image header, frame header, CRC, and image data are described in more detail in the following sections.

3.2 TIRS

3.2.1 TIRS Bands

TIRS has three bands: two clear aperture bands and one blind band. The imaging bands cover two different spectral ranges, one centered on 10.8 μm and one centered on 12.0 μm.

3.2.2 Organization of Detectors

Each TIRS SCA is a two-dimensional array of detectors. All detectors in the array are the same type and have the same spectral response. To achieve the collected spectral bands, incident light passes through filters en route to the detectors. Because the detectors are all of the same type and the two imaging bands only differ by the filter covering them, only one set of reference blind detectors is used for both bands.

To address issues with bad or poor-performing detectors, each of the clear Aperture bands has 35 rows of redundancy and the Blind band has 40 rows of redundancy. On any given collection, two rows are transmitted to ground for each band on an SCA.

TIRS outputs all image data for a single frame at one time. TIRS outputs the data for each band in the order shown in Figure 3-9. Every band contains 3 SCAs * 647 samples per SCA = 1941 * 2 Rows (for redundancy) = 3882 samples * 1.5 = 5823 bytes. The total number of TIRS generated samples for each band is 3888 * 1.5 = 5832 bytes due to the 6 DHeader bytes at the beginning of each band and 3 bytes of padding at the end of each band. An entire frame of TIRS data is 17,534 bytes which includes the frame header at the beginning of the frame and the CRC at the end of the frame. The contents and structure of the TIRS frame header, DHeader, CRC, and image data are described in more detail in 4.2.4.1.

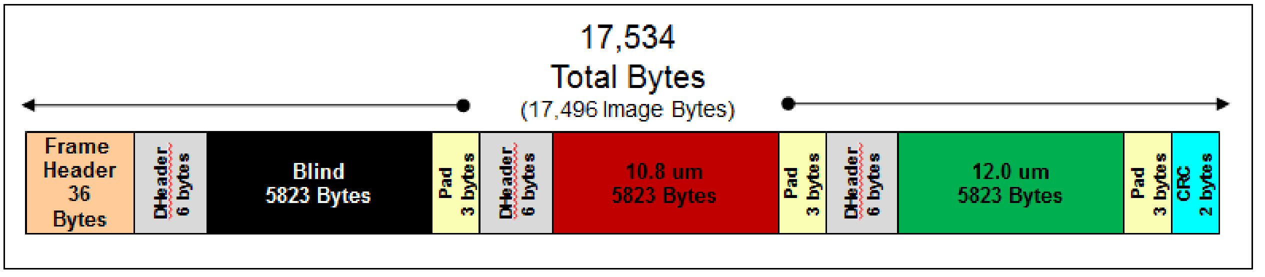

Figure 3-9. TIRS Band Output Order

Figure 3-10 depicts the arrangement of the three TIRS SCAs on the focal plane. Each SCA has 640 columns of detectors. A 35 pixel overlap between adjacent SCAs yields a total of 1,850 unique pixel columns.

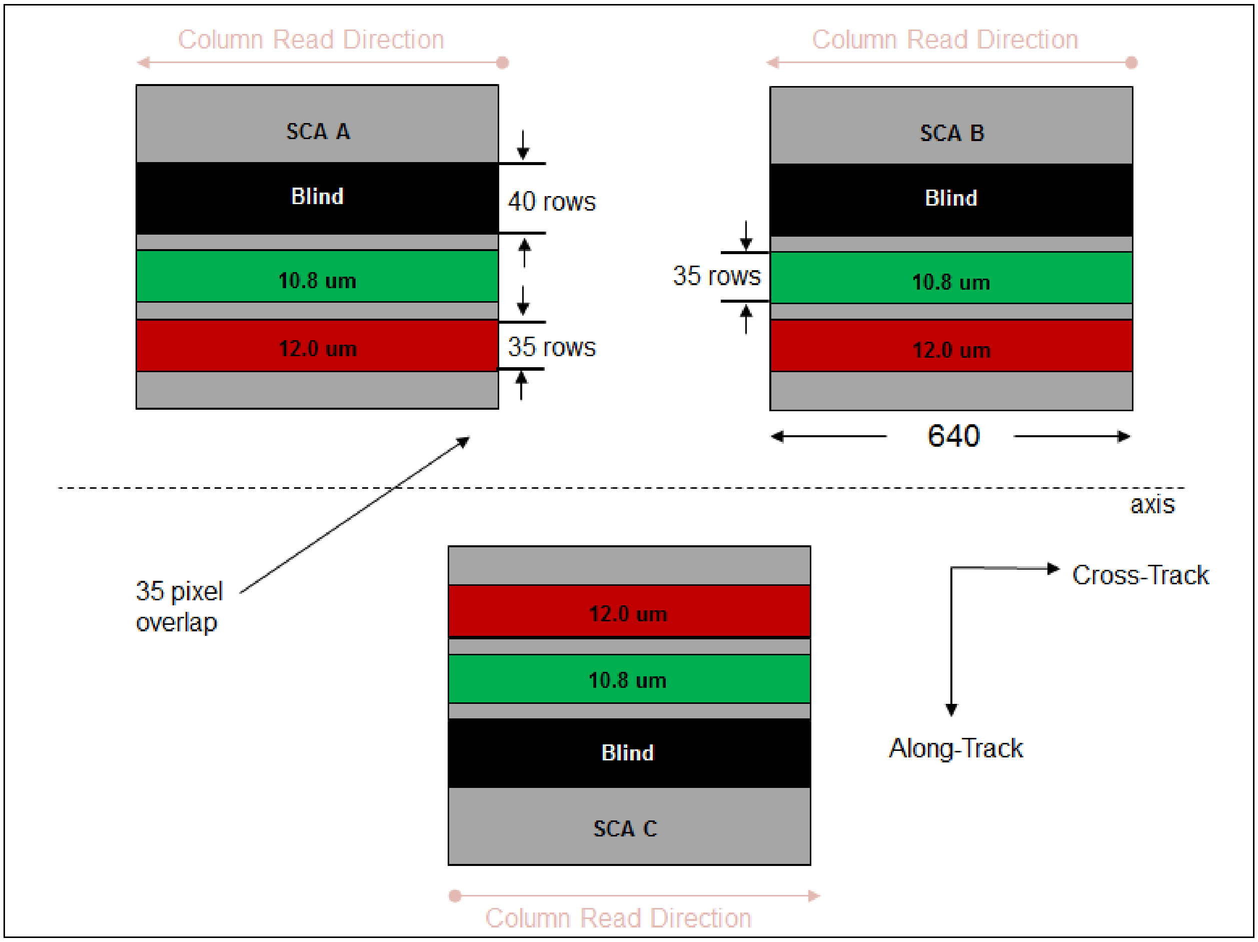

Figure 3-10. TIRS Focal Plane

Section 4 Data Definition

This section provides detailed information regarding each file type format.

4.1 The Interval Definition File (IDF)

The IDF provides information about the interval including the list of file names, sizes, and checksums, and the WRS-2 scenes covered. To create the file, the Ground Station collects the data based on information in the Scene-Interval-File Mapping Table (SIFMT). The Ground Station adds information upon receipt of the data. LDCM-ICD-011 Landsat Data Continuity Mission (LDCM) Mission Operations Element (MOE) to Ground Network Element (GNE) Interface Control Document (ICD) describes the SIFMT file.

The IDF is an Extensible Markup Language (XML) formatted file. The information is divided into a list of records. The IDF has five record types: IDF, Header, Root File, File, and Scene.

The root element in an IDF file is <idf>. Each IDF contains a single IDF record. The IDF record contains standalone variables, in addition to four complex record types that are each encapsulated in an XML element. The names of these elements are “header”, “scene_record”, “rootfile_record”, and “file_record”. Each of the variables defined within a record is a simple element, the text of which is the value for that variable. None of the elements within an IDF file allow attributes.

The number of Scene Records in the file reflects the number of complete WRS-2 scenes that the interval covers. One File Record exists for each file. The IDF contains either one or two Root File Records. Each of the File Records is encapsulated inside a Root File Record. The following subsections define the format and content of each record type.

The applicable XML Schema Definition (XSD) file provides a more explicit definition of the IDF. This file is found on the Landsat Mission Web Site (LMWS).

4.1.1 IDF Record

The following elements appear within the IDF Record.

header - Complex data type described in subsection 4.1.2.

moe_interval_id - A string indicating the ID of the interval that the MOE assigns. This field is an 11-character string, which has the following format: OOOOOO_SS_T, where OOOOOO is the orbit number for the first scene in the interval, SS is the segment number, and T is the type code. The segment number is a counter that resets at the beginning of each orbit. See the list of type codes in Table 2-2.

landsat_interval_id - The Landsat Interval ID as described in subsection 2.2. Either this field or the Landsat Calibration Interval ID, but not both, must be included.

landsat_cal_interval_id - The Landsat Calibration Interval ID as described in subsection 2.2. Either this field or the Landsat Interval ID, but not both, must be included.

moe_interval_complete_flag - A one-character string value indicating if a complete interval has been delivered. Valid values are 'Y' and 'N'. This field may be omitted when an IC generates the IDF.

priority_flag - A one-character string value indicating whether or not the interval contains any priority scenes. Valid values are 'Y' and 'N'. This field may be omitted when an IC generates the IDF.

sensor_id - A three- to eight-character string indicating which instrument recorded the data. For OLI data, the string is "OLI". For TIRS data, the string is "TIRS". For combined data, the string is "OLI_TIRS".

offnadir_flag - A one-character string value indicating whether or not the interval was collected nadir or off-nadir. This field is only used for type "I" (earth imaging) intervals. Valid values are 'Y' and 'N'. This field may be omitted when an IC generates the IDF.

collection_type - Type of data imaged during the interval. This value must be one of the following values: EARTH IMAGING, SHUTTER, LUNAR, LAMP, SOLAR, SIDE SLITHER, STELLAR, OLI TEST PATTERN, SSR PN TEST SEQUENCE, TIRS LINEARITY CALIBRATION, or TIRS NORMAL CALIBRATION.

data_category - Indicates the category of the interval. Legacy use of this field is as follows:

- VALIDATION – Indicates data are from an IC requesting that EROS evaluate their data. Once ten data sets from the IC are successfully validated within a given timeframe, the future data from that IC are labeled EXCHANGE.
- EXCHANGE – Indicates the data are from a validated IC outside the LGN.
- DIAGNOSTIC – Indicates the data contains test patterns from the instrument.
- NOMINAL – Indicates the LGN Ground Station nominally collected data.
- ENGINEERING – Indicates data that should be processed normally, but should not be provided to outside customers. This setting may be used for an interval suspect for one reason or another (e.g., following a maneuver).

wrs_path - An integer indicating the WRS-2 path number of the interval. If the starting path differs from the ending path, the starting path is used. This field is only used for type "I" (earth imaging) intervals. Valid values are from 1 to 233.

wrs_starting_row - An integer indicating the first full WRS-2 row in the interval. This field is only used for type "I" (earth imaging) intervals. Valid values are from 1 to 248.

wrs_ending_row - An integer indicating the last full WRS-2 row in the interval. This field is only used for type “I” (earth imaging) intervals. Valid values are from 1 to 248.

gne_interval_complete_flag - A one-character string value indicating if GNE successfully processed the complete interval. Valid values are ‘Y’ and ‘N’. This field may be omitted when an IC generates the IDF.

rootfile_record - One or two root file records may be included in the IDF. This complex data type is described in subsection 4.1.3.

scene_record - Zero or more scene records may be included in the IDF. This complex data type is described in subsection 4.1.5.

4.1.2 Header Record

The following elements appear within the Header Record.

scid - The three-digit spacecraft identifier that the Consultative Committee for Space Data Systems (CCSDS) assigns (i.e., the 10-bit code). For LDCM, the code is 506.

product_type - The type of file. This field should always be set to “IDF”.

gen_time - UTC time string holding the time that the file was generated. This field is a 21-character string with the following format:

YYYY:DOY:HH:MM:SS.SSS

Source - Originator of the file. This field is either a six- or eight-character string. For LGN Ground Stations, this value is set to “GNE-DCRS”. For ICs, this value is “IC-XXX”, where XXX identifies the originating Ground Station.

mode - Indicates if the system is in production mode or test mode. This field is either a four- or ten-character string. Valid values are “TEST” and “PRODUCTION”.

4.1.3 Root File Record

For all intervals, the IDF contains one or two root files. Each root file corresponds to a directory on the spacecraft SSR. OLI and TIRS intervals are stored in separate directories, creating the possibility for two root files. Each root file record contains a number of file records. The root file record contains the following elements:

root_file_id - An integer indicating the SSR root file directory number, where the interval is stored. Valid values are from 0 to 511.

root_file_complete_flag - A one-character string value indicating if the collection for the root file has been completed. Valid values are ‘Y’ and ‘N’.

sensor id - A three- or four-character string indicating the association between the instrument and the root file. For OLI data, the string is “OLI”. For TIRS data, the string is “TIRS”. A value of “OLI_TIRS” is not valid because a root file can only contain OLI or TIRS data.

landsat_interval_id - The Landsat Interval ID as described in subsection 2.2. Either this field or the Landsat Calibration Interval ID, but not both, must be included.

landsat_cal_interval_id - The Landsat Calibration Interval ID as described in subsection 2.2. Either this field or the Landsat Interval ID, but not both, must be included.

priority_flag - A one-character string value indicating whether or not the interval contains any priority scenes. Valid values are ‘Y’ and ‘N’.

file_record - Zero or more file records may be included in each root file record. Need to have at least one file record for each root file. This complex data type is described in subsection 4.1.4.

4.1.4 File Record

For every mission data file in the interval, the IDF provides a File Record containing the following elements:

file_name - The name of the file, conforming to the file name format specified in subsection 2.2.

station_id - A three-character string identifying the Ground Station receiving the file.

file_checksum - A character string identifying the file’s MD5 checksum value.

file_size - An integer indicating the file’s size in bytes.

4.1.5 Scene Record

For earth imaging intervals, the IDF contains a Scene Record of every scene scheduled for imaging. This record is only present in the IDF for earth imaging intervals. Each record includes the following elements:

wrs_path - An integer indicating the WRS-2 path number of the scene. Valid values are from 1 to 233.

wrs_row - An integer indicating the WRS-2 row number of the scene. Valid values are from 1 to 248.

sensor_id - A three- to eight-character string indicating which instrument recorded the data. For OLI data, the string is “OLI”. For TIRS data, the string is “TIRS”. For combined data, the string is “OLI_TIRS”.

priority_flag - A one-character string value indicating whether or not the scene is a priority. Valid values are ‘Y’ and ‘N’.

4.2 OLI and TIRS Mission Data Files

Each mission data interval contains one or more mission data files. Because of constraints in the underlying transfer protocol, these files are never larger than 1 GB. The data are transmitted from the spacecraft to Ground Stations as 1 GB sub-files. Each of these sub-files contains CCSDS File Delivery Protocol (CFDP) header information. This header information, used in the GNE transfer, is stripped before saving the file to disk. These sub-files, with the header information removed, are referred to as OLI and TIRS mission data files. The amount of header information removed from each file is minimal. With the exception of the final file, each mission data file is near 1 GB in size.

Each mission data file contains data from only one of the instruments (OLI or TIRS). The mission data files are interleaved with ancillary data that the spacecraft collected during the record operation. No other information exists in the files. No special header information (i.e., file order or file size) exists in the individual files. The concatenation of two or more mission data files yields a valid mission data file, presuming the data are concatenated in the original order.

OLI image data may be compressed. The satellite performs this compression after the OLI instrument outputs the data. The CRC value that the OLI calculates is computed from the uncompressed image data. OLI header information is transmitted in its original, uncompressed format. Ancillary data and TIRS data are always uncompressed.

4.2.1 Mission Data File Format

The mission data files are organized as a packet series. Each packet contains exactly one type of data. At the beginning of each packet is a Mission Data Header (MDH), which indicates the type of data in the packet and the length of the data field within the packet. Table 4-1, derived from LDCM-ICD-011 Landsat Data Continuity Mission (LDCM) Mission Operations Element (MOE) to Ground Network Element (GNE) Interface Control Document (ICD), summarizes the structure of a mission data packet.

MDH		Data Field
Mission Data ID	**Mission Data Length**	
2 Bytes	2 Bytes	Variable Length

Table 4-1. Mission Data Packet Format

Six types of data are stored in mission data packets and include spacecraft ancillary data, five types of OLI data, and four types of TIRS data. The OLI packet types are Frame Header, CRC, Image Header, Ancillary Data, Uncompressed Image Data, and Compressed Image Data. The TIRS packet types are Frame Header, CRC, Ancillary Data, and Uncompressed Image Data. The Mission Data ID indicates which types of data are contained within the packet. For compressed and uncompressed image data, the Mission Data ID also indicates which bands of data are contained in the packet. Table 4-2 lists the valid Mission Data IDs and their meanings.

Mission Data ID (Uncompressed)	Mission Data ID (Compressed)	Description
2	N/A	OLI Frame Header
3	N/A	OLI CRC
4	N/A	OLI Image Header
5	N/A	Ancillary Data
768	256	OLI Pan 1 Odd
769	257	OLI Pan 1 Even
770	258	OLI Blue
771	259	OLI C/A
772	260	OLI NIR
773	261	OLI Red
774	262	OLI Green
775	263	OLI Pan 2 Odd
776	264	OLI Pan 2 Even
777	265	OLI SWIR2
778	266	OLI SWIR1
779	267	OLI Cirrus
780	268	OLI Blind
1026	N/A	TIRS Frame Header
1027	N/A	TIRS CRC
1792	N/A	TIRS Blind
1793	N/A	TIRS 10.8
1794	N/A	TIRS 12.0

Table 4-2. Mission Data IDs for Mission Data Packets

Both OLI and TIRS mission data files consist of packets that form frames along with Ancillary Data Packets at a fixed 1 Hertz (Hz) rate. Uncorrupted mission data files contain only full frames. In breaking mission data files at or near the 1 GB boundary, a frame is never split across the break. (e.g., all frames in the mission data files are complete).

4.2.2 Ancillary Data Packets

The spacecraft collects measurements for the Ancillary Data Packets independently of instrument recordings. The ancillary data precedes and follows the instrument data by several seconds. Thus, the planned configuration is for ancillary data to record in conjunction with instrument data with the appropriate margins before and after the instrument recording is performed.

4.2.2.1 Ancillary Data Packet Structure

Ancillary Data Packets are fixed sized and always contain information in the same format. The Ancillary Data Packet Data Field is divided into sections called messages. Table 4-3 identifies the organization of messages with the Ancillary Data Packet.

This subsection describes the overall data portion of the Ancillary Data Packet organization, and provides figures to clarify the organization.

Data Type	Start Byte	Length
Attitude Quaternion	0	1200
Attitude Filter States	1200	80
Inertial Measurement Unit (IMU) Data	1280	708
IMU Latency	1988	120
Spare	2108	80
Ephemeris Data	2188	80
Raw GPS Position Channel	2267	137
Raw GPS Range Data	2405	249
ST Quaternion Output Message	2654	72
ST Centroid Output Message	2726	250
Spare	2976	29
OLI Telemetry	3005	320
OLI & TIRS S/C Temperatures	3325	134
Gyro Temperatures	3459	256
TIRS Telemetry	3715	256
Spare	3971	111
Padding	4082	14
Total Bytes		4096

Table 4-3. Ancillary Data Packet Organization

4.2.2.2 Ancillary Data Group Details

This subsection defines the detailed organization of each message type found in the Ancillary Data Packet. All multi-byte data fields are big-endian unless otherwise specified.

4.2.2.2.1 Attitude

The spacecraft estimates the spacecraft attitude using a Kalman filter applied to Inertial Reference Units (IRUs) and Star Tracker measurements. The attitude estimates are included in the Ancillary Data. The Kalman filter states are included in the Ancillary Data. This information is separated into two messages: the Processed Attitude message and the Attitude Filter States message. The following subsections describe each of these messages in detail.

4.2.2.2.1.1 Processed Attitude Message

The Processed Attitude message is sampled at 50 Hz and generated at 1Hz. The Processed Attitude message contains the following information:

- Attitude quaternion
- Spacecraft body rates
- Time tag for the moment at which the information applies

Table 4-4 identifies the structure of the Processed Attitude Message.

Byte	Description	Bit Length	Type	Units
0-7	Time stamp of the Ancillary Data Quaternion solution, sample 0	64	F64	s
8-11	Ancillary Data Fine Attitude Quaternion Estimate Earth Centered Inertial (ECI) to body [q1], Sample 0	32	I	Unitless
12-15	Ancillary Data Fine Attitude Quaternion Estimate ECI to body [q2], Sample 0	32	I	Unitless
16-19	Ancillary Data Fine Attitude Quaternion Estimate ECI to body [q3], Sample 0	32	I	Unitless
20-23	Ancillary Data Fine Attitude Quaternion Estimate ECI to body [q4], Sample 0	32	I	Unitless
24-1199	Repeat above data 49 more times			

Table 4-4. Processed Attitude Message

4.2.2.2.1.2 Attitude Filter States Message

The Attitude Filter States message is generated at 1 Hz. The Attitude Filter States message contains the following information:

- Time tag for the moment at which the information applies
- Gyro biases
- Gyro misalignments
- Gyro scale factors
- Filter attitude error
- Covariance matrix of the new quaternion to the prior quaternion

Table 4-5 identifies the structure of the Attitude Filter States Message.

Byte	Description	Bit Length	Type	Units
1200-1203	Seconds since the Spacecraft Time Epoch (Jan 1st, 2000 International Atomic Time (TAI)) - UDL Seconds Register	32	UI	s
1204-1207	UDL Sub-Seconds Register	32	UI	10E-7 s
1208-1211	FAD body X estimate of gyro drift bias wrt ADF	32	F32	rad/s
1212-1215	FAD body Y estimate of gyro drift bias wrt ADF	32	F32	rad/s
1216-1219	FAD body Z estimate of gyro drift bias wrt ADF	32	F32	rad/s
1220-1223	FAD estimate of body (X,X) element of gyro correction matrix (scale factor)	32	F32	Unitless
1224-1227	FAD estimate of body (Y,Y) element of gyro correction matrix (scale factor)	32	F32	Unitless
1228-1231	FAD estimate of body (Z,Z) element of gyro correction matrix (scale factor)	32	F32	Unitless
1232-1235	FAD estimate of body (X,Y) element of gyro correction matrix (gyro alignment wrt ADF)	32	F32	rad
1236-1239	FAD estimate of body (X,Z) element of gyro correction matrix (gyro alignment wrt ADF)	32	F32	rad
1240-1243	FAD estimate of body (Y,X) element of gyro correction matrix(gyro alignment wrt ADF)	32	F32	rad
1244-1247	FAD estimate of body (Y,Z) element of gyro correction matrix(gyro alignment wrt ADF)	32	F32	rad
1248-1251	FAD estimate of body (Z,X) element of gyro correction matrix(gyro alignment wrt ADF)	32	F32	rad
1252-1255	FAD estimate of body (Z,Y) element of gyro correction matrix(gyro alignment wrt ADF)	32	F32	rad
1256-1259	Estimated attitude control error about the spacecraft x body axis	32	F32	rad
1260-1263	Estimated attitude control error about the spacecraft y body axis	32	F32	rad
1264-1267	Estimated attitude control error about the spacecraft z body axis	32	F32	rad
1268-1271	FAD state covariance diagonal associated with body X attitude error estimate	32	F32	rad^2
1272-1275	FAD state covariance diagonal associated with body Y attitude error estimate	32	F32	rad^2
1276-1279	FAD state covariance diagonal associated with body Z attitude error estimate	32	F32	rad^2

Table 4-5. Attitude Filter States Message

4.2.2.2.2 Inertial Measurement Unit (IMU) Gyro

The IMU Gyro data are generated at 50 Hz. This data contains the following information:

- Time of the last IMU time sync pulse
- Fifty Gyro samples (each sample includes a Sync event time tag)

Table 4-6 identifies the structure of the IMU Gyro.

Byte	Description	Bit Length	Type	Units
1280-1283	UDL Seconds register value at the time of the last IMU time sync pulse	32	UI	s
1284-1287	UDL sub-seconds register value at the time of the last IMU time sync pulse; 10 MHz counter	32	UI	10E-7 s
1288-1289	IMU Sync Event Time Tag Sample 1 - Oldest	16	I	Unitless
1290-1291	IMU Time Tag Sample 1 - Oldest	16	UI	Unitless
1292	IMU Gyro A WA or FTR state Sample 1 - Oldest	1	D	0 - FTR_MODE 1 - WAS_MODE
1292	IMU Gyro B WA or FTR state Sample 1 - Oldest	1	D	0 - FTR_MODE 1 - WAS_MODE
1292	IMU Gyro C WA or FTR state Sample 1 - Oldest	1	D	0 - FTR_MODE 1 - WAS_MODE
1292	IMU Gyro D WA or FTR state Sample 1 - Oldest	1	D	0 - FTR_MODE 1 - WAS_MODE
1292	IMU Gyro A Mode Status Sample 1 - Oldest	1	D	0 - LOW_RATE 1 - HIGH_RATE
1292	IMU Gyro B Mode Status Sample 1 - Oldest	1	D	0 - LOW_RATE 1 - HIGH_RATE
1292	IMU Gyro C Mode Status Sample 1 - Oldest	1	D	0 - LOW_RATE 1 - HIGH_RATE
1292	IMU Gyro D Mode Status Sample 1 - Oldest	1	D	0 - LOW_RATE 1 - HIGH_RATE
1293	IMU Gyro A Valid Status Sample 1 - Oldest	1	D	0 – INVALID 1 - VALID
1293	IMU Gyro B Valid Status Sample 1 - Oldest	1	D	0 – INVALID 1 – VALID
1293	IMU Gyro C Valid Status Sample 1 - Oldest	1	D	0 – INVALID 1 – VALID
1293	IMU Gyro D Valid Status Sample 1 - Oldest	1	D	0 – INVALID 1 - VALID
1293	*Data validity unused Bits*	4		
1294-1295	IMU Gyro A integrated angle counter Sample 1 - Oldest	16	UI	Unitless
1296-1297	IMU Gyro B integrated angle counter Sample 1 - Oldest	16	UI	Unitless
1298-1299	IMU Gyro C integrated angle counter Sample 1 - Oldest	16	UI	Unitless
1300-1301	IMU Gyro D integrated angle counter Sample 1 - Oldest	16	UI	Unitless
1302-1987	Repeat above data 49 more times			

Table 4-6. IMU Gyro

The Integrated Angles given in the IMU message offer a measure on the amount of rotation the gyroscope has undergone between samples. The gyroscopes can work in either a Low Rate Range mode or a High Rate Range mode. When in Low Rate Range mode, the Integrated Angles unit is 0.05 arc seconds. When rotating quickly, the IMU automatically switches to High Rate Range mode. In this mode, the Integrated Angles unit is 1.6 arc seconds. This rate allows the IMU to correctly represent the rotational rate when the values become large at the expense of reduced resolution.

The greatest change in angle represented when in Low Rate Range mode is ~0.455° (32768 * 0.05 / 3600). At a sampling rate of 50 Hz, a rotational rate of ~22.7°/sec is allowed in either the positive or negative direction. The LDCM spacecraft should never rotate at or above this rate during nominal operations. The High Rate Range mode is not expected to be entered. None of the gyroscopes should experience saturation, which would require an angular rate of 726°/sec.

The time given for each set of gyro samples is a delta from the epoch given at the beginning of the message. The resolution of the time tag delta fields is 4 μs. The maximum value represented by this field is 262.14 ms. The IRU message is generated once every 100 ms. The epoch is reset frequently, if not once every message.

4.2.2.2.3 IMU Latency

IMU Latency data are generated at 10 Hz. Table 4-7 shows the contents of IMU Latency.

Byte	Description	Bit Length	Type	Units
1988-1995	Time stamp of the Fine AD solution	64	F64	s
1996-1999	Measured IMU data latency	32	F32	s
2000-2107	Repeat above data nine more times			

Table 4-7. IMU Latency

4.2.2.2.4 Ephemeris

The spacecraft calculates the ephemeris based on output from the onboard Global Positioning System (GPS) unit. The message generates at 1 Hz. The spacecraft outputs its estimate of the ephemeris as part of each Ancillary Data Packet. The ephemeris information consists of the time for the estimate, the location and velocity of the spacecraft at that time, and GPS position residual error values for both the position and velocity. The spacecraft position and velocity are given in Earth-Centered, Earth-Fixed (ECEF) coordinates. The residuals are given in the Earth Centered Inertial (ECI) J2000 coordinate frame. Table 4-8 shows the contents of the ephemeris message.

Byte	Description	Bit Length	Type	Units
2188-2195	Orbit Propagator Solution Time Tag	64	F64	seconds
2196-2203	Spacecraft Position Estimate x-axis component in ECEF reference frame	64	F64	meters
2204-2211	Spacecraft Position Estimate y-axis component in ECEF reference frame	64	F64	meters
2212-2219	Spacecraft Position Estimate z-axis component in ECEF reference frame	64	F64	meters
2220-	Spacecraft Velocity Estimate x-axis component in	64	F64	meters/second

Byte	Description	Bit Length	Type	Units
2227	ECEF reference frame			
2228-2235	Spacecraft Velocity Estimate y-axis component in ECEF reference frame	64	F64	meters/second
2236-2243	Spacecraft Velocity Estimate z-axis component in ECEF reference frame	64	F64	meters/second
2244-2247	Orbit Determination Filter x position orb frame residual	32	F32	meters
2248-2251	Orbit Determination Filter y position orb frame residual	32	F32	meters
2252-2255	Orbit Determination Filter z position orb frame residual	32	F32	meters
2256-2259	Orbit Determination Filter x velocity orb frame residual	32	F32	meters/second
2260-2263	Orbit Determination Filter y velocity orb frame residual	32	F32	meters/second
2264-2267	Orbit Determination Filter z velocity orb frame residual	32	F32	meters/second

Table 4-8. Ephemeris Message

4.2.2.2.5 GPS

The raw GPS output is transmitted to ground for definitive ephemeris processing in the event that processing is necessary. The GPS output consists of two messages: the Position Channel Status message and the Satellite Range Data message. Each of these messages is output at 1 Hz. One copy of each message is found in each Ancillary Data Packet.

With the exception of the actual position and velocity at the end of the Position Channel Status message, each of the values in these messages is an unsigned integer.

4.2.2.2.5.1 Position Channel Status Message

The Position Channel Status message gives the position of the spacecraft in polar coordinates and Cartesian ECEF coordinates. The velocity is also multiply-defined, both as a vector in ECEF coordinates and as a magnitude and heading. The ECEF values are of primary interest to the ground system. The Position Channel Status message also provides information about the satellites tracked and the overall status of the receiver. Up to 12 satellites may be tracked simultaneously. Table 4-9 identifies the details for the message.

Byte	Description	Bit Length	Type	Units
2268	Selected GPS Position Channel Status Message - Function	8	UI	Unitless
2269	Selected GPS Position Channel Status Message - Sub Function	8	UI	Unitless

Byte	Description	Bit Length	Type	Units
2270	Selected GPS Position Channel Status Message - Month	8	UI	Unitless
2271	Selected GPS Position Channel Status Message - Day	8	UI	Unitless
2272-2273	Selected GPS Position Channel Status Message - Year	16	UI	Unitless
2274	Selected GPS Position Channel Status Message - Hours	8	UI	hr
2275	Selected GPS Position Channel Status Message - Minutes	8	UI	min
2276	Selected GPS Position Channel Status Message - Seconds	8	UI	s
2277-2280	Selected GPS Position Channel Status Message - Fractional Seconds	32	UI	Unitless
2281-2284	Selected GPS Position Channel Status Message - Latitude	32	I	deg
2285-2288	Selected GPS Position Channel Status Message - Longitude	32	I	deg
2289-2292	Selected GPS Position Channel Status Message - Height - GPS Ellipsoid (Uncorrected)	32	I	m
2293-2296	Selected GPS Position Channel Status Message - Height - MSL (Corrected)	32	I	m
2297-2300	Selected GPS Position Channel Status Message - Velocity	32	UI	m/sec
2301-2302	Selected GPS Position Channel Status Message - Heading	16	UI	deg
2303-2304	Selected GPS Position Channel Status Message - Current Dilution of Precision (DOP)	16	UI	Unitless
2305	Selected GPS Position Channel Status Message - DOP Type	8	D	Unitless
2306	Selected GPS Position Channel Status Message - Number of Satellites Visible	8	UI	Unitless
2307	Selected GPS Position Channel Status Message - Number of Satellites Tracked	8	UI	Unitless
2308	Selected GPS Position Channel Status Message - Channel 01 - Satellite ID	8	UI	Unitless
2309	Selected GPS Position Channel Status Message - Channel 01 - Channel Tracking Mode	8	D	0 - CODE_SEARCH 1 - CODE_ACQUIRE 2 - AGC_SET 3 - FREQ_ACQUIRE 4 - BIT_SYNC_DETECT 5 - MSG_SYNC_DETECT 6 - SAT_TIME_AVAIL 7 - EPHEM_ACQUIRE 8 - AVAIL_FOR_POS
2310	Selected GPS Position Channel Status Message - Channel 01 - Signal	8	UI	Unitless

Byte	Description	Bit Length	Type	Units
	Strength			
2311	Selected GPS Position Channel Status Message - Channel 01 - Used For Position Fix (Channel Status Flag Bit 7)	1	D	0 - FALSE 1 - TRUE
2311	Selected GPS Position Channel Status Message - Channel 01 - Satellite Momentum Alert Flag Set (Channel Status Flag Bit 6)	1	D	0 - FALSE 1 - TRUE
2311	Selected GPS Position Channel Status Message - Channel 01 - Satellite Anti-Spoof Flag Set (Channel Status Flag Bit 5)	1	D	0 - FALSE 1 - TRUE
2311	Selected GPS Position Channel Status Message - Channel 01 - Satellite Reported Unhealthy (Channel Status Flag Bit 4)	1	D	0 - HEALTHY 1 - UNHEALTHY
2311	Selected GPS Position Channel Status Message - Channel 01 - Satellite Reported Inaccurate (>16 meters) (Channel Status Flag Bit 3)	1	D	0 - FALSE 1 - TRUE
2311	Selected GPS Position Channel Status Message - Channel 01 - Spare (Channel Status Flag Bit 2)	1	D	0 - FALSE 1 - TRUE
2311	Selected GPS Position Channel Status Message - Channel 01 - Spare (Channel Status Flag Bit 1)	1	D	0 - FALSE 1 - TRUE
2311	Selected GPS Position Channel Status Message - Channel 01 - Parity Error (Channel Status Flag Bit 0)	1	D	0 - FALSE 1 - TRUE
2312-2355	Selected GPS Position Channel Status Message Repeated for Channels 02-12			
2356	Selected GPS Position Channel Status Message - Position Propagate (Receiver Status Message Bit 7)	1	D	0 - FALSE 1 - TRUE
2356	Selected GPS Position Channel Status Message - Poor Geometry (DOP>20) (Receiver Status Message Bit 6)	1	D	0 - FALSE 1 - TRUE
2356	Selected GPS Position Channel Status Message - 3D Fix (Receiver Status Message Bit 5)	1	D	0 - FALSE 1 - TRUE
2356	Selected GPS Position Channel Status Message - Altitude Hold (2D fix) (Receiver Status Message Bit 4)	1	D	0 - FALSE 1 - TRUE
2356	Selected GPS Position Channel Status Message - Acquiring Satellites/Position Hold (Receiver Status Message Bit 3)	1	D	0 - FALSE 1 - TRUE
2356	Selected GPS Position Channel Status Message - Storing New Almanac (Receiver Status Message	1	D	0 - FALSE 1 - TRUE

Byte	Description	Bit Length	Type	Units
	Bit 2)			
2356	Selected GPS Position Channel Status Message - Insufficient Visible Satellites (Less than three) (Receiver Status Message Bit 1)	1	D	0 - FALSE 1 - TRUE
2356	Selected GPS Position Channel Status Message - Bad Almanac (Receiver Status Message Bit 0)	1	D	0 - FALSE 1 - TRUE
2357-2364	Selected GPS Position Channel Status Message - ECEF X Position (Institution of Electrical and Electronics Engineers (IEEE) Double Real Format)	64	F64	Unitless
2365-2372	Selected GPS Position Channel Status Message - ECEF Y Position (IEEE Double Real Format)	64	F64	Unitless
2373-2380	Selected GPS Position Channel Status Message - ECEF Z Position (IEEE Double Real Format)	64	F64	Unitless
2381-2388	Selected GPS Position Channel Status Message - ECEF X Velocity (IEEE Double Real Format)	64	F64	m/sec
2389-2396	Selected GPS Position Channel Status Message - ECEF Y Velocity (IEEE Double Real Format)	64	F64	m/sec
2397-2404	Selected GPS Position Channel Status Message - ECEF Z Velocity (IEEE Double Real Format)	64	F64	m/sec

Table 4-9. GPS Receiver Position Channel Status Message

4.2.2.2.5.2 The Satellite Range Format Message

The Satellite Range Format message provides information used to determine the travel time for each satellite currently tracked. Up to 12 satellites may be tracked simultaneously. Table 4-10 specifies the message format.

Byte	Description	Bit Length	Type	Units
2405	Selected GPS Satellite Range Data Output Message - Function	8	UI	Unitless
2406	Selected GPS Satellite Range Data Output Message - Sub Function	8	UI	Unitless
2407-2409	Selected GPS Satellite Range Data Output Message - GPS Local Time (Seconds)	24	UI	s
2410-2413	Selected GPS Satellite Range Data Output Message - GPS Local Fractional Time (Sub-seconds)	32	UI	Unitless
2414	Selected GPS Satellite Range Data Output Message - Channel 01 - Satellite ID	8	UI	Unitless

Byte	Description	Bit Length	Type	Units
2415	Selected GPS Satellite Range Data Output Message - Channel 01 - Channel Tracking Mode	8	D	0 - CODE_SEARCH& 1 - CODE_ACQUIRE& 2 - AGC_SET& 3 - FREQ_ACQUIRE 4 - BIT_SYNC_DETECT 5 - MSG_SYNC_DETECT 6 - SAT_TIME_AVAIL 7 - EPHEM_ACQUIRE 8 - AVAIL_FOR_POS
2416-2418	Selected GPS Satellite Range Data Output Message - Channel 01 - GPS Satellite Time - Integer Part	24	UI	Unitless
2419-2422	Selected GPS Satellite Range Data Output Message - Channel 01 - GPS Satellite Time - Fractional Part	32	UI	Unitless
2423-2426	Selected GPS Satellite Range Data Output Message - Channel 01 - Integrated Carrier Phase - Integer Part	32	UI	Unitless
2427-2428	Selected GPS Satellite Range Data Output Message - Channel 01 - Integrated Carrier Phase - Fractional Part	16	UI	Unitless
2429-2431	Selected GPS Satellite Range Data Output Message - Channel 01 - Raw Code Phase (carrier cycles)	24	UI	Unitless
2432-2433	Selected GPS Satellite Range Data Output Message - Channel 01 - Code Discriminator Output at Measurement Epoch	16	I	Unitless
2434	Selected GPS Satellite Range Data Output Message Repeated for Channels 02-12			

Table 4-10. GPS Range Data

4.2.2.2.6 Star Tracker

Star Tracker information is also transmitted to ground as part of the Ancillary Data. Star Tracker simultaneously tracks six stars. Star Tracker uses the location of these stars and the observed locations to form a quaternion representing the spacecraft attitude. Three stars are needed for a complete quaternion solution.

A virtual tracker tracks each star. Each virtual tracker is associated with a region on the Star Tracker’s focal plane. To track a star within the virtual tracker region, the virtual tracker positions itself on the focal plane. The virtual tracker follows the stars across the focal plane until the star is out of view.

The Ancillary Data for the Star Tracker is represented using two different message types: the Quaternion message and the Centroid message. The Quaternion message contains the quaternion solution along with information about the health of the Star

Tracker including temperatures, the spacecraft interface, etc. The Centroid message contains information about the specific stars being tracked. The primary output of the Star Tracker is the quaternion solution. The Centroid message provides quaternion solution based information.

Star Tracker generates the Quaternion message at 1 Hz. Star Tracker generates the Centroid message at 4 Hz. The spacecraft polls for both messages at 5 Hz, which gives more than enough resolution to see all the messages. Each Ancillary data Packet contains five Quaternion messages; however, due to a 4 Hz sample rate, every fifth Centroid message is duplicated. Transmission of Ancillary Data Packets (sent at 1 Hz) is not synched with generating the Quaternion message that the Star Tracker produces. It may be that a given Ancillary Data Packet contains information from two distinct Quaternion messages.

4.2.2.2.6.1 Quaternion Message

Table 4-11 identifies the Quaternion Message structure. One of these messages is packaged in every Ancillary Data Packet. All multi-byte items in the message are big-endian.

Byte	Description	Bit Length	Type	Units
2654-2657	UDL seconds register when STA1 time-tag reset command was sent	32	UI	s
2658-2661	UDL sub-seconds register when STA1 time-tag reset command was sent	32	UI	10E-7 s
2662-2665	STA1 Time Tag	32	I	Unitless
2666	STA1 Message Incomplete Flag	1	UI	Unitless
2666	STA1 Quaternion Status	3	D	0 - NO_SOLUTION 1 - PENDING 2 - COMPLETE 3 - INV3 4 - AMBIGUOUS
2666	STA1 Tracker Mode Status	4	D	0 - NO_RESPONSE 1 - START_UP 2 - SELF_TEST 3 - NOMINAL 4 - DIAGNOSTIC 5 - ATTITUDE_INIT 6 - CENTROIDS 7 - FACTORY 8 - INV08 9 - INV09
2667	STA1 ATM Mode Status	1	D	0 - FALSE 1 - TRUE
2667	STA1 ADM Mode Status	1	D	0 - FALSE 1 - TRUE
2667	STA1 Awaiting Catalog	1	D	0 - FALSE 1 - TRUE
2667	STA1 Catalog Complete	1	D	0 - FALSE 1 - TRUE
2667	STA1 Diagnostic Sub-Mode Status	4	D	0 - OFF

Byte	Description	Bit Length	Type	Units
				1 - SIM_DATA 2 - LED_ON 3 - LED_OFF 4 - SPARE 5 - RAW_DATA
2668	STA1 Last Processed Command ID	8	UI	Unitless
2669	STA1 Virtual Tracker #5 State	4	D	0 - OFFLINE 1 - STANDBY 2 - ACQ1 3 - ACQ2 4 - ERROR_B04 5 - ERROR_B05 6 - HAND1 7 - HAND2 8 - HAND3 9 - HAND4 10 - ERROR_B10 11 - TRACK 12 - ERROR_B12 12 - ERROR_B13 13 - ERROR_B14 14 - AWAITING
2669	STA1 Virtual Tracker #4 State	4	D	Same as Virtual Tracker #5 State
2670	STA1 Virtual Tracker #3 State	4	D	Same as Virtual Tracker #5 State
2670	STA1 Virtual Tracker #2 State	4	D	Same as Virtual Tracker #5 State
2671	STA1 Virtual Tracker #1 State	4	D	Same as Virtual Tracker #5 State
2671	STA1 Virtual Tracker #0 State	4	D	Same as Virtual Tracker #5 State
2672	STA1 Fault Detection Summary	1	D	0 – FALSE 1 – TRUE
2672	STA1 Cold Boot Indicator	1	D	0 – FALSE 1 – TRUE
2672	STA1 Time Tag Reset Received	1	D	0 - FALSE 1 - TRUE
2672	STA1 Snapshot Complete	1	D	0 - FALSE 1 - TRUE
2672	STA1 Bright Object Event	1	D	0 - FALSE 1 - TRUE
2672	STA1 Invalid Command	1	D	0 - FALSE 1 - TRUE
2672	STA1 TEC Enabled or Disabled Status	1	D	0 - FALSE 1 - TRUE
2672	STA1 Command Ignored Flag	1	D	0 - FALSE 1 - TRUE
2673	STA1 Time Message Value	8	UI	Unitless
2674	STA1 Camera ID	8	UI	Unitless
2675	STA1 Software Version	8	UI	Unitless
2676-2679	STA1 Quaternion Time	32	I	s
2680-2683	STA1 Quaternion Element 1	32	I	Unitless

Byte	Description	Bit Length	Type	Units
2684-2687	STA1 Quaternion Element 2	32	I	Unitless
2688-2691	STA1 Quaternion Element 3	32	I	Unitless
2692-2695	STA1 Quaternion Element 4	32	I	Unitless
2696-2697	STA1 Loss Function Value	16	UI	Unitless
2698	STA1 4Hz ATM frame count within the 1Hz ADM cycle	2	UI	Unitless
2698	UNUSED BITS	6	UI	Unitless
2699-2701	Reserved	24		
2702	STA1 Total SA Writes	8	UI	Unitless
2703	STA1 Total SA Reads	8	UI	Unitless
2704	STA1 SA-15 Write Counter (Standard Commands)	8	UI	Unitless
2705	STA1 SA-15 Read Counter (Centroid Response)	8	UI	Unitless
2706	STA1 SA-26 Write Counter (Uploads and Catalog Data)	8	UI	Unitless
2707	STA1 SA-29 Read Counter (Standard Response)	8	UI	Unitless
2708	UNUSED BITS	5	D	Unitless
2708	STA1 LED Commanded State	1	D	0 - OFF 1 - ON
2708	STA1 LED Throughput Fail	1	D	0 - PASS 1 - FAIL
2708	STA1 Boot ROM Checksum Fail	1	D	Unitless
2709	STA1 ADM Separation Tolerance	8	UI	arcsec
2710	STA1 ADM Position Tolerance	8	UI	arcsec
2711	STA1 ADM Mag Tolerance	8	UI	Mi
2712	STA1 Mapped Hot Pixel Count	8	UI	Unitless
2713	SSTA1 Hot Pixel Commanded Threshold	8	UI	Unitless
2714	STA1 Track Mode Pixel Commanded Threshold	8	UI	Unitless
2715	STA1 Acquisition Mode pixel Commanded Threshold	8	UI	Unitless
2716-2717	STA1 TEC Commanded Setpoint	16	I	C
2718-2719	STA1 Boresight Column	16	I	Unitless
2720-2721	STA1 Boresight Row	16	I	Unitless
2722-2723	STA1 Temp CCD	16	UI	Unitless
2724-2725	STA1 Temp Lens Cell	16	UI	Unitless

Table 4-11. Star Tracker Quaternion Message

4.2.2.2.6.2 Centroid Message

Table 4-12 identifies the Centroid Message structure. Five samples of this message are packaged in every Ancillary Data Packet. To detect the individual messages, compare the Time Tag at the beginning of the header from one message to the next message.

The main body of the Centroid message is the information about the various virtual trackers and the stars being tracked. The Star Tracker uses the effective focal length field value exclusively.

Byte	Description	Bit Length	Type	Units
2726	STA1 Virtual Tracker #0 Star Valid Bit (1 = Star Valid)	1	D	0 - STAR_INVALID 1 - STAR_VALID
2726-2727	STA1 Virtual Tracker #0 Star Catalog ID	15	UI	Unitless
2728-2729	STA1 Virtual Tracker #0 Background Bias	10	UI	Unitless
2729	STA1 Virtual Tracker #0 Star Magnitude	6	UI	Unitless
2730-2731	STA1 Virtual Tracker #0 Boresight H Component	16	I	deg
2732-2733	STA1 Virtual Tracker #0 Boresight V Component	16	I	deg
2734	STA1 Virtual Tracker #1 Star Valid Bit (1 = Star Valid)	1	D	Unitless
2734-2735	STA1 Virtual Tracker #1 Star Catalog ID	15	UI	Unitless
2736-2737	STA1 Virtual Tracker #1 Background Bias	10	UI	Unitless
2737	STA1 Virtual Tracker #1 Star Magnitude	6	UI	Unitless
2738-2739	STA1 Virtual Tracker #1 Boresight H Component	16	I	deg
2740-2741	STA1 Virtual Tracker #1 Boresight V Component	16	I	deg
2742	STA1 Virtual Tracker #2 Star Valid Bit (1 = Star Valid)	1	D	Unitless
2742-2743	STA1 Virtual Tracker #2 Star Catalog ID	15	UI	Unitless
2744-2745	STA1 Virtual Tracker #2 Background Bias	10	UI	Unitless
2745	STA1 Virtual Tracker #2 Star Magnitude	6	UI	Unitless
2746-2747	STA1 Virtual Tracker #2 Boresight H Component	16	I	deg
2748-2749	STA1 Virtual Tracker #2 Boresight V Component	16	I	deg
2750	STA1 Virtual Tracker #3 Star Valid Bit (1 = Star Valid)	1	D	Unitless
2750-2751	STA1 Virtual Tracker #3 Star Catalog ID	15	UI	Unitless
2752-2753	STA1 Virtual Tracker #3 Background Bias	10	UI	Unitless
2753	STA1 Virtual Tracker #3 Star Magnitude	6	UI	Unitless
2754-2755	STA1 Virtual Tracker #3 Boresight H Component	16	I	deg
2756-2757	STA1 Virtual Tracker #3 Boresight V Component	16	I	deg
2758	STA1 Virtual Tracker #4 Star Valid Bit (1 = Star Valid)	1	D	Unitless
2758-2759	STA1 Virtual Tracker #4 Star Catalog ID	15	UI	Unitless
2760-2761	STA1 Virtual Tracker #4 Background Bias	10	UI	Unitless
2761	STA1 Virtual Tracker #4 Star Magnitude	6	UI	Unitless
2762-2763	STA1 Virtual Tracker #4 Boresight H Component	16	I	deg
2764-2765	STA1 Virtual Tracker #4 Boresight V Component	16	I	deg
2766	STA1 Virtual Tracker #5 Star Valid Bit (1 = Star Valid)	1	D	Unitless

Byte	Description	Bit Length	Type	Units
2766-2767	STA1 Virtual Tracker #5 Star Catalog ID	15	UI	Unitless
2768-2769	STA1 Virtual Tracker #5 Background Bias	10	UI	Unitless
2769	STA1 Virtual Tracker #5 Star Magnitude	6	UI	Unitless
2770-2771	STA1 Virtual Tracker #5 Boresight H Component	16	I	deg
2772-2773	STA1 Virtual Tracker #5 Boresight V Component	16	I	deg
2774-2775	STA1 Effective Focal Length	16	UI	Unitless
2778-2975	Repeat above data 4 more times			

Table 4-12. Star Tracker Centroid Message

4.2.2.2.7 Ancillary OLI Telemetry

Data about the OLI Instrument's function is included in each Ancillary Data Packet. These values verify the proper functioning of the instrument. Table 4-13, Table 4-14, and Table 4-15 identify the structure.

Byte	Description	Bit Length	Type	Units
3005-3006	Telemetry sync word of header 3	16	UI	Unitless
3007-3008	Telemetry ID of header 3	16	UI	Unitless
3009-3010	Days since epoch (January 1st, 2000, midnight) of header 3	16	UI	day
3011-3014	Milliseconds of Day (0 - 86399999) of header 3	32	UI	msec
3015-3016	Microseconds of Millisecond (0-999) of header 3	16	UI	usec
3017-3018	Analog Channel 0 - Stim Lamp Output Current	16	UI	mA
3019-3020	Analog Channel 1 - Stim Lamp Bulb A Voltage	16	UI	cnt
3021-3022	Analog Channel 2 - Stim Lamp Bulb B Voltage	16	UI	cnt
3023-3024	Analog Channel 3 - Stim Lamp Thermistor 1	16	UI	cnt
3025-3026	Analog Channel 4 - Stim Lamp Thermistor 2	16	UI	cnt
3027-3028	Analog Channel 5 - Stim Lamp Photodiode 1	16	UI	cnt
3029-3030	Analog Channel 6 - Focus Motor 1 LVDT	16	UI	cnt
3031-3032	Analog Channel 7 - Focus Motor 2 LVDT	16	UI	cnt
3033-3034	Analog Channel 8 - Focus Motor 3 LVDT	16	UI	cnt
3035-3036	Analog Channel 9 - Positive Z / Minus Y Temperature (baseplate)	16	UI	cnt
3037-3038	Analog Channel 10 - Bench 1 Temperature	16	UI	cnt
3039-3040	Analog Channel 11 - Bench 2 Temperature	16	UI	cnt
3041-3042	Analog Channel 12 - Bench 3	16	UI	cnt

Byte	Description	Bit Length	Type	Units
	Temperature			
3043-3044	Analog Channel 13 - Bench 4 Temperature	16	UI	cnt
3045-3046	Analog Channel 14 - Focal Plane Module 7 Temperature	16	UI	cnt
3047-3048	Analog Channel 15 - Bench 5 Temperature	16	UI	cnt
3049-3050	Analog Channel 16 - Bench 7 Temperature	16	UI	cnt
3051-3052	Analog Channel 17 - Bench 8 Temperature	16	UI	cnt
3053-3054	Analog Channel 18 - Calibration Assembly A Temperature	16	UI	cnt
3055-3056	Analog Channel 19 - Positive Z / Positive Y Fitting Temperature (baseplate)	16	UI	cnt
3057-3058	Analog Channel 20 - Tertiary Mirror Temperature	16	UI	cnt
3059-3060	Analog Channel 21 - Focal Plane Electronics Chassis Temperature	16	UI	cnt
3061-3062	Analog Channel 22 - Positive Y Fitting Temperature (baseplate)	16	UI	cnt
3063-3064	Analog Channel 23 - Focal Plane Assembly HP Evap Temperature	16	UI	cnt
3065-3066	Analog Channel 24 - Focal Plane Assembly Window Temperature	16	UI	cnt
3067-3068	Analog Channel 25 - Minus Z/Positive Y Fitting Temperature (baseplate)	16	UI	cnt
3069-3070	Analog Channel 26 - Minus Z/Minus Y Fitting Temperature (baseplate)	16	UI	cnt
3071-3072	Analog Channel 27 - Minus Y Fitting Temperature (baseplate)	16	UI	cnt
3073-3074	Analog Channel 28 - Focal Plane Module 14 Interface Temperature	16	UI	cnt
3075-3076	Analog Channel 29 - LVPS Temperature	16	UI	cnt
3077-3078	Reserved	16		
3079-3080	Reserved	16		
3081-3082	Analog Channel 32 - Stim Lamp Photodiode 2	16	UI	cnt
3083-3084	Reserved	16		
3085-3086	Reserved	16		
3087-3088	Reserved	16		
3089-3090	Reserved	16		
3091-3092	Reserved	16		
3093-3094	Reserved	16		
3095-3132	Group 3 Spare	304		

Table 4-13. OLI Telemetry Group 3

Byte	Description	Bit Length	Type	Units
3133-3134	Telemetry sync word of header 4	16	UI	Unitless
3135-3136	Telemetry ID of header 4	16	UI	Unitless
3137-3138	Days since epoch (January 1st, 2000, midnight) of header 4	16	UI	day
3139-3142	Milliseconds of Day (0 - 86399999) of header 4	32	UI	msec
3143-3144	Microseconds of Millisecond (0-999) of header 4	16	UI	usec
3145	Mechanism Control Command Reject Counter	8	UI	cnt
3146	Mechanism Control Command Accept Counter	8	UI	cnt
3147	A flag that indicates whether or not a shutter mechanism move is currently active	8	UI	0 - not moving 1 - open loop 2 - closed loop
3148	Opcode of Last Accepted Command	8	D	1 - NOOP 2 - CLEAR_SOH 3 FOCUS_SET_PULSE_WIDTH 4 - FOCUS_SET_DEAD_TIME 5 - FOCUS_CTRL_PWR 6 - FOCUS_MTR_SELECT 7 - FOCUS_MTR_DIR 8 - FOCUS_MTR_STEPS 9 - FOCUS_START 10 - FOCUS_STOP 11 - SD_SET_PULSE_WIDTH 12 - SD_SET_DEAD_TIME 13 - SD_CTRL_PWR 14 - SD_RELAY 15 - SD_MV_STEP 16 - SD_MV_POS 17 - SD_MV_DFLT_POS 18 - SD_STOP
3149	A flag that indicates whether or not a diffuser mechanism move is currently active	8	D	0 - not moving 1 - open loop 2 - closed loop 3 - aborting
3150	When a shutter mechanism closed-loop move is active, this telemetry point reports how many times the shutter motor has been commanded to move; this telemetry point is reset to zero every time a new closed-loop move is started	8	UI	cnt
3151	Indicates whether or not focus motor 1 is included in the next move	1	UI	Boolean
3151	Indicates whether or not focus motor 2 is included in the next move	1	D	Boolean
3151	Indicates whether or not focus motor 3 is included in the next move	1	D	Boolean
3151	Direction of the focus motor move	1	D	0 - FWD 1 - REV

Byte	Description	Bit Length	Type	Units
3151	Focus motor(s) move status	1	D	0 - MOVE_INACTIVE 1 - MOVING
3151	Indicates whether or not the Linear Variable Differential Transformer (LVDT) stays on during a focus motor move	1	D	Boolean
3151	This bit indicates that focus relay 2 (Motor Drive Relay) is being pulsed off	1	D	0 - PULSE_COMPLETE 1 - PULSE_ACTIVE
3151	This bit indicates that focus relay 2 (Motor Drive Relay) is being pulsed on	1	D	0 - PULSE_COMPLETE 1 - PULSE_ACTIVE
3152	When a diffuser mechanism closed-loop move is active, this telemetry point reports how many times the diffuser motor has been commanded to move; this telemetry point is reset to zero every time a new closed-loop move is started	8	UI	cnt
3153	Time between focus motor pulses, in 25 usec increments	8	UI	usec
3154	Length of focus motor pulses, in 0.25 msec increments	8	UI	msec
3155-3156	The number of steps used for a focus motor move	16	UI	cnt
3157	UNUSED BITS	7		
3157	Focus mechanism LVDT relay status	1	D	0 - CLOSED 1 - OPEN
3158	UNUSED BITS	7		
3158	Focus mechanism motor drive relay status	1	D	0 - CLOSED 1 - OPEN
3159	Length of shutter motor pulses, in 0.25 msec increments	8	D	msec
3160	UNUSED BITS	4		
3160	This bit indicates that the shutter / diffuser relay is being pulsed to open the inactive side	1	D	0 - PULSE_COMPLETE 1 - PULSE_ACTIVE
3160	This bit indicates that the shutter / diffuser relay is being pulsed to close the active side	1	D	0 - PULSE_COMPLETE 1 - PULSE_ACTIVE
3160	Shutter motor move status	1	D	0 - MOVE_INACTIVE 1- MOVING
3160	Shutter motor move direction	1	D	0 - CLOSE 1 - OPEN
3161	UNUSED BITS	6		
3161	Diffuser motor move status	1	D	0 - INACTIVE 1 - MOVING
3161	Diffuser motor direction	1	D	0 - CLOSE 1 - OPEN
3162	Time between shutter motor pulses, in 25 usec increments	8	D	usec
3163	Time between diffuser motor pulses, in 25 usec increments	8	UI	usec
3164	Length of diffuser motor pulses, in 0.25 msec increments	8	UI	msec
3165-	The number of steps used for a shutter	16	UI	Unitless

Byte	Description	Bit Length	Type	Units
3166	motor move			
3167-3168	Shutter resolver position	16	UI	cnt
3169-3170	The number of steps used for a diffuser motor move	16	UI	Unitless
3171-3172	Diffuser resolver position	16	UI	cnt
3173	This bit indicates the status of the shutter / diffuser motor drive	1	D	0 - ON 1 - OFF
3173	Shutter / diffuser relay status (active side)	1	D	0 - OPEN 1 - CLOSED
3173	Shutter / diffuser relay status (inactive side)	1	D	0 - OPEN 1 - CLOSED
3173	UNUSED BITS	5		
3174	UNUSED BITS	8		
3175-3176	Reserved	16		
3177	Stim Lamp Control Computer Software Component (CSC) Command Reject Count	8	UI	cnt
3178	Stim Lamp Control CSC Command Accept Count	8	UI	cnt
3179	UNUSED BITS	6		
3179	Actual Main Power Status	1	D	0 - OFF 1 - ON
3179	Actual Output Current Status	1	D	0 - OFF 1 - ON
3180	Opcode of Last Accepted Command	8	D	Unitless
3181	Reserved	8		
3182	UNUSED BITS	5		
3182	Stim Lamp Main Power Status	1	D	0 - ON 1 - OFF
3182	Stim Lamp Bulb Pair Selection	2	D	0 - PRISTINE 1 - BACKUP 2 - WORKING 3 - NONE
3183-3184	Reserved	16		
3185-3196	Group 4 Spare	96		

Table 4-14. OLI Telemetry Group 4

Byte	Description	Bit Length	Type	Units
3197-3198	Telemetry sync word of header 5	16	UI	Unitless
3199-3200	Telemetry ID of header 5	16	UI	Unitless
3201-3202	Days since epoch (January 1st, 2000, midnight) of header 5	16	UI	day
3203-	Milliseconds of Day (0 - 86399999) of header 5	32	UI	msec

Byte	Description	Bit Length	Type	Units
3206				
3207-3208	Microseconds of Millisecond (0-999) of header 5	16	UI	usec
3209	Focal Plane Control Command Reject Counter	8	UI	cnt
3210	Focal Plane Control Command Accept Counter	8	UI	cnt
3211	Number of consecutive unacknowledged telemetry requests allowed before the Flight Software (FSW) transitions to safe mode	8	UI	cnt
3212	Opcode of Last Accepted Command	8	UI	1 - NOOP 2 - CLEAR_SOH 3 - FPE_CMD 4 - SET_FPE_IF 5 - SET_NAK 6 - TIME_MSG
3213	Number of single-bit (corrected) Error Detection and Correction (EDAC) errors detected during Focal Plane Electronics (FPE) message transmission	8	UI	cnt
3214	Consecutive unacknowledged telemetry request count	8	UI	cnt
3215	Number of errors detected in received FPE messages	8	UI	cnt
3216	Number of multiple-bit (uncorrected) EDAC errors detected during FPE message transmission	8	UI	cnt
3217-3218	Number of messages forwarded to the FPE, not including TOD messages	16	UI	cnt
3219	Command sequence count for FPE messages	8	UI	cnt
3220	Number of FPE messages rejected because of an invalid mode	8	UI	cnt
3221	Reserved	8		
3222	Flag to indicate whether the FPE hardware telemetry is valid or not	8	D	0 - INVALID 1 - OK
3223-3224	Reserved	16		
3225-3228	DLVPS Relay +28VDC Voltage 0 - 14bit (0 - 35VDC)	32	UI	cnt
3229-3232	DLVPS +5V Voltage (0 - 6VDC)	32	UI	cnt
3233-3236	DLVPS +15V Voltage (0 - 15VDC)	32	UI	cnt
3237-3240	DLVPS -15V Voltage (0 - -15VDC)	32	UI	cnt
3241-3244	DLVPS +3.3V Voltage (0 - 5VDC)	32	UI	cnt
3245-3248	ALVPS HV Bias +65V Voltage (0 - 75VDC)	32	UI	V
3249-3252	ALVPS +12V Voltage (0 - 15VDC)	32	UI	cnt
3253-3256	ALVPS +7.5V Voltage (0 - 10VDC)	32	UI	cnt
3257-3260	ALVPS -2.5V Voltage (0 - -4VDC)	32	UI	cnt
3261-3264	ALVPS +12V Current (0 - XA)	32	UI	cnt
3265-	ALVPS +7.5V Current (0 - XA)	32	UI	cnt

Byte	Description	Bit Length	Type	Units
3268				
3269-3272	ALVPS +2.5V Current (0 - XA)	32	UI	A
3273-3276	LVPS Temperature Sensor (-20 -100C)	32	UI	cnt
3277-3280	CTLR Temperature Sensor (-20 -100C)	32	UI	cnt
3281-3284	ANA 0 Temperature Sensor (-20 - 100C)	32	UI	cnt
3285-3288	ANA 1 Temperature Sensor (-20 - 100C)	32	UI	cnt
3289-3292	ANA 0 Ch [0] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3293-3296	ANA 0 Ch [1] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3297-3300	ANA 0 Ch [2] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3301-3304	ANA 0 Ch [3] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3305-3308	ANA 0 Ch [4] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3309-3312	ANA 0 Ch [5] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3313-3316	ANA 0 Ch [6] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3317-3320	ANA 0 Ch [7] VPA Bias Voltage (0 - 6.0VDC)	32	UI	cnt
3321-3324	Group 5 Spare	32		

Table 4-15. OLI Telemetry Group 5

4.2.2.2.8 Ancillary OLI and TIRS S/C Temperatures

Table 4-16 identifies the OLI and TIRS temperature structure. One copy of this message is packaged in every Ancillary Data Packet.

Byte	Description	Bit Length	Type	Units
3325-3326	(ATT10) Raw TIB 1 OLI 10 Primary Mirror Flexure Temperature (TB1 CH2 Bank1_2)	16	UI	cnt
3327-3328	(ATT58) Raw TIB 1 OLI 43 Telescope Positive Z Negative Y Strut Tube Temperature (TB1 CH3 Bank1_3)	16	UI	cnt
3329-3330	(ATT00) Raw TIB 1 OLI 44 FPE Heat Pipe Evaporator Temperature (TB1 CH4 Bank1_4)	16	UI	cnt
3331-3332	(ATT 56) Raw TIB 1 OLI 41 Baseplate Positive Z Temperature (TB1 CH5 Bank1_5)	16	UI	cnt
3333-3334	(ATT57) Raw TIB 1 OLI 42 Baseplate Negative Z Temperature (TB1 CH6 BANK1_6)	16	UI	cnt
3335-3336	(ATT11) Raw TIB 1 OLI 11 Primary Mirror Bench at Flex temperature (TB1 CH30 BANK2_14)	16	UI	cnt
3337-3338	(ATT12) Raw TIB 1 OLI 12 Secondary Mirror Center temperature (TB1 CH31 BANK2_15)	16	UI	cnt
3339-3340	(ATT13) Raw TIB 1 OLI 13 Secondary Mirror Edge temperature (TB1 CH32 BANK2_16)	16	UI	cnt
3341-3342	(ATT14) Raw TIB 1 OLI 14 Secondary Mirror Flexure temperature (TB1 CH33 BANK1_1)	16	UI	cnt
3343-3344	(ATT15) Raw TIB 1 OLI 15 Secondary Mirror Bench at Flex temperature (TB1 CH34 BANK3_2)	16	UI	cnt
3345-3346	(ATT16) Raw TIB 1 OLI 16 Tertiary Mirror Center temperature (TB1 CH35 BANK3_3)	16	UI	cnt
3347-3348	(ATT17) Raw TIB 1 OLI 17 Tertiary Mirror Edge temperature (TB1 CH36 BANK3_4)	16	UI	cnt
3349-3350	(ATT18) Raw TIB 1 OLI 18 Tertiary Mirror Flexure temperature (TB1 CH37 BANK3_5)	16	UI	cnt
3351-3352	(ATT19) Raw TIB 1 OLI 19 Tertiary Mirror Bench at Flex temperature (TB1 CH38 BANK3_6)	16	UI	cnt
3353-3354	(ATT20) Raw TIB 1 OLI 20 Quat Mirror Center temperature (TB1 CH39 BANK3_7)	16	UI	cnt
3355-3356	(ATT21) Raw TIB 1 OLI 21 Quat Mirror Edge temperature (TB1 CH40 BANK3_8)	16	UI	cnt
3357-3358	(ATT47) Raw TIB 2 OLI FPA 1 Radiator temperature (TB2 CH45 Bank3_13)	16	UI	cnt
3359-3360	(ATT22) Raw TIB 1 OLI 22 Quat Mirror Flexure temperature (TB1 CH41 BANK3_9)	16	UI	cnt
3361-3362	(ATT48) Raw TIB 2 OLI FPA 2 Heat Pipe Evaporator temperature (TB2 CH46 Bank3_14)	16	UI	cnt
3363-3364	(ATT49) Raw TIB 2 OLI FPA 3 Heat Pipe Condenser temperature (TB2 CH47 Bank3_15)	16	UI	cnt
3365-3366	(ATT42) Raw TIB 2 OLI FPA 4 Moly BP Primary temperature (TB2 CH48 Bank3_16)	16	UI	cnt
3367-3368	(ATT43) Raw TIB 2 OLI FPA 5 Moly BP Redundant temperature (TB2 CH49 Bank4_1)	16	UI	cnt
3369-3370	(ATT32) Raw TIB 2 OLI FPA 6 Sink temperature (TB2 CH50 Bank4_2)	16	UI	cnt
3371-3372	(ATT35) Raw TIB 2 OLI FPA 7 Cold Cable Radiator temperature (TB2 CH51 Bank4_3)	16	UI	cnt
3373-3374	(ATT39) Raw TIB 2 OLI FPA 8 MLI Negative Y Bench Tedlar temperature (TB2 CH52 Bank4_4)	16	UI	cnt

Byte	Description	Bit Length	Type	Units
3375-3376	(ATT60) Raw TIB 2 OLI FPA 9 Foot at Spacecraft Interface temperature (TB2 CH53 Bank4_5)	16	UI	cnt
3377-3378	(ATT59) Raw TIB 2 OLI FPA 10 Condenser temperature (TB2 CH54 Bank4_6)	16	UI	cnt
3379-3380	Raw TIB 1 TIRs 7 Temperature (TB1 CH49 Bank4_01)	16	UI	cnt
3381-3382	Raw TIB 1 TIRs 8 Temperature (TB1 CH50 Bank4_02)	16	UI	cnt
3383-3384	(ATT01) Raw TIB 2 OLI 01 FPE Radiator temperature (TB2 CH55 Bank4_7)	16	UI	cnt
3385-3386	Raw TIB 1 TIRs 9 Temperature (TB1 CH51 Bank4_03)	16	UI	cnt
3387-3388	(ATT02) Raw TIB 2 OLI 02 FPE Heat Ptpt Condenser temperature (TB2 CH56 Bank4_8)	16	UI	cnt
3389-3390	Raw TIB 1 TIRs 10 Temperature (TB1 CH52 Bank4_04)	16	UI	cnt
3391-3392	(ATT03) Raw TIB 2 OLI 03 FPE Chassi Primary temperature (TB2 CH57 Bank4_9)	16	UI	cnt
3393-3394	(ATT54) Raw TIB 2 OLI 39 Baseplate Positive Y temperature (TB2 CH59 Bank4_11)	16	UI	cnt
3395-3396	(ATT04) Raw TIB 2 OLI 04 FPE Chassi Redundant temperature (TB2 CH58 Bank4_10)	16	UI	cnt
3397-3398	(ATT05) Raw TIB 2 OLI 05 ISE Chassis Primary temperature (TB2 CH60 Bank4_12)	16	UI	cnt
3399-3400	(ATT06) Raw TIB 2 OLI 06 ISE Chassis Redundant temperature (TB2 CH61 Bank4_13)	16	UI	cnt
3401-3402	(ATT07) Raw TIB 2 OLI 07 ISE Radiator temperature (TB2 CH62 Bank4_14)	16	UI	cnt
3403-3404	(ATT23) Raw TIB 1 OLI 23 Quat Mirror Bench at Flex temperature (TB1 CH60 Bank4_12)	16	UI	cnt
3405-3406	(ATT24) Raw TIB 1 OLI 24 Bench Positive Y (1) temperature (TB1 CH61 Bank4_13)	16	UI	cnt
3407-3408	(ATT25) Raw TIB 1 OLI 25 Bench Positive Y (2) temperature (TB1 CH62 Bank4_14)	16	UI	cnt
3409-3410	(ATT26) Raw TIB 1 OLI 26 Bench Positive Y (3) temperature (TB1 CH63 Bank4_15)	16	UI	cnt
3411-3412	(ATT27) Raw TIB 1 OLI 27 Bench Negative Y (1) temperature (TB1 CH64 Bank4_16)	16	UI	cnt
3413-3414	(ATT28) Raw TIB 1 OLI 28 Bench Negative Y (2) temperature (TB1 CH65 Bank5_1)	16	UI	cnt
3415-3416	(ATT29) Raw TIB 1 OLI 29 Bench Negative X temperature (TB1 CH66 Bank5_2)	16	UI	cnt
3417-3418	(ATT30) Raw TIB 1 OLI 30 Bench Positive X (1) temperature (TB1 CH67 Bank5_3)	16	UI	cnt
3419-3420	(ATT31) Raw TIB 1 OLI 31 Bench Positive X (2) temperature (TB1 CH68 Bank5_4)	16	UI	cnt
3421-3422	(ATT33) Raw TIB 1 OLI 32 Cal Assembly Diffuser Cover temperature (TB1 CH69 Bank5_5)	16	UI	cnt
3423-3424	(ATT34) Raw TIB 1 OLI 33 Negative X Focus Mechanism temperature (TB1 CH70 Bank5_6)	16	UI	cnt
3425-3426	(ATT36) Raw TIB 1 OLI 34 Stimulation Lamp 1 Diode Board temperature (TB1 CH71 Bank5_7)	16	UI	cnt

Byte	Description	Bit Length	Type	Units
3427-3428	Raw TIB 1 OLI Interface 1 Temperature (TB1 CH72 Bank5_8)	16	UI	cnt
3429-3430	Raw TIB 1 OLI Interface 2 Temperature (TB1 CH73 Bank5_9)	16	UI	cnt
3431-3432	Raw TIB 1 OLI Interface 3 Temperature (TB1 CH74 Bank5_10)	16	UI	cnt
3433-3434	(ATT37) Raw TIB 1 OLI 35 Stimulation Lamp 2 Diode Board temperature (TB1 CH83 Bank6_3)	16	UI	cnt
3435-3436	(ATT38) Raw TIB 1 OLI 36 Bench Negative X Panel temperature (TB1 CH84 Bank6_4)	16	UI	cnt
3437-3438	(ATT40) Raw TIB 1 OLI 37 Diffuser Wheel Motor temperature (TB1 CH85 Bank6_5)	16	UI	cnt
3439-3440	(ATT41) Raw TIB 1 OLI 38 Shutter Wheel Motor temperature (TB1 CH86 Bank6_6)	16	UI	cnt
3441-3442	Raw TIB 1 TIRS 01 Temperature (TB1 CH87 Bank6_7)	16	UI	cnt
3443-3444	Raw TIB 1 TIRS 02 Temperature (TB1 CH88 Bank6_8)	16	UI	cnt
3445-3446	Raw TIB 1 TIRS 03 Temperature (TB1 CH89 Bank6_9)	16	UI	cnt
3447-3448	(ATT55) Raw TIB 2 OLI 40 Baseplate Negative Y temperature (TB2 CH95 Bank6_15)	16	UI	cnt
3449-3450	Raw TIB 1 TIRS 04 Temperature (TB1 CH90 Bank6_10)	16	UI	cnt
3451-3452	(ATT08) Raw TIB 2 OLI 08 Primary Mirror Center temperature (TB2 CH96 Bank6_16)	16	UI	cnt
3453-3454	Raw TIB 1 TIRS 05 Temperature (TB1 CH91 Bank6_11)	16	UI	cnt
3455-3456	(ATT09) Raw TIB 1 OLI 09 Primary Mirror Edge Temperature (TB1 CH1 Bank1_1)	16	UI	cnt
3457-3458	Raw TIB 1 TIRS 06 Temperature (TB1 CH92 Bank6_12)	16	UI	cnt

Table 4-16. OLI and TIRS S/C Temperatures

4.2.2.2.9 Gyro Temperatures

Table 4-17 identifies the Gyroscope Temperature structure. One copy of this message is packaged in every Ancillary Data Packet.

Byte	Description	Bit Length	Type	Units
3459-3460	Reserved	16		
3461-3462	IMU SA21, Gyro A Filtered Resonator Temperature	16	UI	Unitless
3463-3464	IMU SA21, Gyro A Filtered Derivative of Resonator Temperature	16	UI	Unitless
3465-3466	IMU SA21, Gyro A Filtered Electronics Temperature	16	UI	Unitless
3467-3468	IMU SA21, Gyro A Filtered Derivative of Electronics Temperature	16	UI	Unitless

Byte	Description	Bit Length	Type	Units
3469-3470	IMU SA21, Gyro A Filtered Diode Temperature	16	UI	Unitless
3471-3472	IMU SA21, Gyro A Filtered Derivative of Diode Temperature	16	UI	Unitless
3473-3474	IMU SA21, Gyro A Filtered Case Temperature	16	UI	Unitless
3475-3476	IMU SA21, Gyro A Filtered Derivative of Case Temperature	16	UI	Unitless
3477-3522	Reserved	368		
3523-3524	Reserved	16		
3525-3526	IMU SA22, Gyro B Filtered Resonator Temperature	16	UI	Unitless
3527-3528	IMU SA22, Gyro B Filtered Derivative of Resonator Temperature	16	UI	Unitless
3529-3530	IMU SA22, Gyro B Filtered Electronics Temperature	16	UI	Unitless
3531-3532	IMU SA22, Gyro B Filtered Derivative of Electronics Temperature	16	UI	Unitless
3533-3534	IMU SA22, Gyro B Filtered Diode Temperature	16	UI	Unitless
3535-3536	IMU SA22, Gyro B Filtered Derivative of Diode Temperature	16	UI	Unitless
3537-3538	IMU SA22, Gyro B Filtered Case Temperature	16	UI	Unitless
3539-3540	IMU SA22, Gyro B Filtered Derivative of Case Temperature	16	UI	Unitless
3541-3586	Reserved	368		
3587-3588	Reserved	16		
3589-3590	IMU SA23, Gyro C Filtered Resonator Temperature	16	UI	Unitless
3591-3592	IMU SA23, Gyro C Filtered Derivative of Resonator Temperature	16	UI	Unitless
3593-3594	IMU SA23, Gyro C Filtered Electronics Temperature	16	UI	Unitless
3595-3596	IMU SA23, Gyro C Filtered Derivative of Electronics Temperature	16	UI	Unitless
3597-3598	IMU SA23, Gyro C Filtered Diode Temperature	16	UI	Unitless
3599-3600	IMU SA23, Gyro C Filtered Derivative of Diode Temperature	16	UI	Unitless
3601-3602	IMU SA23, Gyro C Filtered Case Temperature	16	UI	Unitless
3603-3604	IMU SA23, Gyro C Filtered Derivative of Case Temperature	16	UI	Unitless
3605-3650	Reserved	368		
3651-3652	Reserved	16		

Byte	Description	Bit Length	Type	Units
3653-3654	IMU SA24, Gyro D Filtered Resonator Temperature	16	UI	Unitless
3655-3656	IMU SA24, Gyro D Filtered Derivative of Resonator Temperature	16	UI	Unitless
3657-3658	IMU SA24, Gyro D Filtered Electronics Temperature	16	UI	Unitless
3659-3660	IMU SA24, Gyro D Filtered Derivative of Electronics Temperature	16	UI	Unitless
3661-3662	IMU SA24, Gyro D Filtered Diode Temperature	16	UI	Unitless
3663-3664	IMU SA24, Gyro D Filtered Derivative of Diode Temperature	16	UI	Unitless
3665-3666	IMU SA24, Gyro D Filtered Case Temperature	16	UI	Unitless
3667-3668	IMU SA24, Gyro D Filtered Derivative of Case Temperature	16	UI	Unitless
3669-3714	Reserved	368		

Table 4-17. Gyro Temperatures

4.2.2.2.10 TIRS Telemetry

Data about the TIRS Instrument's function is included in each Ancillary Data Packet. These values are used to verify the proper functioning of the instrument. Table 4-18, Table 4-19, Table 4-20, and Table 4-21 identify the structure.

Byte	Description	Bit Length	Type	Units
3715	UNACCEPTED COMMAND COUNT	8	UI	cnt
3716	ACCEPTED COMMAND COUNT	8	UI	cnt
3717	Pulse Per Second Count	8	UI	cnt
3718	TOD Command Counter	8	UI	cnt
3719-3720	SSM Bearing Housing Temperature (Fwd)	16	UI	cnt
3721-3722	SSM Bearing Housing Temperature (Aft)	16	UI	cnt
3723-3724	Optical Deck Temperature	16	UI	cnt
3725-3726	Structure (Foot A) Temperature (-Z)	16	UI	cnt
3727-3728	Structure Nadir Aperture Temperature	16	UI	cnt
3729-3730	Structure (Foot C) Temperature (+Z)	16	UI	cnt
3731-3732	TCB Board Temperature	12	UI	cnt
3732-3733	FPE1 FPE A Application Specific Integrated Circuit (ASIC) Temperature	12	UI	cnt
3734-3735	FPE2 FPE BASIC Temperature	12	UI	cnt

Byte	Description	Bit Length	Type	Units
3735-3737	Telescope Aft Barrel Temperature (+Z)	16	UI	cnt
3737-3739	Telescope Aft Barrel Temperature (-Z)	16	UI	cnt
3739-3741	Telescope Fwd Barrel Temperature (+Z)	16	UI	cnt
3741-3743	Telescope Fwd Barrel Temperature (-Z)	16	UI	cnt
3743-3745	Cryo Shroud Outer at Tunnel Temperature	16	UI	cnt
3745-3747	Cryo Shroud Outer Flange Temperature	16	UI	cnt
3747-3749	Blackbody Calibrator 1 Temperature	16	UI	cnt
3749-3751	F2 FPA Fine Sensor 1 Temperature	16	UI	cnt
3751-3753	Blackbody Calibrator 2 Temperature	16	UI	cnt
3753-3755	Blackbody Calibrator 3 Temperature	16	UI	cnt
3755-3757	Blackbody Calibrator 4 Temperature	16	UI	cnt
3757-3759	F6 FPA Fine Sensor 1 Temperature	16	UI	cnt
3759-3761	F7 FPA Fine Sensor 2 Temperature	16	UI	cnt
3761-3762	FPE A +12V Voltage Monitor	8	UI	cnt
3762-3763	FPE B +12V Voltage Monitor	8	UI	cnt
3763-3764	Positive (+5.5V) analog supply voltage monitor for SCA A Read-Out Integrated Circuit (ROIC)	12	UI	cnt
3765-3766	FPA A Detector Substrate Connection (~5.5V-8.5V) for SCA A ROIC	12	UI	cnt
3766-3767	Positive (+5.5V) analog supply voltage monitor for SCA B ROIC	12	UI	cnt
3768-3769	Detector Substrate Connection (~5.5V-8.5V) for SCA B ROIC	12	UI	cnt
3769-3770	Positive (+5.5V) analog supply voltage monitor for SCA C ROIC	12	UI	cnt
3771-3772	Logic (Digital) Positive Supply (+5.5V) voltage monitor for SCA C ROIC	12	UI	cnt
3772-3773	Detector Substrate Connection (~5.5V-8.5V) for SCA C ROIC	12	UI	cnt
3774	FPE A A_VPD_Current_1	8	UI	cnt
3775	FPE A A_VPD_Current_2	8	UI	cnt
3776	FPE A A_VPD_Current_3	8	UI	cnt
3777	10V supply for SCA A current monitor (Max: 500mA)	8	UI	cnt
3778	10V supply for SCA B current monitor (Max: 500mA)	8	UI	cnt

Table 4-18. TIRS Telemetry Block1

Byte	Description	Bit Length	Type	Units
3779	10V supply for SCA C current monitor (Max: 500mA)	8	UI	cnt
3780	FPE A ASIC_Temp	8	UI	cnt
3781-3782	Positive (+5.5V) analog supply voltage monitor for SCA A ROIC	12	UI	cnt
3782-3783	FPA B Detector Substrate Connection (~5.5V-8.5V) for SCA A ROIC	12	UI	cnt
3784-3785	Positive (+5.5V) analog supply voltage monitor for SCA B ROIC	12	UI	cnt
3785-3786	Detector Substrate Connection (~5.5V-8.5V) for SCA B ROIC	12	UI	cnt
3787-3788	Positive (+5.5V) analog supply voltage monitor for SCA C ROIC	12	UI	cnt
3788-3789	Detector Substrate Connection (~5.5V-8.5V) for SCA C ROIC	12	UI	cnt
3790-3791	Output Reference Level (5.5V) voltage monitor for SCA C ROIC	12	UI	cnt
3791-3792	FPE B A_VPD_Current_1	8	UI	cnt
3792-3793	FPE B A_VPD_Current_2	8	UI	cnt
3793-3794	FPE B A_VPD_Current_3	8	UI	cnt
3794-3795	10V supply for SCA C current monitor (Max: 500mA)	8	UI	cnt
3795-3796	10V supply for SCA B current monitor (Max: 500mA)	8	UI	cnt
3796-3797	10V supply for SCA C current monitor (Max: 500mA)	8	UI	cnt
3797-3798	FPE B ASIC_Temp	8	UI	cnt
3798-3800	Telescope Stage OP2 A Temperature	16	UI	cnt
3800-3802	Telescope Aft OP3 A Temperature	16	UI	cnt
3802-3804	Telescope Fwd OP4 A Temperature	16	UI	cnt
3804-3806	SSM BH OP5 A Temperature	16	UI	cnt
3806-3808	FPE OP6 A Temperature	16	UI	cnt
3808-3810	BBCAL OP7 A Temperature	16	UI	cnt
3810-3812	BBCAL SUPP 1 Temperature	16	UI	cnt
3812-3814	Telescope Stage OP2 B Temperature	16	UI	cnt
3814-3816	Telescope Aft OP3 B Temperature	16	UI	cnt
3816-3818	Telescope Fwd OP4 B Temperature	16	UI	cnt

Byte	Description	Bit Length	Type	Units
3818-3820	SSM BH OP5 B Temperature	16	UI	cnt
3820-3822	FPE OP6 B Temperature	16	UI	cnt
3822-3824	BBCAL OP7 B Temperature	16	UI	cnt
3824-3826	Time of Day 'Day' Value	16	UI	d
3826-3828	Time of Day Upper Millisecond Value	16	UI	msec
3828-3830	Time of Day Lower Millisecond Value	16	UI	msec
3830	ssm_position_sel [2:0]	4	UI	Unitless
3831	"NOBIT" mnemonic	4	UI	0
3831	enc_pwr_stat	1	D	0 - DISABLED 1 - ENABLED
3831	enc_ramp_sel	1	D	0 - RAMP_0 1 - RAMP_1
3831	enc_idx	1	D	0 - IDX_0 1 - IDX_1
3831	enc_idx_acq	1	D	0 - IDX_ACQ_0 1 - IDX_ACQ_1
3832-3833	Cosine Motor Drive Current for MCE	12	UI	cnt
3833-3834	Sine Motor Drive Current for MCE	12	UI	cnt
3835-3836	Cosine D/A Converter Voltage Telemetry for MCE	12	UI	cnt
3836-3837	Sine D/A Converter Voltage Telemetry for MCE	12	UI	cnt
3838-3839	SSM Encoder Remote Electronics (A/B)	12	UI	cnt
3839-3840	SSM Motor Housing (A/B)	12	UI	cnt
3841-3842	SSM Encoder Read Head (A/B) Sensor 1 (A/B) Temperature	12	UI	cnt
3842	UNUSED BITS	4	UI	cnt

Table 4-19. TIRS Telemetry Block2

Byte	Description	Bit Length	Type	Units
3843-3845	20Hz sample # 01	24	U	CNT
3846-3848	20Hz sample # 02	24	U	CNT
3849-3851	20Hz sample # 03	24	UI	CNT
3852-3854	20Hz sample # 04	24	UI	CNT
3855-3857	20Hz sample # 05	24	UI	CNT
3858-3860	20Hz sample # 06	24	UI	CNT
3861-3863	20Hz sample # 07	24	UI	CNT
3864-3866	20Hz sample # 08	24	UI	CNT
3867-3869	20Hz sample # 09	24	UI	CNT

Byte	Description	Bit Length	Type	Units
3870-3872	20Hz sample # 10	24	UI	CNT
3873-3875	20Hz sample # 11	24	UI	CNT
3876-3878	20Hz sample # 12	24	UI	CNT
3879-3881	20Hz sample # 13	24	UI	CNT
3882-3884	20Hz sample # 14	24	UI	CNT
3885-3887	20Hz sample # 15	24	UI	CNT
3888-3890	20Hz sample # 16	24	UI	CNT
3891-3893	20Hz sample # 17	24	UI	CNT
3894-3896	20Hz sample # 18	24	UI	CNT
3897-3899	20Hz sample # 19	24	UI	CNT
3900-3902	20Hz sample # 20	24	UI	CNT
3903-3904	SSM Bearing Housing, Aft Hot Side (A/B)	12	UI	CNT
3904-3905	SSM Bearing Housing Fwd Hot Side (A/B)	12	UI	CNT
3906	UNUSED BITS	8		

Table 4-20. TIRS Telemetry Block3

Byte	Description	Bit Length	Type	Units
3907-3908	SSM Bearing Housing Aft Space Side (A/B)	12	UI	cnt
3908-3909	SSM Bearing Housing Fwd Space Side (A/B)	12	UI	cnt
3910-3911	Fixed Baffle, Nadir Port, Aft Hot Corner (A/B)	12	UI	cnt
3911-3912	Fixed Baffle, Nadir Port, Fwd Hot Corner (A/B)	12	UI	cnt
3913-3914	Fixed Baffle, Nadir Port , Fwd Space Corner (A/B)	12	UI	cnt
3914-3915	Fixed Baffle, Nadir Port, Aft Space Corner (A/B)	12	UI	cnt
3916-3917	Spare 4 Thermistor	12	UI	cnt
3917-3918	Spare 5 Thermistor	12	UI	cnt
3919-3920	Science Data, Frame Capture Count	16	UI	cnt
3921-3922	Science Acquisition Frame Rate	16	UI	cnt
3923	Active (selected) Timing Table Pattern (0, 1, 2, or 3)	4	UI	Unitless
3923-3925	Mode Register	16	UI	Unitless
3925-3926	Timing Table Pattern ID assigned by LDCM Scientist (1/3)	8	UI	Unitless
3926-3927	Timing Table Pattern ID assigned by LDCM Scientist (2/3)	8	UI	Unitless
3927-3928	Timing Table Pattern ID assigned by LDCM Scientist (3/3)	8	UI	Unitless
3928-3930	Cryo diode T4 measured temperature	16	UI	K
3930-	Cryo diode T3 measured temperature	16	UI	K

Byte	Description	Bit Length	Type	Units
3932				
3932-3934	FPA Fine Sensor 3 Temperature	16	UI	cnt
3934-3935	Cold-Stage Heat Strap CF I/F Temperature	16	UI	cnt
3936-3937	VPE A A_Video_Refn	12	UI	cnt
3938-3939	VPE A B_Video_REF	12	UI	cnt
3939-3940	Output driver Positive (+5.5V) supply voltage monitor for SCA C ROIC	12	UI	cnt
3941-3942	Output Reference Level (1.6V) voltage monitor for SCA C ROIC	12	UI	cnt
3942-3943	Analog Channel Reference Supply (1.6V) for SCA C ROIC	12	UI	cnt
3944-3945	VPE A C_Video_REF	12	UI	cnt
3945-3946	Output Reference Level (5.5V) voltage monitor for SCA C ROIC	12	UI	cnt
3947-3948	VPE B A_Video_REF	12	UI	cnt
3948-3949	VPE B B_Video_REF	12	UI	cnt
3950-3951	Logic (Digital) Positive Supply (+5.5V) voltage monitor for SCA C ROIC	12	UI	cnt
3951-3952	Output driver Positive (+5.5V) supply voltage monitor for SCA C ROIC	12	UI	cnt
3953-3954	Output Reference Level (1.6V) voltage monitor for SCA C ROIC	12	UI	cnt
3954-3955	Analog Channel Reference Supply (1.6V) for SCA C ROIC	12	UI	cnt
3956-3957	VPE B C_Video_REF	12	UI	cnt
3957-3960	data_enc_epos	24	UI	cnt
3960-3961	HSIB +3.3V Current Monitor	12	UI	cnt
3962	fpe_b_enable	1	D	0–DISABLED 1 - ENABLED
3962	fpe_a_enable	1	D	0–DISABLED 1 - ENABLED
3962	mce_b_enable	1	D	0–DISABLED 1 - ENABLED
3962	mce_a_enable	1	D	0–DISABLED 1 - ENABLED
3962	mode_mech_ssm	4	UI	cnt
3963-3970	UNUSED BITS	64		

Table 4-21. TIRS Telemetry Block4

4.2.3 OLI Data Packet Types

As described in subsection 4.2.1, all OLI output is organized as packets before transmission. Several packets form a single frame of OLI data. Two possibilities exist for the list of packet types in an OLI frame. Either the frame contains an image header and has the following structure:

1. Frame Header Packet – Application Identification (APID) 2
2. Image Header Packet – APID 4
3. CRC Packet – APID 3

Or the frame contains an image frame and has the following structure:

1. Frame Header Packet – APID 2
2. Thirteen packets for each band, starting with PAN 1 Odd and ending with the Blind band – APIDs 256 – 268 (Compressed) 768 – 780 (Uncompressed). (See subsection 3.1.5 for the pattern followed by the band packets.)
3. CRC Packet – APID 3

Each band packet also contains four pad pixels at the end, which is essentially the last pixel repeated four times, regardless of compression. These pixels can be discarded and are not included in the CRC calculation.

Ancillary Data Packets occur at 1 Hz intervals amongst the packets used for the OLI frames.

Figure 4-1 displays an example of a typical mission data file that contains OLI data for an interval entirely contained within a single file. Several Ancillary Data Packets are at the beginning of the example file. An image header frame, an uncompressed image frame, and a compressed image frame follow these packets. The file continues with image frames and occasional Ancillary Data Packets. Following the final image frame are several Ancillary Data Packets.

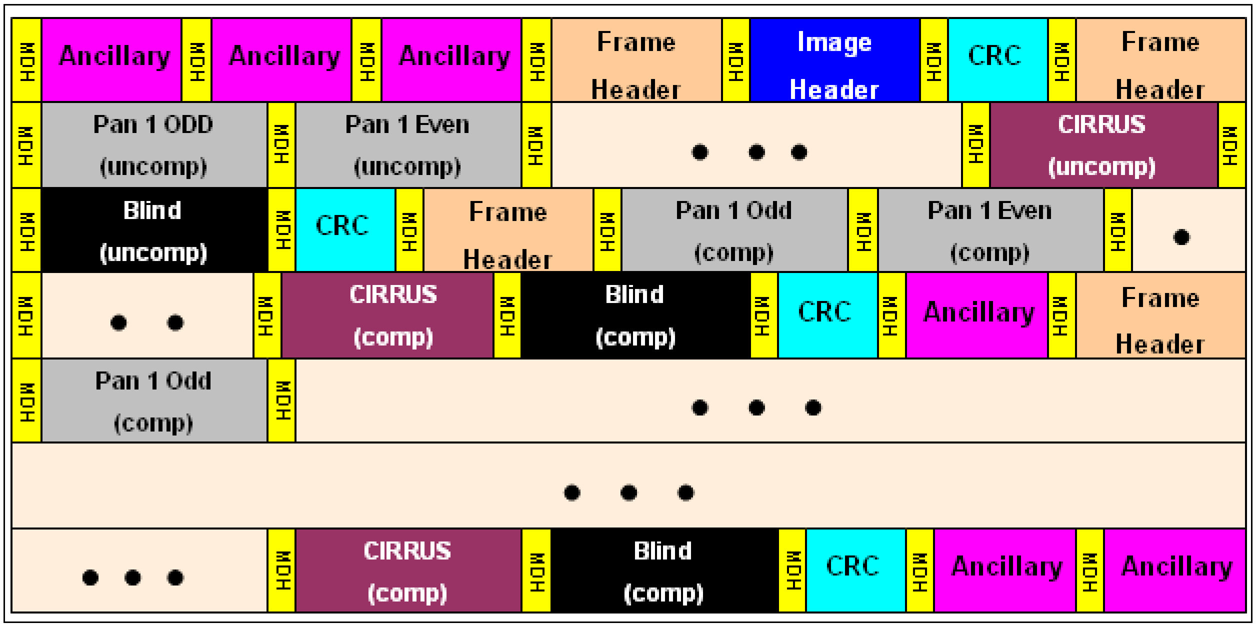

Figure 4-1. OLI Mission Data File Structure

4.2.3.1 OLI Frame Header Packets

The Data Field of a Frame Header Packet is 16 bytes long. Table 4-22, derived from 70-P58230P[B]-SC-GND_ICD Spacecraft to Ground Interface Control Document (see References), provides the structure of the header. A Frame Header provides several pieces of information such as the frame number and a timestamp for the frame. The first frame, frame zero, is associated with the Image Header frame. Subsequent frames are always image frames and the frame number increases by one from frame to frame. The time indicated by the remaining fields corresponds to the end of the detector integration for the frame.

Field Location	Description
Bytes 0–3	Frame Number (big-endian)
Bytes 4–5	Day (big-endian)
Bytes 6–9	Milliseconds of day (big-endian)
Bytes 10–11	Microseconds (big-endian)
Byte 12	Time Error where 1 indicates time information may be degraded (big-endian)
Byte 13	Reserved
Byte 14	Blind Data in current frame, 0 indicates no blind data and 1 indicates blind data; this value is always 1, except for the frame header associated with the image header (big-endian)
Bytes 15	Reserved

Table 4-22. Frame Header Structure

The timestamp conveyed in bytes 4 through 11 conform to the CCSDS Day Segmented time code format in CCSDS 301.0-B-3, Recommendation, Time Code Formats (see References). Each of the three fields, Day, Milliseconds of day, and Microseconds, are zero-based counters that roll over on the appropriate values. The Day counter rolls over when it reaches the maximum value represented by an unsigned 16-bit integer. The Milliseconds of day counter rolls over at 86,400,000. The Microseconds counter rolls over at 1,000. A new day begins when the milliseconds and microseconds counters roll over to 0. Leap seconds are not accounted for in the Space Craft time.

The epoch for the timestamps used within Frame Header packets is J2000.0. A zero value for the day, milliseconds, and microseconds fields indicates the J2000.0 epoch. This is equivalent to:

1. The Julian date 2451545.00 TT (Terrestrial Time), or January 1, 2000, noon TT
2. January 1, 2000, 11:59:27.816 TAI (International Atomic Time)
3. January 1, 2000, 11:58:55.816 UTC (Coordinated Universal Time)

4.2.3.2 OLI CRC Packets

The Data Field of an OLI CRC Packet contains the 32-bit CRC value in little-endian format. The instrument calculates CRC values for all data that the instrument outputs. The following definition of the CRC is derived from 70-P58230P[B]-SC-GND_ICD Spacecraft to Ground Interface Control Document (see References):

CRC Name:	CRC-32-IEEE 802.3
CRC Polynomial:	1 + x + x^2 + x^4 + x^5 + x^7 + x^8 + x^10 + x^11 + x^12 + x^16 + x^22 + x^23 + x^26 + x^32 (0xEDB88320)
Initial value:	0xFFFFFFFF (direct – no augmented zero bits)
Reverse/reflect data bytes:	YES (LSB first, MSB last)
Final XOR value:	0xFFFFFFFF (one's complement of final CRC – transmitter only)
CRC transmission:	Low Byte first
CRC good:	0xDEBB20E3 (calculated over received data and received CRC)

Table 4-23. OLI CRC Definition

The instrument, rather than the spacecraft, calculates the CRC. This method has several effects on the calculation. The calculation is performed before the spacecraft performs image compression and before the spacecraft adds the MDH to the beginning of each packet. The computation is performed on the data as OLI provides the output.

OLI outputs 12-bit values to the spacecraft. This output includes the 12-bit image data and the header data contained in the Frame Header and Image Header fields. For the header information, each 8-bit octet is padded with four 0-bits to create a 12-bit value. A 16-byte Frame Header is output as 16 12-bit values, each in the range of 0 to 255.

When the CRC computation is performed, each 8-bit value is padded with eight 0-bits to create a 16-bit value. The 16-byte Frame Header is now represented by 16 big-endian, 2-byte words each having a value in the range of 0 to 255.

For an image frame, the CRC is calculated over the Frame Header, followed by the 13 image bands and the CRC. The four padded pixels at the end of each band are not included in the CRC calculation. The CRC calculation is made after decompressing the image data. For the Image Header frame, the CRC is calculated over the Frame Header followed by the Image Header and the CRC.

4.2.3.3 OLI Image Header Packets

Exactly one image header exists per OLI interval, and exactly one image header exists per "Image Acquire" command.

The Data Field for an Image Header Packet contains the image header for an OLI frame. An Image Header is 52-bytes long. Table 4-24 summarizes the structure of an Image Header, which is derived from 70-P58230P[B]-SC-GND_ICD Spacecraft to Ground Interface Control Document (see References).

Field Location	Description	Possible Values
Bytes 0-3	Length of Image In Frames (big-endian)	0 to 1048575
Bytes 4-7	Image Content Definition (big-endian)	Default – 0 Other values are Ball proprietary
Bytes 8-9	MS Integration Time, the number of Performance Monitoring Counter (PMC) clock cycles from the start of MS programming (big-endian)	14 to 4133
Bytes 10-11	PAN Integration Time, the number of PMC clock cycles from the start of MS programming (big-endian)	14 to 2015
Bytes 12-15	MS Data Word (big-endian)*	
Bytes 16-19	PAN Data Word (big-endian)*	
Byte 20	Line Time (NORMAL or LONG 8)	0 – Normal 1 – LONG_8 (8X normal)
Byte 21	Blind Band Record Rate	0 – Blind data not present 1 – Blind data present in every frame
Byte 22	Test Pattern Setting	0 – Video data sent to SSR 1 – Test pattern sent to SSR
Byte 23	Current Detector Select Table	Select the group of detectors used. The default value of 5 indicates the ID in "Current Detector Select Table" is the table being used. Groups 1 through 4 contain special groups of detectors used only for testing purposes.

Field Location	Description	Possible Values
		1: All Select 0 2: All Select 1 3: All Select 2 4: All Select 3 5: All Select Memory – Default 0,6,7: Reserved
Byte 24-26	Reserved	
Byte 27-30	Detector Select Table ID Number (big endian)	The ID of the table created which contains the detectors to use. Only meaningful when “Detector Select Table ID Number” has the default value of 5. 0 to 255
Byte 31	Image Data Truncation Setting (upper or lower 12 bits for IMAGE pixels only)	0 – upper 12 bits transmitted 1 – lower 12 bit transmitted
Bytes 32-51	Reserved	
* The MS and PAN Data Words are reserved for debug purposes only		

Table 4-24. Image Header Structure

An Image Header Packet is preceded immediately by a Frame Header Packet and followed immediately by a CRC Packet.

4.2.3.4 Uncompressed OLI Image Packets

The Data Field of an Uncompressed Image is identical to the OLI data output for a single band. The Uncompressed Image Packet is always 10,632 bytes long ((7084 samples + 4 pad pixels) * 12 bits per sample). The data, as described in subsection 3.1.5, are 12-bit samples, interleaved by SCA, and adjacent SCAs cross the Image Plane in opposite directions. When reading the uncompressed data, each 12-bit pixel is stored as the least significant bits of a 16-bit value.

4.2.3.5 Compressed OLI Image Packets

The Data Field of a Compressed Image Packet has variable length. The Compressed Image Packet is the only type of packet that has a variable length Data Field. Each band is compressed independently; the compression of data in one packet has absolutely no effect on compression in a different band packet. An error in one band has no effect on other bands. However, all bands in a frame are either compressed or uncompressed.

The first frame of image data in an OLI mission data file is always uncompressed to provide a reference for compressed frames. This frame is followed by 1023 compressed frames. The next frame, following these compressed frames, is uncompressed and the same number of compressed frames follows. This pattern continues to the end of the file.

The result of uncompressing the data on a given frame depends on the uncompressed values from the previous frame. Therefore, an error in one frame propagates to the following frame, and to the next frame, and the next frame, etc. Any decompression errors also results in failed CRCs for the affected frames. The periodic uncompressed frames serve to “reset” the decompression process. The uncompressed data are provided with an uncompressed APID every 1024 frames. Also, if the end of a mission data file is missing or corrupt, the uncompressed frame at the beginning of the next mission data file allows processing to recover at that point.

Once the data for a Compressed Image Packet are uncompressed, the result is identical to the data that would have been in the same packet if it had been an Uncompressed Image Packet. The satellite does no manipulation the data prior to compression.

Compression yields words, which are not necessarily a multiple of 8-bits in length. Compression may not complete on a byte boundary. In these cases, the remaining bits of the last byte are set to zero. The decompression software should ignore these bits.

4.2.3.5.1 Image Compression

The image compression algorithm used to compress OLI image data conforms to the CCSDS Recommendation on Lossless Data Compression. The image compression algorithm is described in detail in CCSDS 120.0-G-2, Informational Report, Lossless Data Compression, Issue 2, CCSDS 121.0-B-1, Recommendation, Lossless Data Compression, Issue 1, Corrigendum 2, and summarized in 70-P58230P[B]-SC-GND_ICD Spacecraft to Ground Interface Control Document (see References).

Compression uses a predictor to determine the expected value of a sample, taking the difference between the expected and observed values, and using a block encoder to create a code word that represents these differences. The code words, also known as Coded Data Segments (CDSs), concatenate to form the compressed representation of the data. Each CDS represents a block of 16 12-bit samples.

Because there are 7084 samples in an OLI data frame for a single band, there are up to 443 CDSs. In some cases, a single CDS can represent many blocks. The number of blocks that a single CDS represents is constrained to a division called a segment. A segment is a series of consecutive blocks. For OLI compression, a single band consists of six 64-block segments followed by a 59-block segment for a total of 443 blocks. The fewest number of CDSs that might represent a single band is seven, one for each segment.

The decompression results in a 7088 sample frame. The last four pixels are padding and can be discarded after decompression; these four pixels are not used in the CRC computation.

The prediction method used for OLI image compression works best for a push broom scanner. This approach is to compare each sample in the current frame to the corresponding sample in the previous frame. This means the first frame of data must be uncompressed. If the first frame of data is not uncompressed, there would be no predictors to decompress the frame. Any error in compression propagates from one frame to the next. A missing frame means that further decompression is frustrated. To mitigate these issues, the first frame in each OLI mission data file is always uncompressed; the satellite periodically transmits uncompressed frames throughout each mission data file.

4.2.4 TIRS Data Packet Types

Similar to OLI, all TIRS output is organized as packets before transmission. Several packets form a single TIRS data frame. Unlike OLI, TIRS does not contain an Image Header. TIRS data are always uncompressed. Therefore, only one possibility exists for the list of packet types in a TIRS frame. TIRS Data Packets have the following structure:

1. Frame Header Packet – APID 1026
2. Blind Band Packet – APID 1792
3. 10.8 μ Band Packet – APID 1793
4. 12 μ Band Packet – APID 1794
5. CRC Packet – APID 1027

Ancillary Data Packets occur at 1 Hz intervals amongst the packets used for the TIRS frames.

Figure 4-2 displays an example of a typical mission data file that contains TIRS data for an interval entirely contained within a single file. Several Ancillary Data Packets are at the beginning of the example file. These packets are followed by a frame header and an image packet. The file continues with image packets and occasional Ancillary Data Packets. Following the final image frame is an Ancillary Data Packet.

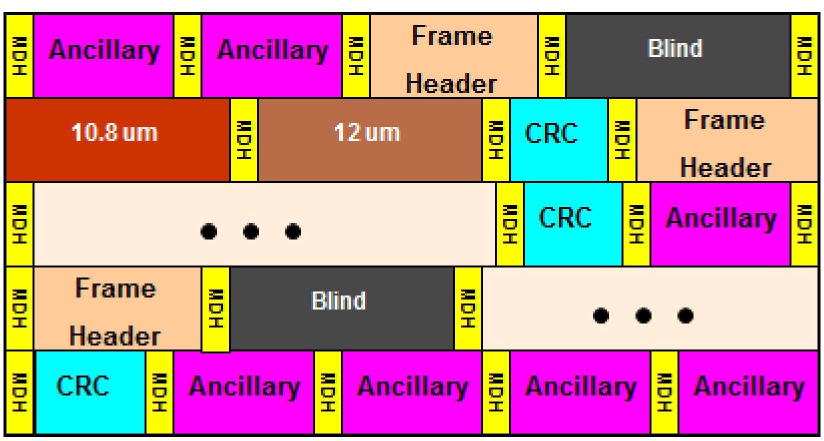

Figure 4-2. TIRS Mission Data File Structure

4.2.4.1 TIRS Frame Header Packets

Table 4-25 shows the format outline for the TIRS frame headers.

Byte	Description
1	Sync Byte
2	Reserved
3-4	Days (since J2000 TAI) (big endian)
5-8	Millisecond of the day (big endian)
9-10	Microsecond of the day (big endian)
11	Data Type: Imagery (0x30), Diagnostic (0x0C), Test Pattern (0x03)
12	Integration Duration (Number of 31.25us intervals during FSYNC low)
13-15	Line Sequence Number (big-endian)
16-18	Total number of frames (big endian)
19	SCA A Blind Row 1
20	SCA A Blind Row 2
21	SCA B Blind Row 1
22	SCA B Blind Row 2
23	SCA C Blind Row 1
24	SCA C Blind Row 2
25	SCA A 10.8µ Offset Row 1
26	SCA A 10.8µ Offset Row 2
27	SCA B 10.8µ Offset Row 1
28	SCA B 10.8µ Offset Row 2
29	SCA C 10.8µ Offset Row 1
30	SCA C 10.8µ Offset Row 2
31	SCA A 12µ Offset Row 1
32	SCA A 12µ Offset Row 2
33	SCA B 12µ Offset Row 1
34	SCA B 12µ Offset Row 2
35	SCA C 12µ Offset Row 1
36	SCA C 12µ Offset Row 2

Table 4-25. TIRS Frame Header Structure

4.2.4.2 TIRS CRC Packets

The Data Field of a TIRS CRC Packet contains the 12-bit CRC value in big-endian format. The instrument calculates CRC values for all data the instrument outputs. Table 4-26 provides a definition of the CRC.

CRC Name:	CRC-12
CRC Polynomial:	1 + x + x2 + x3 + x11 + x12 (0x80F)
Initial value:	0xFFF
Reverse/reflect data bytes:	MSB first, LSB last
CRC transmission:	High Byte first
CRC good:	0x03A (calculated over received data and received CRC)

Table 4-26. TIRS CRC Definition

The instrument, rather than the spacecraft, calculates CRC. This method has several effects on the calculation. The calculation is performed before the spacecraft adds the MDH to the beginning of each packet. The computation is performed on the data as TIRS provides the output. Additionally, each TIRS image packet is padded with two 12-bit pixels, which are not included in the CRC calculation because the spacecraft (not TIRS) adds them.

TIRS outputs 12-bit values to the spacecraft. This output includes the 12-bit image data and the header data contained in the Frame Header fields. For the Frame Header information, each 8-bit octet is padded with four 0-bits on the high side to create a 12-bit value for the CRC calculation.

For an image frame, the CRC is calculated over the Frame Header, followed by three image bands and the actual CRC.

4.2.4.3 Image Packets

All TIRS image packets are the same length and contain the data for a single TIRS band which includes a primary row and a secondary row for redundancy. A TIRS image packet is comprised of 3886 samples at 12-bits per sample plus 2 pad pixels (24-bits) for a total of 5,832 bytes per packet. The DHeader and FPE words are part of the samples in the packet; Figure 4-3 displays the arrangement.

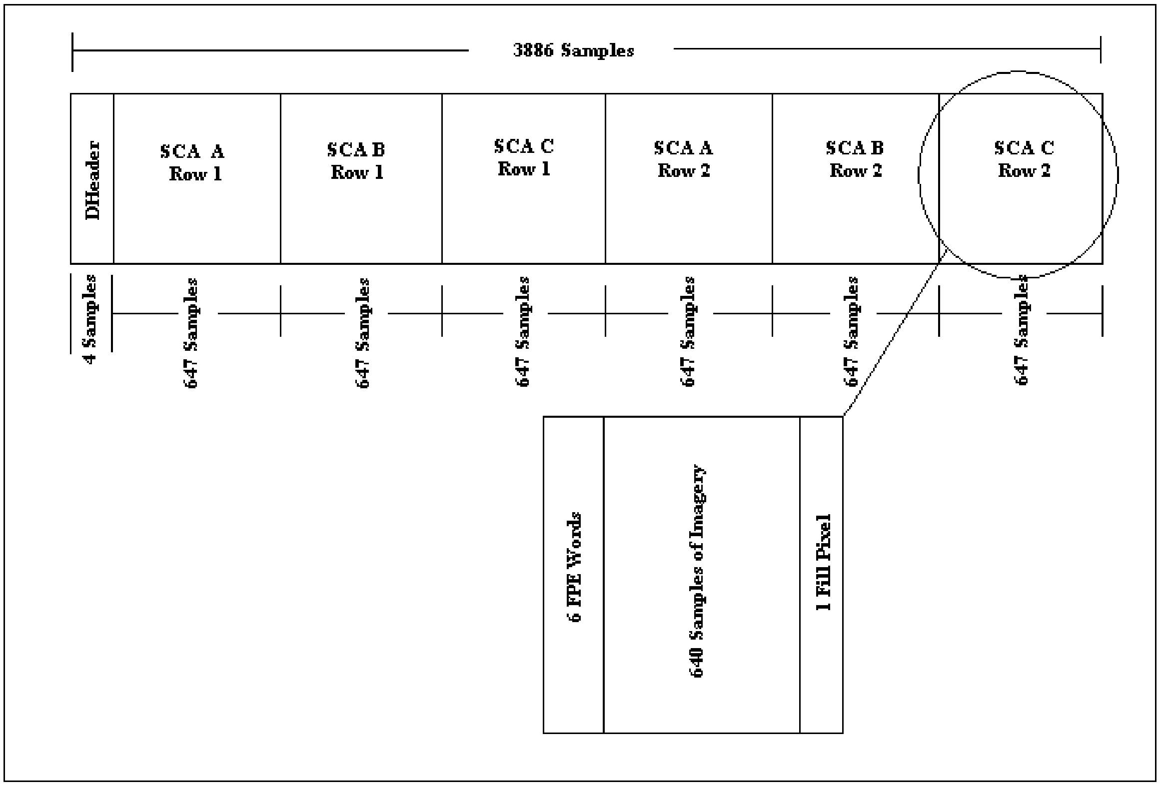

Figure 4-3. TIRS Image Frame Packet Organization

The DHeader contains a sync byte in the first sample, the Read-Out Integrated Circuit (ROIC) CRC status in the second sample; the final two samples are reserved space.

The FPE Words contain a start code, Application Specific Integrated Circuit (ASIC) ID, data type, time stamp, line count, and ASIC status in the order listed. The start code is a static value of 0x666. The ASIC ID is a static value of 0x77f. The data type is a static value of 0x003. The time stamp varies by band, sca, and row. The line count is an incremental counter that rolls over at 0x3ff. The ASIC status contains a static value of 0x000. See 70-P58230P[B]-SC-GND_ICD Spacecraft to Ground Interface Control Document for more details (see References).

The TIRS image packets must follow the order given in subsection 4.2.4.

4.3 Checksum File

The Checksum file contains the MD5 checksum for each mission data file, which includes both the IDF and the data files sorted in order by root_file_id. The file consists of two columns separated by two spaces. The first column contains the calculated sum. The second column contains the filename for the sum. File names are listed in lexicographical order within the checksum file. Appendix B provides an example Checksum file.

4.3.1 Checksum Column

This column contains the calculated 128-bit checksum for a file. The Checksum is stored in the file as 32 digits of hexadecimal (using lowercase letters).

4.3.2 Filename Column

This column contains the relative (no path) filename for which the checksum is generated. The filenames are sorted in order per the root_file_id (e.g., 123.000, 123.001, 123.002, 234.000, 234.001,…).

Appendix A Example Interval Definition Files

Example A: OLI-only earth imaging interval covering ten WRS-2 scenes and requiring six mission data files. This IDF file would be named LO82220010102014286LGN00_IDF.xml.


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<idf xmlns="http://ldcm.usgs.gov/schema/idf">
    <header>
        <scid>506</scid>
        <product_type>IDF</product_type>
        <gen_time>2014:286:13:56:19.110</gen_time>
        <source>GNE-DCRS</source>
        <mode>PRODUCTION</mode>
    </header>
    <moe_interval_id>012345_01_I</moe_interval_id>
    <landsat_interval_id>LO82220010102014286LGN00</landsat_interval_id>
    <moe_interval_complete_flag>Y</moe_interval_complete_flag>
    <priority_flag>N</priority_flag>
    <sensor_id>OLI</sensor_id>
    <offnadir_flag>N</offnadir_flag>
    <collection_type>EARTH IMAGING</collection_type>
    <data_category>NOMINAL</data_category>
    <wrs_path>222</wrs_path>
    <wrs_starting_row>1</wrs_starting_row>
    <wrs_ending_row>10</wrs_ending_row>
    <gne_interval_complete_flag>Y</gne_interval_complete_flag>
    <rootfile>
        <root_file_id>189</root_file_id>
        <root_file_complete_flag>Y</root_file_complete_flag>
        <sensor_id>OLI</sensor_id>
        <landsat_interval_id>LO82220010102014286LGN00</landsat_interval_id>
        <priority_flag>N</priority_flag>
        <file>
            <file_name>189.000.2014286134234476.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>20ffe8d347f118002864bb724cf38a00</file_checksum>
            <file_size>994567890</file_size>
        </file>
        <file>
            <file_name>189.001.2014286134411345.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>7561582f6ffa3400151f8659f31fc600</file_checksum>
            <file_size>996538724</file_size>
        </file>
        <file>
            <file_name>189.002.2014286134743213.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>51427721180da0001ad9a05d9f3ac800</file_checksum>
            <file_size>981238497</file_size>
        </file>
        <file>
            <file_name>189.003.2014286134853745.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>51427721180da0001ad9a05d9f3ac800</file_checksum>
```

```
        <file_size>1034957961</file_size>
    </file>
    <file>
        <file_name>189.004.2014286134922645.LGS</file_name>
        <station_id>LGS</station_id>
        <file_checksum>707f1a8633e1c80018150c6d598f8800</file_checksum>
        <file_size>991235671</file_size>
    </file>
    <file>
        <file_name>189.005.2014286135223165.LGS</file_name>
        <station_id>LGS</station_id>
        <file_checksum>434e109f5ef9400015133e8ac01ebb00</file_checksum>
        <file_size>326817934</file_size>
    </file>
</rootfile>
<scene>
    <wrs_path>222</wrs_path>
    <wrs_row>1</wrs_row>
    <sensor_id>OLI</sensor_id>
    <priority_flag>N</priority_flag>
</scene>
<scene>
    <wrs_path>222</wrs_path>
    <wrs_row>2</wrs_row>
    <sensor_id>OLI</sensor_id>
    <priority_flag>N</priority_flag>
</scene>
<scene>
    <wrs_path>222</wrs_path>
    <wrs_row>3</wrs_row>
    <sensor_id>OLI</sensor_id>
    <priority_flag>N</priority_flag>
</scene>
<scene>
    <wrs_path>222</wrs_path>
    <wrs_row>4</wrs_row>
    <sensor_id>OLI</sensor_id>
    <priority_flag>N</priority_flag>
</scene>
<scene>
    <wrs_path>222</wrs_path>
    <wrs_row>5</wrs_row>
    <sensor_id>OLI</sensor_id>
    <priority_flag>N</priority_flag>
</scene>
<scene>
    <wrs_path>222</wrs_path>
    <wrs_row>6</wrs_row>
    <sensor_id>OLI</sensor_id>
    <priority_flag>N</priority_flag>
</scene>
<scene>
    <wrs_path>222</wrs_path>
    <wrs_row>7</wrs_row>
    <sensor_id>OLI</sensor_id>
    <priority_flag>N</priority_flag>
</scene>
```

```
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>8</wrs_row>
        <sensor_id>OLI</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>9</wrs_row>
        <sensor_id>OLI</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>10</wrs_row>
        <sensor_id>OLI</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
</idf>
```

Example B: OLI Shutter Calibration interval requiring five mission data files. This IDF file would be named LO800S2219412014286LGN00_IDF.xml.


```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<idf xmlns="http://ldcm.usgs.gov/schema/idf">
    <header>
        <scid>506</scid>
        <product_type>IDF</product_type>
        <gen_time>2014:286:13:50:04.008</gen_time>
        <source>GNE-DCRS</source>
        <mode>PRODUCTION</mode>
    </header>
    <moe_interval_id>012345_01_S</moe_interval_id>
    <landsat_cal_interval_id>LO800S1852322014208LGN00
        </landsat_cal_interval_id>
    <moe_interval_complete_flag>Y</moe_interval_complete_flag>
    <priority_flag>N</priority_flag>
    <sensor_id>OLI</sensor_id>
    <collection_type>SHUTTER</collection_type>
    <data_category>NOMINAL</data_category>
    <gne_interval_complete_flag>Y</gne_interval_complete_flag>
    <rootfile>
        <root_file_id>341</root_file_id>
        <root_file_complete_flag>Y</root_file_complete_flag>
        <sensor_id>OLI</sensor_id>
        <landsat_cal_interval_id>LO800S1852322014208LGN00
            </landsat_cal_interval_id>
        <priority_flag>N</priority_flag>
        <file>
            <file_name>341.000.2014286134232476.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>32eceeee80fdd800443dfd38d39f1c00</file_checksum>
            <file_size>994567890</file_size>
        </file>
        <file>
            <file_name>341.001.2014286134451345.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>7e4d09c199cb9c0024cfd18a5ecc2e00</file_checksum>
            <file_size>996538724</file_size>
        </file>
        <file>
            <file_name>341.002.2014286134744213.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>7bf46575ae6c54001e9470447d711000</file_checksum>
            <file_size>981238497</file_size>
        </file>
        <file>
            <file_name>341.003.2014286134851745.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>768a062a5497f4000592170294a0b7c0</file_checksum>
            <file_size>1034957961</file_size>
        </file>
        <file>
            <file_name>341.004.2014286134903645.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>2cffd60d3906b4001af479fcbd031100</file_checksum>
```

```
            <file_size>991235671</file_size>
        </file>
    </rootfile>
</idf>
```

Example C: TIRS-only earth imaging interval covering six WRS-2 scenes and requiring one mission data file. This IDF file would be named LT80202052102014264LGN00_IDF.xml.


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<idf xmlns="http://ldcm.usgs.gov/schema/idf">
    <header>
        <scid>506</scid>
        <product_type>IDF</product_type>
        <gen_time>2014:265:17:57:40.778</gen_time>
        <source>GNE-DCRS</source>
        <mode>PRODUCTION</mode>
    </header>
    <moe_interval_id>123441_02_I</moe_interval_id>
    <landsat_interval_id>LT80202052102014264LGN00</landsat_interval_id>
    <moe_interval_complete_flag>Y</moe_interval_complete_flag>
    <priority_flag>N</priority_flag>
    <sensor_id>TIRS</sensor_id>
    <offnadir_flag>N</offnadir_flag>
    <collection_type>EARTH IMAGING</collection_type>
    <data_category>NOMINAL</data_category>
    <wrs_path>20</wrs_path>
    <wrs_starting_row>205</wrs_starting_row>
    <wrs_ending_row>210</wrs_ending_row>
    <gne_interval_complete_flag>Y</gne_interval_complete_flag>
    <rootfile>
        <root_file_id>499</root_file_id>
        <root_file_complete_flag>Y</root_file_complete_flag>
        <sensor_id>TIRS</sensor_id>
        <landsat_interval_id>LT80202052102014264LGN00</landsat_interval_id>
        <priority_flag>N</priority_flag>
        <file>
            <file_name>499.000.2014264173745245.GLC</file_name>
            <station_id>GLC</station_id>
            <file_checksum>589fb5d323c8dc003e338affb0e30a00</file_checksum>
            <file_size>179426831</file_size>
        </file>
    </rootfile>
    <scene>
        <wrs_path>20</wrs_path>
        <wrs_row>205</wrs_row>
        <sensor_id>TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>20</wrs_path>
        <wrs_row>206</wrs_row>
        <sensor_id>TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>20</wrs_path>
        <wrs_row>207</wrs_row>
        <sensor_id>TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
```

```
    <scene>
        <wrs_path>20</wrs_path>
        <wrs_row>208</wrs_row>
        <sensor_id>TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>20</wrs_path>
        <wrs_row>209</wrs_row>
        <sensor_id>TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>20</wrs_path>
        <wrs_row>210</wrs_row>
        <sensor_id>TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
</idf>
```

Example D: OLI and TIRS earth imaging interval covering nine WRS-2 scenes and requiring seven mission data files. This IDF file would be named LC82220010092014286LGN00_IDF.xml.


```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<idf xmlns="http://ldcm.usgs.gov/schema/idf">
    <header>
        <scid>506</scid>
        <product_type>IDF</product_type>
        <gen_time>2014:286:13:56:19.110</gen_time>
        <source>GNE-DCRS</source>
        <mode>PRODUCTION</mode>
    </header>
    <moe_interval_id>012345_01_I</moe_interval_id>
    <landsat_interval_id>LC82220010092014286LGN00</landsat_interval_id>
    <moe_interval_complete_flag>Y</moe_interval_complete_flag>
    <priority_flag>N</priority_flag>
    <sensor_id>OLI_TIRS</sensor_id>
    <offnadir_flag>N</offnadir_flag>
    <collection_type>EARTH IMAGING</collection_type>
    <data_category>NOMINAL</data_category>
    <wrs_path>222</wrs_path>
    <wrs_starting_row>1</wrs_starting_row>
    <wrs_ending_row>9</wrs_ending_row>
    <gne_interval_complete_flag>Y</gne_interval_complete_flag>
    <rootfile>
        <root_file_id>267</root_file_id>
        <root_file_complete_flag>Y</root_file_complete_flag>
        <sensor_id>OLI</sensor_id>
        <landsat_interval_id>LO82220010092014286LGN00</landsat_interval_id>
        <priority_flag>N</priority_flag>
        <file>
            <file_name>267.000.2014286134214476.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>32fbf57fb4dbf00038847d9bced8d000</file_checksum>
            <file_size>994567890</file_size>
        </file>
        <file>
            <file_name>267.001.2014286134412345.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>794ad0a8636cfc00344f5ed661835200</file_checksum>
            <file_size>996538724</file_size>
        </file>
        <file>
            <file_name>267.002.2014286134755213.GLC</file_name>
            <station_id>GLC</station_id>
            <file_checksum>546794639c97480080b913762b2cc800</file_checksum>
            <file_size>981238497</file_size>
        </file>
        <file>
            <file_name>267.003.2014286134823745.GLC</file_name>
            <station_id>GLC</station_id>
            <file_checksum>69933a0eb422200005bbeebb94522600</file_checksum>
            <file_size>1034957961</file_size>
        </file>
        <file>
```

```
            <file_name>267.004.2014286134911645.GLC</file_name>
            <station_id>GLC</station_id>
            <file_checksum>59ca68dadae82c0010c0dad2fc8a0200</file_checksum>
            <file_size>991235671</file_size>
        </file>
    </rootfile>
    <rootfile>
        <root_file_id>442</root_file_id>
        <root_file_complete_flag>Y</root_file_complete_flag>
        <sensor_id>TIRS</sensor_id>
        <landsat_interval_id>LT82220010092014286LGN00</landsat_interval_id>
        <priority_flag>N</priority_flag>
        <file>
            <file_name>442.000.2014286135246165.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>32fbf57fb4dbf00038847d9bced8d000</file_checksum>
            <file_size>1026817934</file_size>
        </file>
        <file>
            <file_name>442.001.2014286135319675.LGS</file_name>
            <station_id>LGS</station_id>
            <file_checksum>794ad0a8636cfc00344f5ed661835200</file_checksum>
            <file_size>985103596</file_size>
        </file>
    </rootfile>
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>1</wrs_row>
        <sensor_id>OLI_TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>2</wrs_row>
        <sensor_id>OLI_TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>3</wrs_row>
        <sensor_id>OLI_TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>4</wrs_row>
        <sensor_id>OLI_TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>222</wrs_path>
        <wrs_row>5</wrs_row>
        <sensor_id>OLI_TIRS</sensor_id>
        <priority_flag>N</priority_flag>
    </scene>
    <scene>
        <wrs_path>222</wrs_path>
```

```
        &lt;wrs_row&gt;6&lt;/wrs_row&gt;
        &lt;sensor_id&gt;OLI_TIRS&lt;/sensor_id&gt;
        &lt;priority_flag&gt;N&lt;/priority_flag&gt;
    &lt;/scene&gt;
    &lt;scene&gt;
        &lt;wrs_path&gt;222&lt;/wrs_path&gt;
        &lt;wrs_row&gt;7&lt;/wrs_row&gt;
        &lt;sensor_id&gt;OLI_TIRS&lt;/sensor_id&gt;
        &lt;priority_flag&gt;N&lt;/priority_flag&gt;
    &lt;/scene&gt;
    &lt;scene&gt;
        &lt;wrs_path&gt;222&lt;/wrs_path&gt;
        &lt;wrs_row&gt;8&lt;/wrs_row&gt;
        &lt;sensor_id&gt;OLI_TIRS&lt;/sensor_id&gt;
        &lt;priority_flag&gt;N&lt;/priority_flag&gt;
    &lt;/scene&gt;
    &lt;scene&gt;
        &lt;wrs_path&gt;222&lt;/wrs_path&gt;
        &lt;wrs_row&gt;9&lt;/wrs_row&gt;
        &lt;sensor_id&gt;OLI_TIRS&lt;/sensor_id&gt;
        &lt;priority_flag&gt;N&lt;/priority_flag&gt;
    &lt;/scene&gt;
&lt;/idf&gt;
```

Appendix B Example Checksum File

Example A: OLI and TIRS earth imaging interval requiring seven mission data files. This is the same interval described in the last IDF example in Appendix B.

```
4fd9d40816e97a2dd61bb5a800094b54  267.000.2014286134211476.LGS
72c81bc0bab5b2738b9b05add205bdbd  267.001.2014286134453345.LGS
9cb205628fafcd004eff1138a7d3016b  267.002.2014286134757213.LGS
34e10bf0699d7d76b68d3bc8a5a5562d  267.003.2014286134823745.LGS
c7fc891fa83359275128f9926902eb99  267.004.2014286134903645.LGS
d8e88c342fbd3bda9bdbb88d6354aa93  442.000.2014286135201165.LGS
d94cb51dc91dfd6d57275bac12a2e1aa  442.001.2014286135342675.LGS
bb627528e2ac2dfa1af66d1b1df573d3  LC82220010122014286LGN00_IDF.xml
```

Appendix C Glossary

Image Frame: The structure generated by OLI in response to an “Image Acquire” command. It consists of an Image Header and a series of image frames where each frame includes a Frame Header and a CRC checksum.

Interval: A scheduled period of time during which the spacecraft performs a record operation, collecting ancillary data, and collecting output from OLI and/or TIRS. Also refers to the data collected during a specific time.

Mission Data: Data GNE collected and stored to the mission data files. This data includes OLI data and/or TIRS data, and Ancillary Data. In addition, mission data includes associated files that GNE created.

Sensor Chip Assembly (SCA): One of fourteen identical assemblies placed in the focal plane of the OLI instrument or one of three identical assemblies placed in the focal plane of the TIRS instrument. All detector arrays are found on these assemblies.

References

Please see http://landsat.usgs.gov/tools_acronyms_ALL.php for a list of acronyms.

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