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Joint Polar Satellite System (JPSS) Flight
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472-00251

Mission Data Format Control Book Joint Polar Satellite System-1 (JPSS-1) (MDFCB)

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National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Mission Data Format Control Book Joint Polar Satellite System-1 (JPSS-1) (MDFCB)

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Preface

This document is under JPSS Flight configuration control. Once this document is approved, JPSS approved changes are handled in accordance with Class I and Class II change control requirements as described in the JPSS Configuration Management Procedures, and changes to this document shall be made by complete revision.

Any questions should be addressed to:

JPSS Configuration Management Office
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Change History Log

Revision	Effective Date	Description of Changes
Rev -	April 11, 2013	Initial Release per 472-CCR-13-0295
Rev A	July 31, 2014	Rev A released per 472-CCR-14-0618. Updates included: 1) Removal of the mission data packet structure figures and content tables; as they are replaced by the following new documents that contain the same information in XML format: 472-00331 JPSS-1 OMPS Mission Data Packet Structures 472-00332 JPSS-1 CERES Mission Data Packet Structures 472-00333 JPSS-1 CrIS Mission Data Packet Structures 472-00334 JPSS-1 ATMS Mission Data Packet Structures 472-00335 JPSS-1 VIIRS Mission Data Packet Structures 2) Removal of the APID to VCID and APID to HRD/SMD downlink information, as that information now resides in 472-00328 JPSS-1 APID to VCID Map 3) Updated OMPS section to reflect FSW version 6.0 update. This includes descriptions of several new APIDs, Compression, and data rate configurations. 4) Addition of Appendix B - which contains the Spacecraft Mission Data Structure XML files
Rev B	January 22, 2015	Rev B released per 472-CCR-14-0802 (1/22/15). Raytheon added new JPSS-1 mission data packets in the VIIRS FSW 0x5012 release. These changes impact the JPSS-1 Mission Data Format Control Book (472-00251).
Rev C	August 4, 2016	Rev C released per 472-CCR-16-1098 (8/4/16). Updates included: 1) Incorporate CrIS Enhanced Spectral Range Updates received from Harris 2) Remove ITAR markings (only applicable to App) 3) ATMS cleanup (Diag/Dwell packet clarification) 4) S/C Test/Fill Packet Correction Also included in this revision is the incorporation of CCR 472-CCR-14-0751.

Table of TBDs/TBRs

Item No.	Location	Summary	Individual/ Organization	Due Date

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1 Introduction

1.1 Scope

This control book describes the data formats and contents of the Joint Polar Satellite System 1 (JPSS-1) satellite mission data. The JPSS-1 mission data are transmitted via two (2) different RF links: the Ka-band Stored Mission Data (SMD) and X-band High-Rate Data (HRD) streams. The Ka and X-band mission data streams are wideband data streams that are distinct from the narrowband data stream (S-band TT&C RF link) containing the satellite's housekeeping telemetry. Yet some narrowband content is present in the wideband transmissions. Descriptions in this control book are limited to data (at the packet level) unique to the wideband links. The Command and Telemetry (C&T) Handbook and Database describe the narrowband content. In addition to providing information about the structure of the mission data, this document also describes the context of the data in terms of the scientific mission and the observatory of which it is a part. Thus, this document describes how and when each instrument outputs science, calibration, engineering, dwell and diagnostic data.

This SMD and HRD content is configurable via an uploadable spacecraft Flight Software table. This document references 472-00328 JPSS-1 Application Process Identifier (APID) to Virtual Channel Identifier (VCID) Map for that information.

The document provides information to identify, distinguish and extract all of the wideband unique source packets from the satellite's mission data streams. This document references the instrument specific documents that provide detail of the mission data packet structures, including header format, user field bit offsets, conversion coefficients, state values, etc. The packet structures are provided in ingestible Extensible Markup Language (XML) file format to allow for ingest into the Ground System. These files will be included in the Common Ground System's (CGS) Data Product Generation Database (DPGD), which resides in the Common Format Control Repository (CFCR). The instrument-specific mission data packet structure documents are the following:

472-00331 JPSS-1 OMPS Mission Data Packet Structures
472-00332 JPSS-1 CERES Mission Data Packet Structures
472-00333 JPSS-1 CrIS Mission Data Packet Structures
472-00334 JPSS-1 ATMS Mission Data Packet Structures
472-00335 JPSS-1 VIIRS Mission Data Packet Structures

It is outside the scope of this document to provide detailed information, such as calibration values, compression schemes, etc., required to interpret every data point inside the packets or to perform science data analyses. Instrument-specific documentation should be consulted for that information.

This document describes the Consultative Committee for Space Data Systems (CCSDS) Path Protocol Data Unit (CP_PDU) Source packet formats of all Ka-band and X-band downlinked mission data. The spacecraft performs additional formatting for lower CCSDS protocol layers. The JPSS-1 HRD Data Format ICD, JPSS-1 SMD ICD, and JPSS-1 TT&C Data Format ICD provide additional data format descriptions of all CCSDS protocol layers, including the Multiplexing Protocol Data Unit (M_PDU), Virtual Channel Data Unit (VCDU), Coded Virtual Channel Data Unit (CVCDU), and Channel Access Data Unit (CADU).

1.2 Responsibility/Configuration Management Process

During the JPSS-1 development and in-orbit checkout (IOC) and calibration phases, it is the responsibility of the National Aeronautics and Space Administration (NASA) to maintain the contents of this document.

This document will be maintained as a Class I document because its contents drive the design of the ground segments along with the SMD and HRD Data Format ICDs. Information that will change frequently during the implementation and early orbit phases are maintained elsewhere as Class II document(s).

1.3 Document Organization

Section 1 is this introduction.

Section 2 lists the applicable documents and documents used as reference.

Section 3 describes the general characteristics of the Mission Data Systems. Provided is an overview of the mission data including processing, storage, and downlinking of the data by the spacecraft. Also provided is a description of the spacecraft state, spacecraft modes, and instrument modes affecting the mission data streams.

Section 4 is the detailed description of the mission data formats for the five instruments: ATMS, CERES, CrIS, OMPS, and VIIRS. It also contains a section for selected data generated by the spacecraft.

Appendix A is a listing of acronyms and abbreviations used in this document.

Appendix B contains the XML formatted files that define the Spacecraft mission data packet structures.

1.4 Document Conventions

The following general conventions are used in this document:

- Byte and word numbers are counted from the first byte transmitted and start with zero (0).
- Bit numbers start with zero (0), which designates the most significant bit (MSB), the left-most bit, and the first bit transmitted (per CCSDS standards).
- All numbers shown are in decimal unless otherwise noted.
  0bnnn or b'nn' = binary, 0xnnnn or x'nnnn' = hexadecimal.
- The term spacecraft refers to the spacecraft bus and its subsystems (e.g. C&DH, attitude determination and control, RF, thermal, propulsion, power)
- The term satellite refers to the spacecraft plus the instruments.
- Instruments output mission data in packets. Some of the Instrument reference documents use the term “RDR” whereas this document consistently uses “packet”.
- “Grouped” or “segmented” packets contain mission data exceeding the size of a single CCSDS packet.

- The Data Types listed in the packets' User Data Field tables have the following meaning:

Abbreviation	Data Type
B	Bit Field
U	Unsigned Integer
S	Signed Integer
F	Floating Point

2 Documents

2.1 Applicable Documents

472-00160	JPSS-1 Spacecraft Telemetry, Tracking & Command (TT&C) to Ground Segment (GS) Radio Frequency (RF) Interface Control document (ICD).
472-00161	JPSS-1 TT&C Data Format ICD.
472-00162	JPSS-1 Spacecraft Stored Mission Data (SMD) to Ground Segment (GS) Radio Frequency (RF) Interface Control document (ICD).
472-00163	JPSS-1 Mission Data Format Interface Control Document (ICD).
472-00165	JPSS-1 Spacecraft High Rate Date (HRD) to Direct Broadcast Stations (DBS) Radio Frequency (RF) Interface Control Document (ICD)
472-00173	JPSS IRD (Interface Requirements Document) for RF Interfaces To and From The Joint Polar Satellite System Satellites
474-00629	JPSS CGS Application Packet Schema
472-00331	JPSS-1 OMPS Mission Data Packet Structures
472-00332	JPSS-1 CERES Mission Data Packet Structures
472-00333	JPSS-1 CrIS Mission Data Packet Structures
472-00334	JPSS-1 ATMS Mission Data Packet Structures
472-00335	JPSS-1 VIIRS Mission Data Packet Structures
472-00328	JPSS-1 APID to VCID Map

2.2 Reference Documents

301.0-B-2-S	Consultative Committee for Space Data Systems (CCSDS) Recommendations for Space Data System Standards – Time Code Formats
701.0-B-3-S	Consultative Committee for Space Data Systems (CCSDS) Recommendations for Advanced Orbiting Systems (AOS) - Networks and Data Links: Architectural Specification
BATC 2405144	JPSS-1 Command and Telemetry (C&T) Database
472-00009	JPSS-1 RAPID III Satellite Requirements Specification
472-00244	JPSS Data Formats Requirements Document
472-00254	VIIRS Table Description Document (TDD)
472-00255	CrIS Table Description Document (TDD)

472-00256	OMPS Table Description Document (TDD)
472-00257	ATMS Table Description Document (TDD)
474-00001-02-B0200	JPSS Common Data Format Control Book - External - Volume II - RDR Formats – Block 2.0.0
Exelis 8251540	CrIS Command and Data Packet Dictionary
BATC IN0092-115	OMPS Command & Telemetry Handbook
BATC IN0092-701	OMPS Software User Manual (SUM)
Raytheon EDD154640-109	VIIRS Command, Telemetry, Science & Engineering Data Description
BATC IN0092-167	OMPS Post-Delivery and On-Orbit Maintenance Manual
BATC IN0092-166	On Orbit Operators Manual for the Ozone Mapping and Profiler Suite
Raytheon OMM-OMM-154640-102	VIIRS Operations and Maintenance Manual
ENB VIIRS.02.05.074 J1	EFR3567 DNB Non-Linearity Summary and EDD Supplemental for Reduced Aggregation Mode Tables
Raytheon OCD-154640-102	Operations Concept Description VIIRS, OCD
Exelis 8252811	CrIS Flight Operations Manual
NGES Report 14754	ATMS COMMAND ALLOCATION DOCUMENT (CAD) FOR NPOESS, Rev. A
NGES Report 14753	NPOESS ATMS TELEMETRY ALLOCATION DOCUMENT (TAD), Rev -
NGES Report 14840	NPOESS ATMS INTRUMENT OPERATION AND MAINTENANCE MANUAL FOR FM-1 (S/N 303)
NGES Report 14029	Calibration Data Book ATMS PFM P/N 1362460-1 S/N 303
TM-04-161A	ATMS Memory Interface technical memo, Rev A.
BATC IN0092CCD-003B	OMPS CCD Reference Figures.
BATC IN0092SW-026A	OMPS Image Binning Algorithm.

BATC IN0092SYS2-104	OMPS-J1 Timing Pattern Definition
BATC IN0092SYS2-712	JPSS-1 OMPS Data Compression Study
NGSMS D54528	CERES Instrument Operations Manual
BATC 568423	JPSS-1 Spacecraft C&T Handbook.

3 Mission Data Systems

3.1 Mission Data Overview

Mission data are collected from each of the five instruments:

- Visible Infrared Imaging Radiometer Suite (VIIRS)
- Ozone Mapping Profiling Suite (OMPS)
- Cross-track Infrared Sounder (CrIS)
- Advanced Technology Microwave Sounder (ATMS)
- Clouds and the Earth's Radiant Energy System (CERES)

These data, along with spacecraft housekeeping (HSK) data, are merged and provided to the ground on a real-time 15 Mbps downlink, called HRD direct broadcast. Instrument and HSK data are also provided to the Solid State Recorder (SSR) for onboard storage and playback as SMD.

The SMD are stored in the spacecraft's Solid State Recorder (SSR) and downlinked at 150 Mbps with convolutional encoding enabled, or at 300 Mbps without convolutional encoding enabled through playback of the SSR to the polar ground stations or at 150 Mbps through Tracking Data Relay Satellite (TDRS). The SMD stream contains:

- Science and calibration data from the JPSS instruments;
- Diagnostic data from the JPSS instruments when commanded;
- Engineering data from the instruments;
- Spacecraft attitude and ephemeris data, and
- Satellite housekeeping data (a superset of the stored state of health telemetry from the spacecraft and sensors containing higher-rate sampling of many measurements).

The HRD stream is similar to the SMD as it consists of instrument science, calibration and engineering data, but it generally does not contain data from instrument diagnostic activities. The HRD is constantly transmitted in real time by the spacecraft to distributed direct-broadcast users. Output to the HRD transmitter is at a constant 15 Mbps rate. Fill data are added as needed to maintain that rate. The HRD stream is not stored separately on the spacecraft, but its content is a subset of the SMD stored on the SSR.

3.1.1 Spacecraft Processing of Mission Data

The spacecraft performs several processing functions of the JPSS mission data:

- Provides a data collection/filtering/formatting/multiplexing operation;
- Provides CCSDS formatting for the Stored Mission Data;

- Provides CCSDS formatting for the High Rate Data.

The spacecraft collects the science and HSK data from the instruments and HSK, ephemeris, and attitude data from the spacecraft components. The data is then merged together to form the contents of the HRD and SMD. A filter capability is provided to selectively exclude data from either, or both channels. This data filtering capability provides the mission operations team a means of maintaining the 15 Mbps HRD rate in the event an operational mode exceeds this maximum rate while allowing higher rate data to be recorded as SMD. The spacecraft formats the SMD and HRD independently due to the different interfaces with the separate transmitters. The JPSS HRD and SMD Data Format Interface Control Documents describe the details of the formatting processes.

The filter capability mentioned above is achieved through satellite, user-configurable tables. These tables assign specific application process identifiers (APIDs) to a specific Virtual Channel (VC), and assign specific VC Identifiers (VCIDs) to the HRD, SMD or both mission data streams. The mapping of virtual channels to HRD and SMD and the mapping of APIDs to VCIDs are documented in 472-00328 JPSS-1 APID to VCID Map.

3.1.2 Mission Data Storage

The spacecraft's Solid State Recorder provides back-orbit storage of the SMD between ground station contacts. The SSR contains 343 gigabits of memory accommodating more than 3.5 orbits of SMD input at the nominal, aggregate, input data rate of approximately 15 Mbps. The recorder has separate record and playback pointers and supports simultaneous recording and playback operations. All data stored on the SSR are Reed-Solomon encoded for error detection and correction prior to being recorded.

3.1.3 Mission Data Downlinking

The communication links that carry the satellite's mission data to the ground are made up of two separate downlinks from two separate transmitters on the spacecraft. The HRD is downlinked constantly to Direct Broadcast Users, while the SMD is downlinked as playback from the SSR during satellite contacts with the Norway ground station and through Tracking Data Relay Satellite (TDRS) via Ka-band. Figure 3.1-1 illustrates the JPSS-1 mission communications structure and the HRD and SMD links within that structure. Detailed information, including RF characteristics, may be found in the JPSS-1 Spacecraft HRD to Direct Broadcast Stations RF ICD and JPSS-1 Spacecraft SMD to Ground Segment RF ICD.

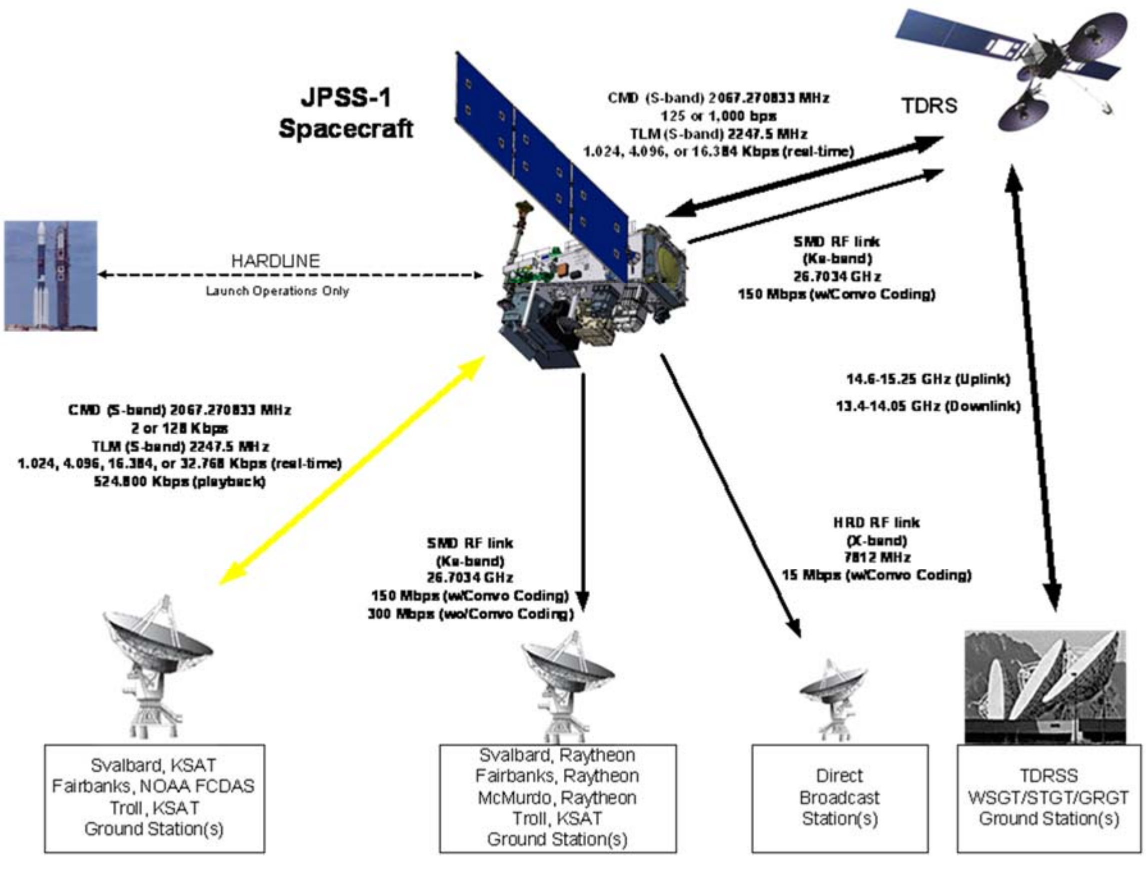

Figure 3.1-1 JPSS-1 Satellite Communication Links

3.1.4 HRD Fill Data

As mentioned, output to the HRD transmitter is at a constant 15 Mbps rate and fill data is added as needed to maintain that rate. The Fill Data is inserted at the Virtual Channel Data Unit (VCDU) level (Virtual Channel 63). Lower level (M_PDU and Packet level) formatting is not valid within the VCDU for Virtual Channel (VC) 63. VCDU data zone does not contain a M_PDU or a Source Packet, but the entire 886 octets contains the repeating pattern "0x0B" ("0b00001011").

3.2 Operational Modes

3.2.1 Satellite Modes

A "mode" defines the operational status of the satellite with the spacecraft and instruments commanded to a specific configuration to perform required operations. During a specific mission phase, the satellite may be operated in more than one mode. The mode dictates a specific spacecraft state, but the spacecraft state does not dictate a specific satellite mode (i.e., the S/C may be in Point State to support Science Mode, but the instruments and supporting components must also be properly configured to support full Science Mode.) The mode requires the appropriate configuration of spacecraft state, components, and instrument operations.

The JPSS-1 satellite supports six (6) operational modes shown in Table 3.2.1-1 with mission data availability noted. Mission data are not available in Launch Mode. In Outgassing and Safe Modes, mission data collection depends on the instrument configuration.

Table 3.2.1-1 JPSS-1 Satellite Modes

Launch Mode	Spacecraft attitude is not controlled
	Instruments are powered off with survival heaters enabled (OMPS survival heaters are not enabled until post-launch)
	No Mission Data available
Science Mode	Spacecraft maintains fine attitude pointing/determination (Point State).
	Instruments are on, commanded to appropriate operational mode
	Mission data collected and stored on Solid State Recorder (SSR)
	Real-time Science data transmitted on High Rate Data link
	Playback Stored Mission Data transmitted on Ka-band link
Science Calibration Mode	Spacecraft performs special calibration maneuvers, including roll, yaw and pitch-over
	Spacecraft remains in Point State
	Instruments are on, commanded to appropriate operational mode
	Inst. calibration data collected and stored on SSR
	HRD is suspended when pointing constraints exist
Orbit Adjust Mode	Spacecraft is in Delta-V State
	Spacecraft nominally exits Delta-V to Point State (non-thruster based mode)
	Instrument modes controlled via ground or stored command
	Mission data collected and stored on SSR (but instruments may be safed) HRD may be suspended due to pointing constraints
Safe Modes Safehold/Mission Point	Spacecraft in Point State, maintaining fine pointing attitude (nadir target) Instruments safed No mission data; Health &Safety data only
Safehold/Earth-Point	Spacecraft in Earth-Safe State, nadir pointing Instruments safed There is no or limited missiondata stored to SSR, H&S data only; HRD transmitter is off if if payload component group (PLCG) is shed

Safehold/Sun-Point	Spacecraft in Sun-Safe State, sun point attitude Instruments safed or safed and powered off No mission data,H&S data only. Defaults to 1K R/T critical telemetry
Survival/Sun-Point	Spacecraft in Sun-Safe State, sun point attitude Instruments safed (if possible), all components other than those in essential component group (ESCG) are shed No mission data; Defaults to1K R/T critical telemetry initially
Outgassing Mode	Spacecraft in Point or Earth-Safe State
	Instruments configured for outgassing or desired operational mode
	Mission data collected and stored on SSR when appropriate

3.2.2 Instrument Operational Modes

The instrument modes of operation are configurable by ground or stored command or by autonomous command for fault situations. The Mission Management Center (MMC) configures instruments to a number of operational modes within a given satellite mode as required.

Table 3.2.2-1 shows the relationship between instrument modes and satellite modes.

Table 3.2.2-1 JPSS Operational Modes and Instrument Modes

JPSS Mode	ADCS State	Inst. Power	ATMS	CrIS	OMPS	VIIRS	CERES
Launch	Wait	Off	Survival/Launch	Survival/Launch	Off/Launch	Survival/Launch	Survival/Launch
Science	Point	On	Operational	Operational,	Operational	Operational, Diagnostic	Operational
Science Calibration	Point	On	Operational, Diagnostic	Operational, Diagnostic	Operational, Diagnostic**	Operational, Diagnostic	Operational, Diagnostic
Orbit Adjust	Delta-V	On	Operational*	Operational*	Operational*	Operational*	Operational*
SafeHold/ MPM	Point	On	Safe	Safe	Safe	Safe	Safe
SafeHold/ EPM (power fault)	Earth-Safe	Off	Survival	Survival	Survival	Survival	Survival
SafeHold/ EPM (non-power fault)	Earth-Safe	On	Safe	Safe	Safe	Safe	Safe
Survival/ SPM (power fault)	Sun-Safe	Off	Survival	Survival	Survival	Survival	Survival
SafeHold/ SPM (non-power fault)	Sun-Safe	On	Safe	Safe	Safe	Safe	Safe

NOTES:

* Instrument Mode during Orbit Adjust is at the instruments/operations team discretion. May remain Operational or be safed.

** OMPS can generate diagnostic APIDs but does not have a diagnostic 'mode'

The instruments output mission data only when in their Operational and Diagnostic Modes. The CrIS outputs a subset of its mission data – engineering and calibration data but not science data – in its Outgas and Safe Modes. Thus, in JPSS Science and Science Calibration Mode, all instruments gather mission data according to their mode. No mission data are generated when JPSS is in its Launch Mode and the MPM and power fault EPM SafeHold Modes. All the instruments generate mission data when in Orbit Adjust Mode unless the flight operations team configures them to Safe Mode. During the Orbit Adjust Mode, the non-power fault EPM, the CrIS, in its Safe or Outgas Mode, will produce a subset of its mission data.

4 Mission Data Formats

This section provides a top level description of each instrument and their modes of operation. It provides detailed information that is needed for the Ground Segment to interpret downlinked mission data. Each mission data packet header format is defined, and each packet user field bit position, description, units or state value, conversion coefficients, and data type are listed.

As specified in the JPSS-1 Data Formats Requirement Document, each mission data packet has a primary header containing three 16-bit words (one 16-bit word = 2 octets). Additionally, standalone packets and the first packet in a grouped packet have a secondary header containing a 64-bit JPSS Universal Time Code (UTC). The format for standalone packets is shown in Figure 3.2-1. The format for first, middle, and last packets in a grouped pack are shown in Figure 3.2-2, Figure 3.2-3, and Figure 3.2-4, respectively. Exceptions to these formats are noted in individual instrument sections. The UTC contains 4 words (8 octets) and represents the time accurate to 1 μsec. The format of the UTC is provided in Table 4.0.1.

Field Name	Primary Header							Secondary Header	Data Field
SubField Name	Packet ID				Packet Seq Control (PCS)		Packet Length		
Subfield Lenth (bits)	3	1	1	11	2	14	16	X	Variable
Subfield Value	000	0	*0 or 1*	(0 - 2047)	*11*	(0 - 16383)	(0 - 65535)	X	Variable
SubField Bit Definitions	Forced by CCSDS	Type is Telemetry	Secondary Header Flag (Optional)	APID	Sequence Flag (11 = Standalone Packet)	Packet Sequence Count	Packet Data Length (Octets) (Data Fields including optional secondary header - 1)	(Optional)	

Figure 3.2-1 Standalone Packet Format

Field Name	Primary Header							Secondary Header			Data Field
SubField Name	Packet ID				Packet Seq Control (PCS)		Packet Length				
Subfield Lenth (bits)	3	1	1	11	2	14	16	64	8	8	Variable
Subfield Value	000	0	*1*	(0 - 2047)	*01*	(0 - 16383)	(0 - 65535)	X	X	00000000	Variable
SubField Bit Definitions	Forced by CCSDS	Type is Telemetry	Secondary Header Flag	APID	Sequence Flag (01 = 1st Packet)	Packet Sequence Count	Packet Data Length (Secondary Header plus Data Fields - 1)	CCSDS Time Code	PCS Type = 01 # of Packet Segments - 1	Spare	

Figure 3.2-2 First Packet Format

Field Name	Primary Header							Data Field
SubField Name	Packet ID				Packet Seq Control (PCS)		Packet Length	
Subfield Lenth (bits)	3	1	1	11	2	14	16	Variable
Subfield Value	000	0	*0*	(0 - 2047)	*00*	(0 - 16383)	(0 - 65535)	Variable
SubField Bit Definitions	Forced by CCSDS	Type is Telemetry	Secondary Header Flag	APID	Sequence Flag (00 = Cont. Packet)	Packet Sequence Count	Packet Data Length (Octets) (Data Fields - 1)	

Figure 3.2-3 Middle Packet Format

Field Name	Primary Header							Data Field
SubField Name	Packet ID				Packet Seq Control (PCS)		Packet Length	
Subfield Lenth (bits)	3	1	1	11	2	14	16	Variable
Subfield Value	000	0	*0*	(0 - 2047)	*10*	(0 - 16383)	(0 - 65535)	Variable
SubField Bit Definitions	Forced by CCSDS	Type is Telemetry	Secondary Header Flag	APID	Sequence Flag (10 = Last Packet)	Packet Sequence Count	Packet Data Length (Octets) (Data Fields - 1)	

Figure 3.2-4 Last Packet Format

Table 4.0.1 JPSS Universal Time Code Format

Time Code Format			
Bits	0 to 15	16 to 47	48 to 63
Parameter	Day	msec of Day	μsec of msec
Range of Values	0 to (2^{16}-1)	0 to 86,399,999	0 to 999

For each mission data packet, the expected data rate and packet size are listed for each instrument. For the Housekeeping and LEO&A packets, this information is contained in the JPSS-1 C&T Handbook or individual instrument documentation. In some cases noted below, the packet size is configurable and therefore not specified here. Refer to the JPSS Common Data Format Control Book - External - Volume II - RDR Formats for maximum allowable Raw Data Record (RDR) sizes.

For additional information on the instruments' function, refer to the individual instrument references listed in section 2.2.

4.1 ATMS

4.1.1 Introduction

The ATMS is a 22-channel millimeter-wave radiometer measuring upwelling radiances in six frequency bands centered at 23 GHz, 31 GHz, 50-58 GHz, 89 GHz, 166 GHz, and 183 GHz. The ATMS is a total-power radiometer, with "through-the-antenna" radiometric calibration. A pair of antenna apertures, scanned by rotating flat-plate reflectors, collects radiometric data. Scanning is performed cross-track to the satellite motion from sun to anti-sun, using the "integrate-while scan" type data collection. The scan period is 8/3 second, synchronized to the Cross-track Infrared Sounder (CrIS) using a spacecraft-provided scan synchronization pulse. The ATMS is compatible with both the JPSS-1 and NPP satellite architectures.

The primary roles of the ATMS are to obtain data during overcast conditions, to provide corrections for cloud effects in partly cloudy conditions, and to provide a "first-guess" for iterative physical retrievals. Processed mission data from the ATMS and the CrIS produce EDR(s) containing the following types of data:

- Atmospheric Temperature Profiles
- Atmospheric Moisture Profiles
- Atmospheric Pressure Profiles

4.1.2 Modes and Packet Structure

The ATMS instrument implements the following modes of operation:

- Off/Survival Mode
- Operational Mode
- Diagnostic Mode
- Safe Hold Mode

The functionality of the four instrument modes, and methods for executing transitions, are shown in Figure 4.1-1.

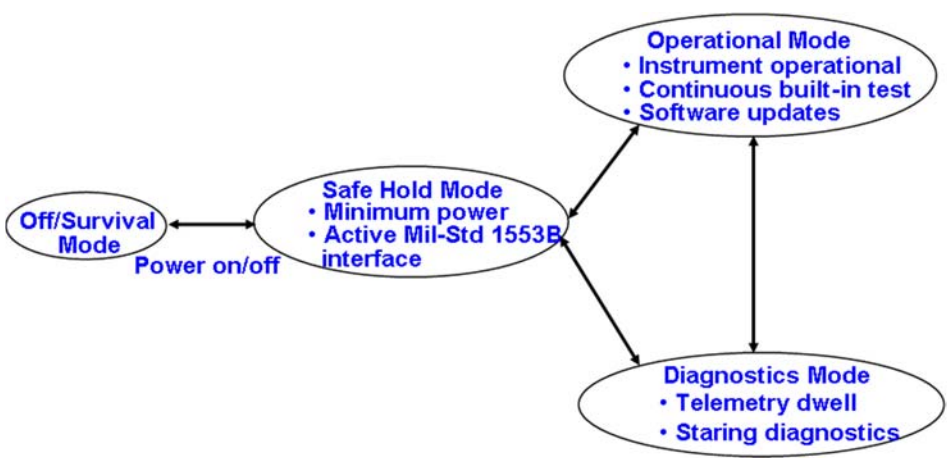

Figure 4.1-1 ATMS Modes and Mode Transitions

The ATMS outputs several packets relating to Mission Data: the Science packet, the Calibration packet, two types of Engineering packets, Memory Dump and Diagnostic packets. These packets unique to Mission data are not output in Off/Survival and Safe Hold Modes. The telemetry types, APID assignments and packet size for the ATMS mission data are listed in Table 4.1.2-1 with data rate by the ATMS mode.

Table 4.1.2-1 ATMS Mission Data Packet Types

$APID_{10}$	Telemetry Packet Name	Data Rate (bps) by Mode		Packet Size (octets)
		Operational	Diagnostic	
512	Command Status, Note 1	Note 1	Note 1	Note 1
513	LEO&A, Note 1	Note 1	Note 1	Note 1
515	Calibration	444	444	444
516	Diagnostic	--	622	622
517	Dwell	--	936	312
518	Housekeeping, Note 1	Note 1	Note 1	Note 1
528	Science	19,344	19,344	62
536	Science (Point and Stare or Continuous Sampling) (Note 2)	-	19,344 or 27,528	62
530	Engineering – Hot Cal Temps	144	144	48
531	Engineering – Health and Status	162	162	162
524	Memory Dump	--	variable	<= 1024
543	Hardware Error Status, Note 1	Note 1	Note 1	Note 1
514	Test, Note 1	--	24,576 Note 3	256

1. Documented in the JPSS-1 Command & Telemetry Handbook and Database
2. APIDs 528 and 536 are never output simultaneously. See the ATMS Science Data Section for further details.
3. The test packet data rate is determined by the spacecraft polling rate, not by the ATMS scan rate as data rates for other ATMS packets are.

4.1.2.1 *Off/Survival Mode*

In the Off or Survival mode, no primary power is supplied to the instrument. In Survival Mode, power is available on the Survival Heater bus, enabling operation of survival heaters if needed. No mission data is output in Off or Survival Mode.

4.1.2.2 *Operational Mode*

In OPERATIONAL mode, the ATMS executes the earth-view scanning profile. Science data are output in APID 528. The ATMS generates calibration data during each scan period and also performs Continuous Built-In Tests (CBITs) that monitor and verify performance. The ATMS data consist of radiometric counts and housekeeping data. The housekeeping and engineering data provide information for verifying instrument health and status and to support mission data processing. Software memory loads and dumps can be performed in Operational Mode

The ATMS scanning geometry and corresponding angular velocity profile are illustrated in Figure 4.1-2. Every 8/3 second scan period is divided into 148 equal epochs of approximately 18 msec. During Operational mode, the radiometric signals are sampled for 96 Earth scene epochs, 4 cold calibration epochs and 4 hot calibration target epochs as shown in Figure 4.1-2. During Diagnostic mode, the scan profile can be commanded to change and the radiometric signals can be sampled at all 148 epochs.

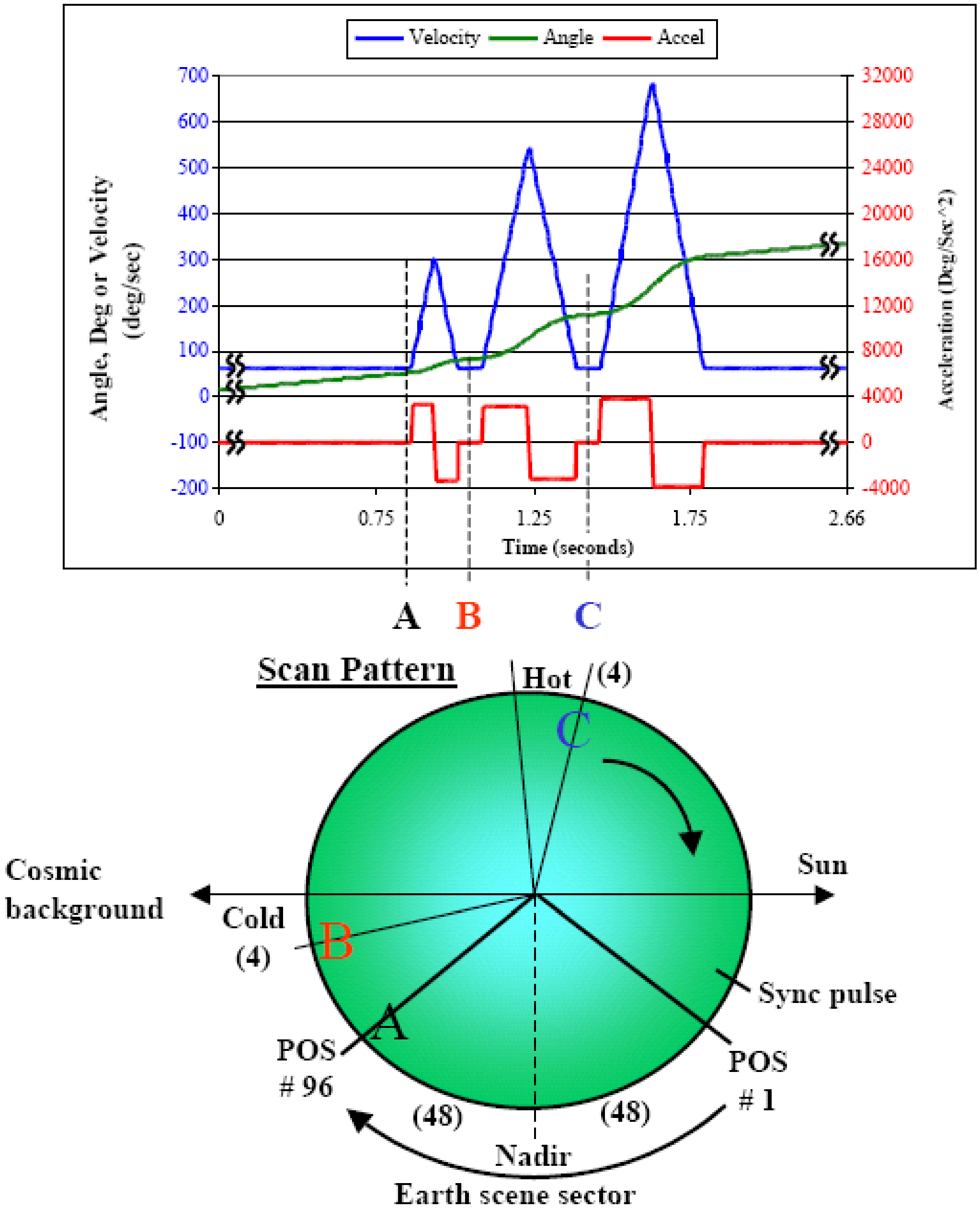

Figure 4.1-2 ATMS Operational Scan Pattern

4.1.2.3 *Diagnostic Mode*

Diagnostic "mode" is not established by a unique "mode" command. The ATMS enters Diagnostic mode when commanded to Continuous Sampling, Dwell or Point and Stare or when output of the

Dwell or Diagnostic packets is enabled. If only Dwell or Diagnostic packets are enabled, the ATMS continues to output Science (in APID 528), Calibration and Engineering packets. If commanded to Continuous Sampling or Point and Stare, the Science data is output in APID 536 instead of APID 528; otherwise it continues to be output in APID 528. The ATMS Instrument Operation and Maintenance Manual describes the sensor's built-in diagnostic tests. Several telemetry types can be initiated to determine the state of the instrument or sources of error in the following sub-modes.

4.1.2.3.1 Telemetry Dwell

The ATMS has the capability for high-rate sampling (55.5 Hz maximum) of selected housekeeping telemetry channels. When this function is commanded, the ATMS samples one of the housekeeping telemetry parameters, selected by command, at the same rate as a radiometric signal channel. The telemetry dwell data packet carries this data. It may be used to isolate noise sources due to supply voltage EMI or intermittencies.

4.1.2.3.2 Point and Stare

In the Diagnostic Mode, the ATMS Instrument can point the antenna reflector to any commanded scan angle. The commanded position is maintained until a new pointing or scanning command is received.

4.1.2.4 *Safe Hold*

In the event of a serious spacecraft or instrument anomaly, the instrument may be commanded to enter the SAFE-HOLD mode to minimize power consumption. Transition to Safe Hold also occurs autonomously when programmable limits are exceeded on a safety-critical telemetry parameter or when the instrument does not receive 12 consecutive time-of-day messages.

No mission data are output in Safe Mode. The ATMS communicates with the spacecraft via the C&T bus to provide health and status data.

4.1.3 Mission Data

The ATMS telemetry transferred via the MIL-STD-1553B bus consists of data packets in the Consultative Committee for Space Data Systems (CCSDS) Path Protocol Data Unit format described in ref. 2.2. Each packet has a primary header containing three 16-bit words (one 16-bit word = 2 octets) and a secondary header containing a 64-bit UTC time code. The only exceptions are the LEO&A and Test packets which do not contain the time code. These two packets are not mission data. All fields in the ATMS data packets are big endian.

The secondary header contains the Universal Time Code (UTC). The UTC contains 4 words (8 octets) and represents the time accurate to 1 μsec. The format of the UTC is provided in Table 4.0.1.

For science packets, the time tag indicates the time of the boundary pulse following the included data. For all other packets the UTC time represents the time of the oldest sample of the collection. Since data values are sampled in the order they appear in the packet, Housekeeping, Dwell and the Engineering packet's UTC time refers to the time of the first data value. The UTC times are calculated from the last second's UTC time plus the time difference in microseconds between the sample's 24 bit time value and the 24 bit timestamp register value for the one second time.

472-00334 JPSS-1 ATMS Mission Data Packet Structures documents the detailed packet structure and user field content for ATMS mission data.

4.1.3.1 *ATMS Temperature Data*

The ATMS uses three types of temperature monitoring:

- Temperature of the instrument mounting interface, monitored by the spacecraft, and reported in spacecraft telemetry.
- Passive Analog Temperature (PAT) sensors within the instrument, powered by the spacecraft. The signals are processed by the spacecraft and reported in spacecraft telemetry. The ATMS instrument uses five redundant PAT sensors.
- Platinum resistance temperature sensors (PRTs) within the instrument, processed by the instrument, and digitized for inclusion in the ATMS Housekeeping and Engineering data packets.

Unique coefficients for each PRT based on the manufacturer's data are required to determine the temperature. The signal from each PRT is digitized via an A-to-D converter aboard the ATMS instrument, providing a count from 0 to 65,535 representing the resistance of a given PRT. The count to resistance relationship is given by the following equation:

$$R = \frac{\gamma_R}{\gamma_1 - \gamma_0}[C - \gamma_0] - R_C \qquad (1)$$

Where: C = number of counts measured for the PRT
R_C = resistance of cable to the PRT (applicable only to 2 wire PRTs)
and γ_R, γ_0, and γ_1 are parameters defined in Table 4.1.3-1.

Table 4.1.3-1 ATMS Counts Conversion Parameters

Parameter	4-Wire PRTs	2-Wire PRTs
γ_R	PAM resistance (word 1 or 2 of Calibration Data Packet)	Housekeeping reference resistance = MUXREST1_A, MUXREST2_A, MUXREST1_B, MUXREST2_B (words 212 – 215 of Calibration Data Packet)
γ_0	4W_GND_A or _B (word 46 of Hkpg and Engr Data Packet)	2W_GND_A or _B (word 47 of Hkpg and Engr Data Packet)
γ_1	KV_WL_4WRES or WG_WL_4WRES (word 9 or 17 of Eng-HotCal Temperatures Data Packet)	[HK_2WREST1_A, HK_2WREST2_A] or, [HK_2WREST1_B,

		HK_2WREST2_B] (words 44 and 45 of HK and Engr Data Packets)

After computing the resistance, R, the Callendar-Van Dusen equation is then used to determine the physical temperature of each PRT. The equation is given below:

$$R = R_0\left[1+\alpha\left(T-\delta\left(\frac{T}{100}-1\right)\left(\frac{T}{100}\right)-\beta\left(\frac{T}{100}-1\right)\left(\frac{T}{100}\right)^3\right)\right] \quad (2)$$

Where:

T = physical temperature of the PRT
R = resistance (ohms) of the PRT (from equation 1)
R_o = resistance at ice point of the PRT (supplied by PRT vendor)
α, δ, β = constants measured for the PRT (supplied by PRT vendor)

The Newton-Raphson technique is used to perform the inversion, to compute T for a given R.

4.1.3.2 ***4-Wire PRTs***

The 4-wire PRTs measure the temperature of the ATMS calibration loads. This information is needed in SDR processing, so temperature measurements are in the Engineering--Hot Cal Temps Packet. To support the processing of the 4-wire PRTs as described above, the following coefficients are provided in data words 3-62 of the Calibration Data Packet: R_0, α, δ, β.

4.1.3.3 ***Receiver Shelf 2-Wire PRTs***

All 2-wire PRTs assess the health and status of the instrument. They are not needed in producing SDRs, so measurements are included in the Engineering—Health and Status Packet.

Processing of the receiver shelf 2-wire PRTs is identical to the 4-wire PRT processing, except that β is assumed to be 0 and is not transmitted as part of the calibration data packet for those sensors. R_0, α, and δ are provided in words 140-155 of the Calibration Data Packet. The cable resistance, Rc, is also provided, for use in the counts-to-resistance conversion (equation 1).

4.1.3.4 ***Other 2-Wire PRTs***

Other 2-wire PRTs are used purely as health and status indicators and do not require the same precision as the 4-wire and receiver shelf PRTs. These temperatures, therefore, are processed according to the following linear equation, except for the scan drive PRTs:

$$T = A_1(R - R_0) = A_1(R' - R'_0)$$

$$R' = R + R_C = \frac{\gamma_R}{\gamma_1 - \gamma_0}[C - \gamma_0] \qquad (3)$$

$$R'_0 = R_0 + R_C$$

where

T is the temperature, in degrees C,
R'_0 and A_1 are parameters transmitted in the Calibration Data Packet, words 156-211

The parameter A_1 is related to the Calendar-Van Dusen parameters by the following equation:

$$A_1 = \frac{1}{\alpha(1 + \delta/100)R_0}$$

The scan drive PRTs (words #40 and 41 of the housekeeping packet) are processed using the equation defined in the conversion coefficient column of Table IIIB in NGES Report 14753.

4.1.3.5 *Science Data*

The ATMS Science Data packets (APIDs 528 and 536) contain scan angle counts, error status flags, and radiometric counts for channels 1 through 22 at a single scan position. The operational mode science packet (APID 528) is output for 104 positions every scan (96 Earth scene positions, 4 cold calibration and 4 hot calibration positions). Since the scan duration is 8/3 seconds, the operational data rate is19,344 bps. In diagnostic mode, the science packet (APID 536) may be output 104 times every 8/3 seconds if the ATMS is in Point and Stare mode without Continuous Sampling enabled or may be generated approximately every 18 milliseconds if Continuous Sampling is enabled, thereby increasing the downlink rate to 27,528 bps.

The science packets contain a secondary header with a time tag indicating the time of the boundary pulse that follows the included data. For the scan angle value the full 16-bit range corresponds to 360 degrees, which means the scale factor is 5.493×10^{-3} degrees per count. The packet length is fixed at 62 octets.

4.1.3.6 *Calibration Data*

The ATMS Calibration Packet (APID 515) contains constants unique to each ATMS unit necessary to process the mission and housekeeping data. The parameters calibrate the receiver outputs, temperature sensors and the optical alignment of the sensor. See Section 4.1.3 for more information on PRT temperature sensors.

4.1.3.7 *APID 515 is output once every 8 seconds.Engineering Data – Hot Cal Temperatures*

The ATMS Hot Calibration Target Temperature Engineering Packet (APID 530) contains data used for SDR processing and is output every 8/3 seconds. It contains platinum resistance temperature (PRT) sensor data for the two hot calibration targets.

4.1.3.8 *Engineering Data – Health and Status*

The ATMS Health and Status Engineering Packet (APID 531) is output every 8 seconds, or every 3 scans. The contents are identical to the ATMS LEO&A and Housekeeping Packets: 2-wire temperature sensors, voltage monitors, scan drive telemetry and three status words -- SD_MODE_ERRORS, INSTRUMENT_MODE, and ERROR_STATUS (words 72, 73, and 74). The UTC time in the secondary header represents the time the first sample is taken.

4.1.3.9 *Diagnostic Data*

Output of the ATMS diagnostic packet is not planned or anticipated under normal conditions. The diagnostic data packet should not be confused with the instrument Diagnostic mode. Enabling the diagnostic packet puts the ATMS into Diagnostic Mode but does not by itself change the Science APID from APID 528 to APID 536. The diagnostic data packet is used to gain familiarity with the instrument on-orbit, or to gain additional information on any anomalous conditions. The ATMS diagnostic packet (APID 516) contains test channel data consisting of 148 samples of test data from the lower band shelves (KAV) and 148 samples from the upper band shelves (WG). The samples monitor two stable reference signals to help determine whether signal contamination is pre- or post-detection. The ATMS outputs the diagnostic packet once every 8 seconds in Diagnostic mode. The fixed packet length is 622 octets.

4.1.3.10 *Dwell Data*

The ATMS instrument reports selected housekeeping telemetry channels at the same rate as a radiometric signal channel (up to 55.5 Hz) in the dwell packet. The telemetry item is commanded to be one of the following Data Word Numbers from the Engineering Data – Health and Status packet:

Table 4.1.3-2 Valid ATMS Telemetry Dwell Parameters

Data Word Number	Telemetry Mnemonic
2 to 25	SPA_P5V_A_VMON(SPA_P5V_B_VMON) thru G2_IF_PRT
30 to 47	RCVPS_A_PRT thru 2W_GND_A(2W_GND_B)
56 to 72	SD_P5V_VMON thru SD_MODE_ERRORS

The Dwell data packet, APID 517, is sent once every 8/3 seconds after a command request when the ATMS is in diagnostic mode.

4.1.3.11 *Memory Dump*

Memory Dump packets (APID 524) are generated in response to a memory dump command. To confirm a memory load, the operator can compare the Memory Dump contents to what was loaded or calculate a 16-bit checksum of the load, send a Memory Checksum Command to have ATMS return its checksum of the received load and then compare the ground calculated checksum with the one ATMS calculated. The checksum is defined as the 16-bit sum of the 16-bit words over the memory range with the overflow discarded. The memory dump command can request memory from program RAM, data RAM, an I/O address, or the SDE. The ATMS Memory Interface technical memo, TM-04-161A, as well as 472-00257 ATMS Table Description Document (TDD) discuss these sections of the ATMS memory in greater detail. A memory dump request can request any size dump up to and including a complete dump of any one of the ATMS memory locations. The first memory dump packet user data field contains the type of memory, the memory start address, number of words to follow in the dump, and the actual memory data (contents of the memory data field). The packet is variable in length (up to 1024 octets) with an integral even number of octets. The Start of Data field (Secondary Header) in the memory dump packet indicates the time the dump packet was created.

Multiple dump packets are needed in order to retrieve the sections of memory larger than 1002 octets. For dumps larger than 1002 octets, all packets will be flagged as standalone and have secondary header timestamps with the time each individual packet was created. The Number of Words to Follow field always indicates the total number of words remaining in the dump. Since the CCSDS recommendations for grouped packets is not employed for the multiple packet dump (Packet Sequence Flag will always indicate standalone packets), sequencing of packets can be accomplished using either one or both the Packet Sequence field (Packet Sequence Control) and/or the Start of Data field (Secondary Header). Alternatively, larger blocks of memory may be dumped via multiple dump requests for 1002 octets or less. The JPSS ATMS CONOPS is only to perform multiple dump requests for blocks of memory that are larger than 1000 octets. Initial, follow on, and final dump packet formats are not currently supported by the ground dump processing.

The maximum rate of memory dump packets is limited to 30 kbps, the maximum ATMS rate for mission data. Memory dump packets are sent at a rate that will not exceed the 30 kbps rate when combined with other ATMS mission data.

4.1.3.12 *Test Packet*

When commanded, ATMS will output one Test packet every time it is polled (10 Hz) until disabled by command. The Test packet consists of a packet header with APID 514 and a fixed data pattern of 250 ‘CC’ hex characters for a total of 256 bytes. It should be noted that enabling the Test packet is considered a hazardous command due to the fact that it increases the ATMS 1553 data rate far above the normal operational or diagnostic mode rates.

4.2 CrIS

4.2.1 Introduction

The Cross-track Infrared Sounder (CrIS), shown in Figure 4.2-1, is a dynamically aligned Michelson interferometer covering 3 bands over a spectral range of 3.92 µm to 15.38 µm (650 cm^{-1} to 2550 cm^{-1}). The 8-second cross-track scan is controlled by a step-and settle-positioning system with 30 earth scene positions centered about nadir.

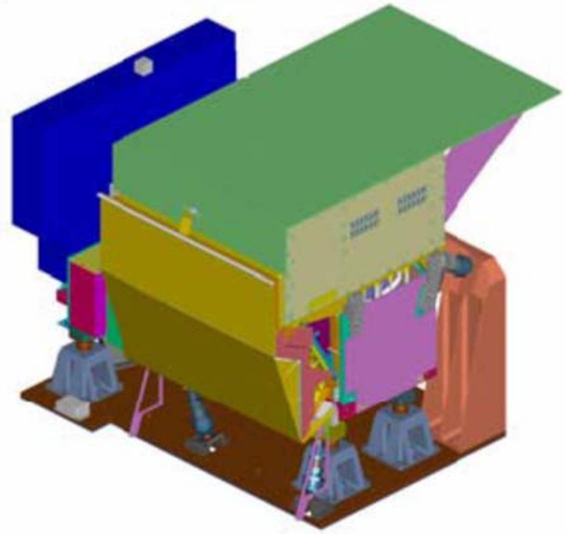

Figure 4.2-1 CrIS Drawing of the Instrument

Double-sided interferograms are collected from 9 fields of view (FOV) in a 3x3 array configuration at each position or field of regard (FOR) as shown in Figure 4.2-2. This figure shows the 9 FOVs as they would appear when the instrument is aligned to view nadir. A LW, MW, and SW band detector corresponds to each FOV, totaling 27 detectors. The FOVs will rotate and elongate during east-west scanning. The FOV diameter at nadir is 0.944 deg.

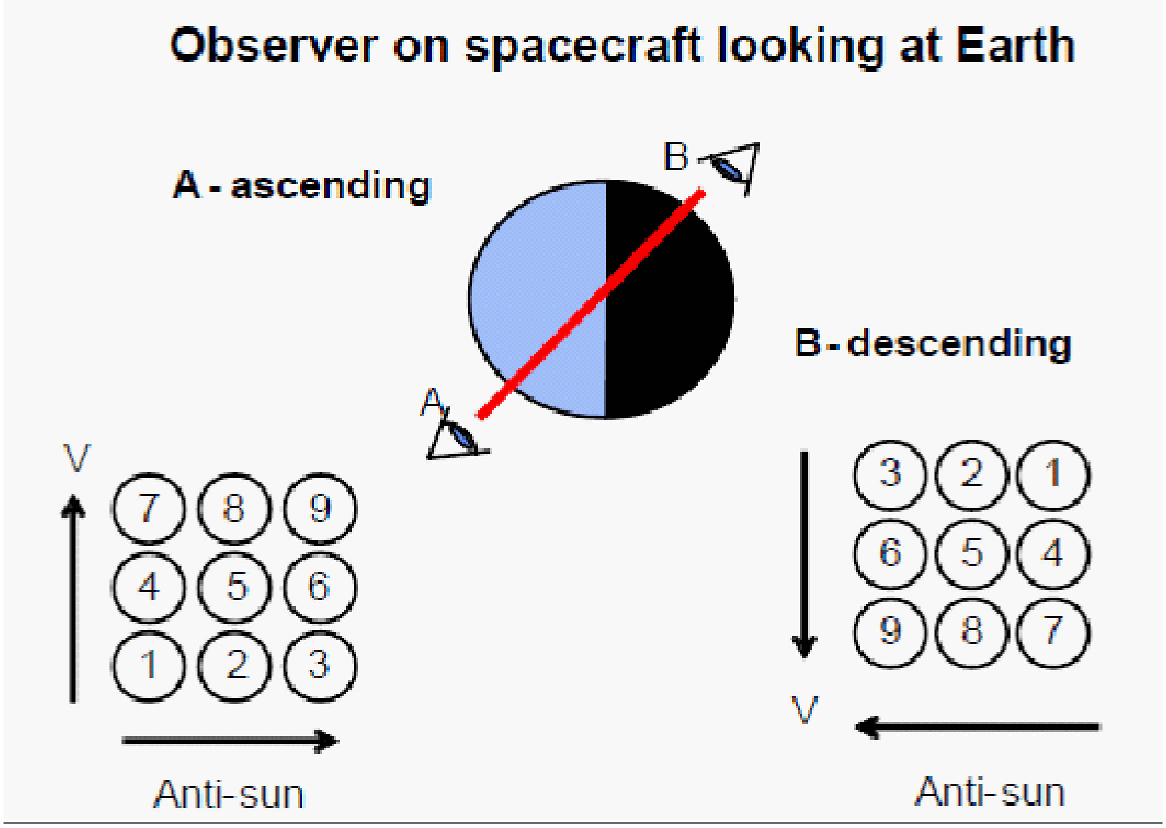

Figure 4.2-2 CrIS Field of Regard About Nadir and 9 Field of Views

The CrIS's mission is to collect upwelling infrared spectra at very high spectral resolution, and with excellent radiometric precision. This data is then merged with microwave data collected by the Advanced Technology Microwave Sounder (ATMS) to construct highly accurate temperature, moisture, and pressure profiles of the earth's atmosphere. Collectively, the CrIS and the ATMS sensors are referred to as the Crosstrack Infrared and Microwave Sounding Suite (CrIMSS).

The CrIS sensor system produces three key EDRs:

- Atmospheric Vertical Moisture Profiles
- Atmospheric Vertical Temperature Profiles
- Atmospheric Vertical Pressure Profiles

CrIS's Scene Selection Module (SSM) directs Earth scene and calibration radiance into CrIS optical modules. Figure 4.2-3 shows the scene viewed by CrIS, which consists of 30 steps of 3.33 degrees each with 0.167-second dwell time reaching full ±48.3-degree scene coverage. The 3 x 3 array of 14 km diameter CrIS FOV undergoes a rotation during the cross-track scan and grows to maximum of 49 x 31 km ellipses as the scan progresses away from nadir. The SSM views the 30 Earth Scene (ES) positions, the Deep Space (DS) position and the Internal Calibration Target (ICT) position every 8 seconds. The scan system also includes in-track velocity compensation.

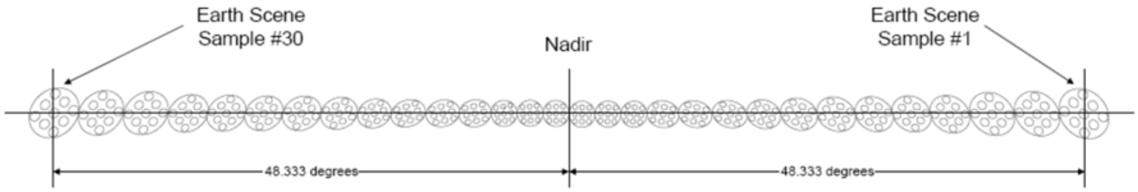

Figure 4.2-3 CrIS Scene View: 30 Steps per 8 Second Scan

After completing the 30 steps through the Earth Scene positions, the SSM slews from ES 30 to the Deep Space position at 70.3 degrees off of NADIR and settles for two consecutive samples, then slews to the ICT position (180 degrees) and settles for two additional samples before slewing again to the first Earth Scene. The double dwell at Space and ICT are to allow calibration data to be collected in both sweep directions of the interferometer's porch swing mirror.

The SSM directs incoming radiation to be modulated by the Interferometer Module and separated into the SWIR, MWIR, and LWIR bands by the Aft Optics Module before reaching the detectors as show in Figure 4.2-4. CrIS can operate in "truncated" or "full spectrum" modes. In truncated mode, the CrIS instrument processes and downlinks different length interferograms for each band - the entire interferogram for the Long-wave Infrared (LWIR) , the Mid-wave Infrared (MWIR) interferogram at half the resolution of the LWIR, and the Short-wave (SWIR) interferogram at half that of the MWIR. In full spectrum mode, the CrIS instrument processes and downlinks full length interferograms in all bands. Full spectral resolution is the baseline operational mode. The spectral ranges, resolutions and maximum path differences (MPD) for the LWIR, MWIR, and SWIR are given in Table 4.2.1-1. Note that for the LWIR band, although the MPD and number of in-band samples are the same for truncated and full spectrum mode, it is seen in section 4.2.3 below that the data rates are slightly different between them. This is due to the addition of 10 out-of-band LWIR samples in full spectrum mode to support a ground processing correction for spectral ringing seen on-orbit. The truncated mode configuration does not include the extended samples to ensure the LWIR configuration is consistent with the MWIR and SWIR bands. The full spectral resolution values for MPD assume a 1550 nm laser metrology wavelength.

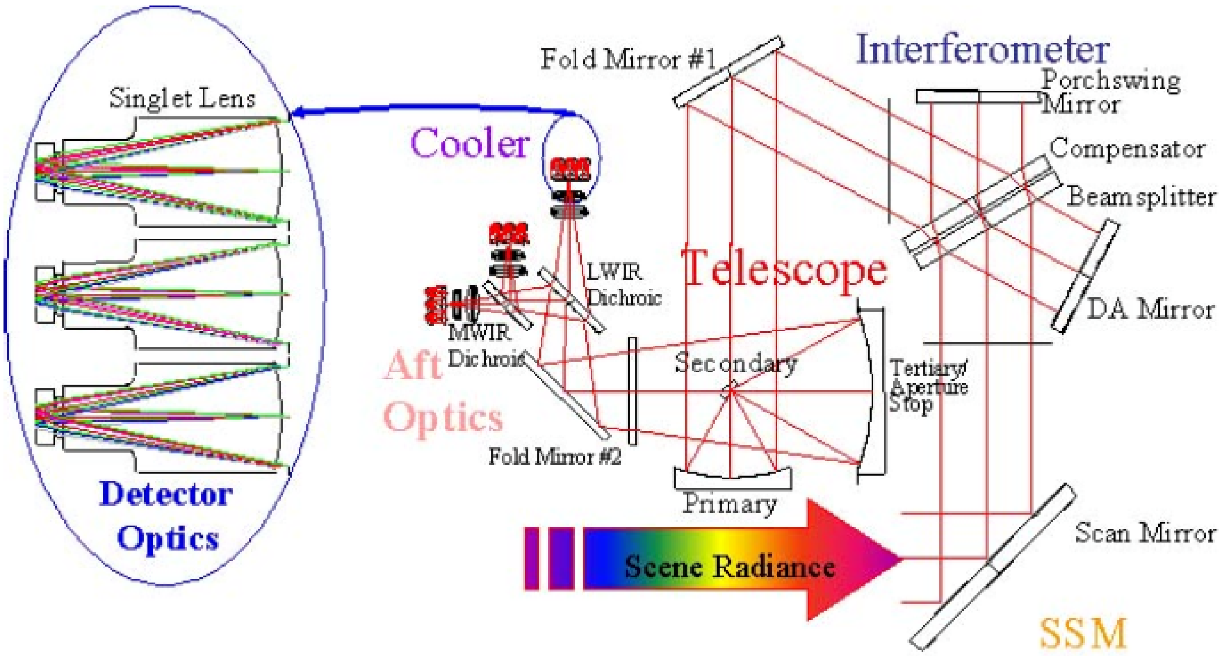

Figure 4.2-4 CrIS Signal Radiance Flow to Detectors

Table 4.2.1-1 CrIS Spectral Band Coverage and Resolution

Band	Spectral Range [cm-1]	Spectral Range [μm-1]	Band Width [cm-1]	Resolution (Truncated) [cm-1]	Resolution (Full Spectral) [cm-1]	MPD (Truncated) [cm-1]	MPD (Full Spectral) [cm-1]
LW	650-1095	15.4-9.1	445	0.625	0.625	0.8	0.8
MW	1210-1750	8.3-5.7	540	1.25	0.625	0.4	0.8
SW	2155-2550	4.6-3.9	395	2.5	0.625	0.2	0.8

4.2.2 Modes and Packet Structure

The CrIS functional modes are:

- OFF
- Survival
- Safe
- Diagnostic
- Operational
- Outgas

CrIS sensor operations are categorized into the six functional modes shown in Figure 4.2-5. These modes are not entirely unique. OFF and Survival modes share the common trait that the CrIS sensor provides no functionality. The reason is that power is not supplied to any of the functional components of the instrument in either mode but only to the survival and warm-up heaters when in Survival mode. In Safe and Outgas modes the CrIS sensor is only partially powered. As such these provide only limited functionality. In Operational and Diagnostic modes the full functionality of the CrIS sensor can be exercised. This requires that all subsystems be powered, which is not a requirement to be in Diagnostic mode. In the event that all subsystems are not powered then Diagnostic mode may bear a closer resemblance to Safe mode than to Operational. The Flight Software controls the instrument mode transitions.

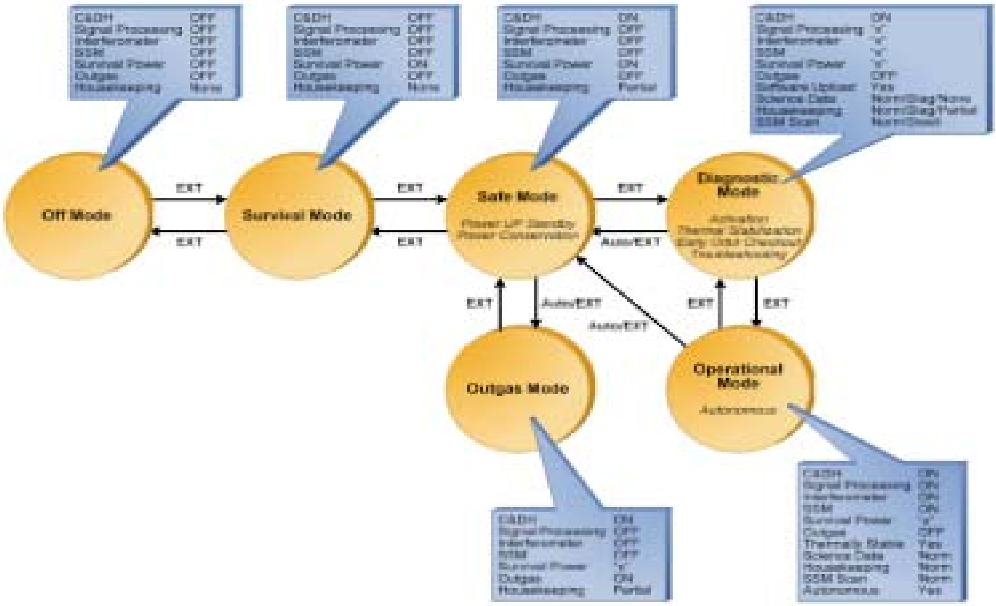

Figure 4.2-5 CrIS Modes and Mode Transitions

Within these modes the functions of activation and checkout for the CrIS sensor are supported. Activation refers to CrIS turn-on, and subsequent component warm up, or cool down, to operating temperatures. Activation terminates when the Scene Selection Module (SSM), Interferometer Module (IM) and Signal Processors (SPs) have been fully powered and properly configured. This also includes ensuring that all temperatures, biases, and currents have stabilized within specified operational limits. For CrIS, this refers to a period of time, rather than a different state of the instrument. Activation also includes the opening of the Deployable Cooler Cover

4.2.2.1 *Off Mode*

In the OFF Mode, the CrIS receives no external power for operation, including survival heater power. CrIS OFF mode is used for ground storage and transportation, launch, and spacecraft power crisis situations.

4.2.2.2 *Survival Mode*

Instrument operational power will be off but spacecraft will supply power to instrument survival and warm up heaters. In Survival Mode, the spacecraft is responsible for sampling critical instrument temperatures via the instrument passive analog temperature sensors. Normal instrument telemetry is not available with operational power off.

4.2.2.3 *Safe Mode*

The Safe Mode is an intermediate state between OFF/Survival mode and the other modes. In the Safe Mode the CrIS sensor is partially powered up and operating. Housekeeping telemetry, science/calibration telemetry and engineering packets are produced and transmitted in Safe Mode, however no science data is produced.

4.2.2.4 *Diagnostic Mode*

Diagnostic Mode capability is initiated by the ground or Spacecraft to operate CrIS in manner outside of the other standard modes. In the Diagnostic Mode, CrIS is capable of operation and supports the following:

1. Normal transition between the safe mode and the operational mode.
2. Early on-orbit checkout to verify the operability of the CrIS sensor. This is done via an ability to transmit raw undecimated interferograms, and to dwell on selected telemetry points so as to transmit data from these points at a high rate.
3. Support troubleshooting and/or instrument characterization.
4. Software uploads.
5. Staring at a single target location (i.e., Earth Scene, Deep Space or ICT)

In Diagnostic Mode, CrIS can be configured to:

1. Transmit undecimated interferograms for any single FOV in each of the three spectral bands.
2. Position the SSM to stare at any position within it cross-track scan. Typically this is use to collected extended views of the Internal Calibration Target (ICT) or Space.
3. Process all 40 frames per each 8-second scan period rather than skipping those frames collected during the slews performed between ICT and ES 1, ES 30 and Deep Space, and Deep Space and ICT. This is the typical configuration when the SSM is positioned to stare at a given location.
4. Transmit high data rate telemetry (Dwell Data or Dwell Telemetry) at a combined rate of 3200 samples per second. Housekeeping, interferometer and SSM telemetry can each be independently configured in this manner.

The definition of the Dwell Telemetry that can be transmitted in Diagnostic Mode can be found in Section 4.111.1.4.

CrIS accommodates the specified diagnostic mode by receipt of a command or series of commands that set up the desired diagnostic data output.

4.2.2.5 *Operational Mode*

When in the Operational Mode, the CrIS sensor is collecting mission and calibration data in its normal, continuous 8-second cross-track scan cycle. From Operational Mode, CrIS can transition to either Safe Mode or Diagnostic Mode. The transition to Safe Mode is done either by ground station command or autonomously by the flight software. The flight software will initiate a transition to Safe Mode when a critical fault is detected at which point it turns off the signal processors, Interferometer Module and Scene Select Module (after parking the SSM mirror at the ICT position).

CrIS is capable of remaining in normal Operational mode while the spacecraft performs orbit correction within the rates specified in the *Joint Polar Satellite System (JPSS-1) Spacecraft to the Cross-Track Infrared Sounder (CrIS) Instrument Interface Control Document (ICD),* GSFC Document 472-00021. The CrIS sensor is also capable of continued autonomous operation despite the occurrence of external CrIS synchronization errors. When a synchronization error occurs, it is reported in telemetry.

IM and SSM high data rate telemetry (Dwell Data) is active in Operational mode. The definition of the Dwell Telemetry that can be transmitted in Diagnostic Mode can be found in Section 4.111.1.4

4.2.2.6 ***Outgas Mode***

The Outgas Mode provides the function of purging contaminants from the CrIS sensor, by heating portions of the sensor to elevated temperatures. This mode is essentially the same as the instrument safe mode. No science data are collected while in this mode. The CrIS housekeeping, science/calibration and engineering packets are transmitted during this mode.

4.2.3 Mission Data

The CrIS generates mission data on an 8-second scan cycle. The 8-second scan is broken into forty 200 msec epochs beginning with the CrIS internal 8-second synchronization pulse which follows the CrIMSS pulse by 7.367 seconds. During proper synchronization, the pulse begins the slew (3 epochs) to the observation of the first of thirty Earth Scenes. After 30 epochs observing the Earth, the CrIS uses one epoch to slew to the Deep Space, two epochs to collect calibration interferograms of Deep Space, two epochs to slew to the ICT and two epochs collecting calibration inteferograms of the ICT. The CrIS scan sequence is shown in Figure 4.2-6, the Sync referenced in the figure is the CrIMSS Sync Pulse.

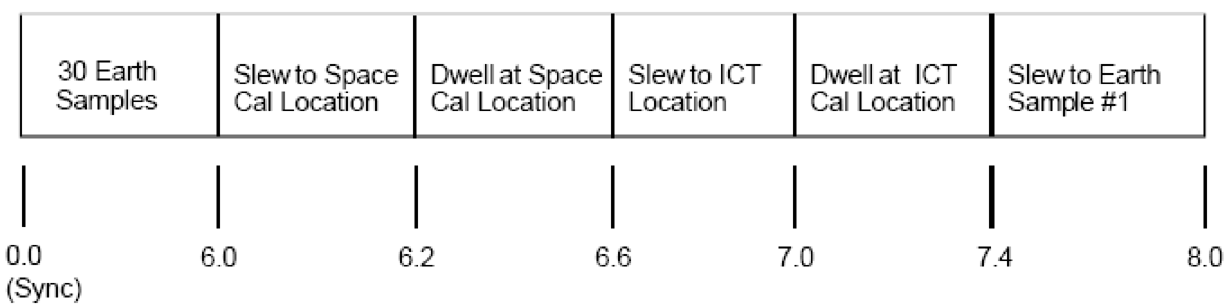

Figure 4.2-6 CrIS Normal Cross-track Scan Sequence (Timing in seconds)

All interferogram packets are formatted alike, though different APIDs contain Earth Scene, Deep Space, and ICT views. In Operational mode, the CrIS generates a set of 27 packets for each observing epoch. In Diagnostic Mode, one of four data outputs are possible. In the first scenario, only 3 packets (one per band) containing undecimated interferograms instead of 27decimated are output for each observing epoch. The second scenario consists of the CrIS generating a set of 27 packets for each of the 34 observing epoch, but only of the APID type associated with the staring location (i.e. Earth Scene, Deep Space, or ICT). The third and fourth scenarios produce either the 3 undecimated packets or the 27 packets with the same APID type but the packets are generated in 40 sampling epochs during the 8-second scan period. For interferogram packets, the UTC formatted timestamp in the secondary header (Table 4.0.1) indicates the time at the end of the interferogram sweep (+/- 1 msec). The time of the center of the Interferogram sweep can be determined by post-processing the UTC timestamp utilizing the timestamp bias parameter contained in the Engineering packet.

In addition to the interferogram packets, the CrIS outputs one Science Telemetry Packet per 8 second scan period, an Engineering packet every 4 minutes, 8 LEO&A and 8 housekeeping telemetry packets per 8 second scan period in Operational Mode. In Diagnostic Mode, CrIS generates Dwell packets every epoch (40 times per scan or every 200 msec) when requested. When a Memory Dump is requested, packets will come out every 200 msec until the total amount of data requested has been dumped (up to 40 times per scan). The JPSS-1 C&T Handbook describes the LEO&A and Housekeeping packet contents. For packets other than interferogram packets, the UTC formatted timestamp in the secondary header (Table 4.0.1) indicates the time the packet is generated.

Packet formats comply with the CCSDS Standards, as tailored for JPSS use per the Data Formats Requirement Document. The CCSDS packet fields are in big-endian byte order. 472-00333 JPSS-1 CrIS Mission Data Packet Structures documents the detailed packet structure and user field content.

4.2.3.1 *Science Data*

Table 4.2.3-1 lists all the mission data packets output by the CrIS.

Table 4.2.3-1 CrIS Mission Data Packet Types

$APID_{10}$	Telemetry Packet Name	Data Rate (bps) by Mode				Packet Size (octets) Truncated	Packet Size (octets) Full Spectral
		Operational Truncated	Diagnostic Truncated	Operational Full Spectral	Diagnostic Full Spectral		
1280	Instrument HK Telemetry Sub-Packet #1, Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1281	Instrument HK Telemetry Sub-Packet #2, Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1282	Instrument HK Telemetry Sub-Packet #3, Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1283	Instrument HK Telemetry Sub-Packet #4, Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1284	Instrument HK Telemetry Sub-Packet #5, Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1285	Instrument HK Telemetry Sub-Packet	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1

APID$_{10}$	Telemetry Packet Name	Data Rate (bps) by Mode				Packet Size (octets) Truncated	Packet Size (octets) Full Spectral
		Operational Truncated	Diagnostic Truncated	Operational Full Spectral	Diagnostic Full Spectral		
	#6, Note 1						
1286	Instrument HK Telemetry Sub-Packet #7, Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1287	Instrument HK Telemetry Sub-Packet #8, Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1288	LEO&A, Note1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
1289	Eight Second Science/Calibration Telemetry Packet	560	560	560	560	560	560
1290	Four Minute Engineering Telemetry Packet	257.7	257.7	257.7	257.7	7730	7730
1291	HK Telemetry Dwell Packet	---	39520	Note 5	39520	988	988
1292	SSM Telemetry Dwell Packet	---	46000	46000	46000	1150	1150
1293	IM Telemetry Dwell Packet	---	46000	46000	46000	1150	1150
1294	LW Diagnostic Interferogram Packet	---	1431604 / 1684240 (Note 2)	---	1447924 / 1703440 (Note 2, Note 3)	42106*	Note 3
1295	MW Diagnostic Interferogram Packet	---	739092 / 869520 (Note 2)	---	1449012 / 1704720 (Note 2, Note 3)	21738*	Note 3
1296	SW Diagnostic Interferogram Packet	---	375428 / 441680 (Note 2)	---	1446836 / 1702160 (Note 2, Note 3)	11042*	Note 3
1315	LW 1 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1316	LW 2 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1317	LW 3 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1318	LW 4 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1319	LW 5 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1320	LW 6 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1321	LW 7 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1322	LW 8 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1323	LW 9 Earth Scene	80700/91460/ 96840/107600***	---	81420/92276/97704/ 108560***	---	2690**	2714**
1324	MW 1 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1325	MW 2 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1326	MW 3 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1327	MW 4 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1328	MW 5 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**

APID$_{10}$	Telemetry Packet Name	Data Rate (bps) by Mode				Packet Size (octets) Truncated	Packet Size (octets) Full Spectral
		Operational Truncated	Diagnostic Truncated	Operational Full Spectral	Diagnostic Full Spectral		
1329	MW 6 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1330	MW 7 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1331	MW 8 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1332	MW 9 Earth Scene	57060/64668/ 68472/76080***	---	90540/102612/1086 48/120720***	---	1902**	3018**
1333	SW 1 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1334	SW 2 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1335	SW 3 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1336	SW 4 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1337	SW 5 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1338	SW 6 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1339	SW 7 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1340	SW 8 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1341	SW 9 Earth Scene	18060/20468/ 21672/24080***	---	55860/63308/67032/ 74480***	---	602**	1862**
1342	LW 1 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1343	LW 2 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1344	LW 3 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1345	LW 4 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1346	LW 5 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1347	LW 6 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1348	LW 7 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1349	LW 8 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1350	LW 9 Deep Space	5380/91460/ 5380/107600***	---	5428/92276/5428/10 8560***	---	2690**	2714**
1351	MW 1Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1352	MW 2 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1353	MW 3 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1354	MW 4 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1355	MW 5 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1356	MW 6 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1357	MW 7 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1358	MW 8 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1359	MW 9 Deep Space	3804/64668/ 3804/76080***	---	6036/102612/6036/1 20720***	---	1902**	3018**
1360	SW 1 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74 480***	---	602**	1862**
1361	SW 2 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74 480***	---	602**	1862**
1362	SW 3 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74 480***	---	602**	1862**
1363	SW 4 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74 480***	---	602**	1862**

APID$_{10}$	Telemetry Packet Name	Data Rate (bps) by Mode				Packet Size (octets) Truncated	Packet Size (octets) Full Spectral
		Operational Truncated	Diagnostic Truncated	Operational Full Spectral	Diagnostic Full Spectral		
1364	SW 5 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1365	SW 6 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1366	SW 7 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1367	SW 8 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1368	SW 9 Deep Space	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1369	LW 1 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1370	LW 2 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1371	LW 3 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1372	LW 4 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1373	LW 5 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1374	LW 6 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1375	LW 7 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1376	LW 8 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1377	LW 9 Internal Calibration on Target	5380/91460/ 5380/107600***	---	5428/92276/5428/108560***	---	2690**	2714**
1378	MW 1 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1379	MW 2 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1380	MW 3 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1381	MW 4 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1382	MW 5 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1383	MW 6 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1384	MW 7 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1385	MW 8 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1386	MW 9 Internal Calibration on Target	3804/64668/ 3804/76080***	---	6036/102612/6036/120720***	---	1902**	3018**
1387	SW 1 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1388	SW 2 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**

APID$_{10}$	Telemetry Packet Name	Data Rate (bps) by Mode				Packet Size (octets) Truncated	Packet Size (octets) Full Spectral
		Operational Truncated	Diagnostic Truncated	Operational Full Spectral	Diagnostic Full Spectral		
1389	SW 3 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1390	SW 4 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1391	SW 5 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1392	SW 6 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1393	SW 7 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1394	SW 8 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1395	SW 9 Internal Calibration on Target	1204/20468/ 1204/24080***	---	3724/63308/3724/74480***	---	602**	1862**
1397	Memory Dump	---	variable	---	variable	Up to 32792	Up to 32792
1398	Test Packet, Note 1	---	10240	---	10240	256	256

1. Documented in the JPSS-1 Command and Telemetry Handbook and Database
2. Data Rates for diagnostic interferogram APIDs 1294-1296 are listed as 34 packets, and 40 packets per scan are output, however 40 frame output exceeds current J1 data rate specifications. No difference between scanning and staring data rates. See Diagnostic Data section.
3. Full Spectral Resolution Diagnostic Interferograms include the extended LWIR and SWIR sample configuration that has been incorporated into the Operational Full Spectral Resolution configuration. However, full spectral resolution diagnostic interferograms exceed current J1 data rate specifications. See Diagnostic Data section.
4. Enabling any of the Dwell APIDs will result in both peak (3.3 Mbps) and average (2.6 Mbps) data rate specifications being exceeded.
5. Housekeeping Dwell is enabled in the Telemetry Diagnostic configuration per the specification.

* The maximum size of the diagnostic packets is 42618 octets.

** The maximum size of these packets is 4734 octets.

*** The data rates for APIDs 1315 through 1395 are listed as normal scanning (34-frame), 34-frame stare, 40-frame scanning, or 40-frame stare per 8-second scan period. The nominal scanning configuration is 34-frame mode, while the nominal staring configuration is 40-frame. One total data rate exists for 34-frame mode (applies to data rate specification) and one for 40-frame mode, regardless of whether CrIS is staring or scanning. However, when breaking out data rates by APID, these 4 configurations determine the packet data rates at this lower level. In 34-frame mode, the 6 “slew” epochs are not output. If scanning, 34-frame mode yields 30 Earth Scene (ES), 2 Internal Calibration Target (ICT), and 2 Deep Space (DS) packets per band/FOV per scan period. If staring, 34-frame mode yields 34 packets for whichever scene is being viewed per band/FOV per scan period. In 40-frame mode, the 6 slew epochs are output in the ES APIDs. If scanning, 40-frame mode yields 36 ES, 2 ICT, and 2 DS packets per band/FOV per scan period. If staring, 40-frame mode yields 40 packets for whichever scene is being viewed per band/FOV per scan period.

The CrIS outputs Earth Scene data in APIDs 1315 through 1341 thirty times (once per Earth Scene FOR) every 8 second scan when in Operational Mode. The 30 FORs are output at 200 msec intervals within the scan. The packets are configurable because the number of samples is fixed for each band and the size of each sample is configurable by command. The default sizes are below and the maximum sizes are included in the footnotes to Table 4.2.3-1.

Table 4.2.3-2 CrIS Operational Interferogram Samples by IR Band

IR Band	Post Processing Bits (for each I and Q)		Number of Samples (for each I and Q)	
	Truncated	Full Spectral	Truncated	Full Spectral
LW	18	18	866	876
MW	17	17	530	1052
SW	15	15	202	808

In Operational Mode, each IR band's interferogram samples a different number of complex numbers (see Table 4.2.3-2). The bit size of each sample after filtering and decimation but before bit trimming differs between bands. These data then pass through the programmable bit trimming process. The bit trimming for each band is divided into up to 16 zones, each with its unique bit trimmed sample length. The start and stop bit of the 40-bit filter response accumulator (defining the trimmed length) and the boundary of each zone is included in the Engineering Packet. Table 4.2.3-3 documents the default trimmed lengths for the default zones of the LW, MW and SW packets. The bits not used in the last 16-bit word of the I data block and Q data block are filled with zeros.

Table 4.2.3-3 CrIS Default Bit Trimming Output

	LW				MW				SW			
		4			Truncated	Full Spectral	Truncated	Full Spectral	Truncated	Full Spectral	Truncated	Full Spectral
	4.7 End Sample Index		4.8		End Sample Index		Sample Bit Length		End Sample Index		Sample Bit Length	

Zone 0	50		11		134	116	13	10	42	94	10	8
Zone 1	91				205	316	14	11	69		10	9
Zone 2	375				207	507	14	12	71	243	10	8
Zone 3	421				209	509	14	12	73	324	10	9
Zone 4	445			18	315	543	17		75	377	10	10
Zone 5	491		13		317	545	14	12	77	379	10	10
Zone 6	775				319	736	14	12	125	429	15	15
Zone 7	816				390	936	14	11	127	431	10	10
Zone 8	866				530	1052	13	10	129	484	10	10
Zone 9	4.	N/A		N/A			N/A	N/A	131	565	10	9
Zone 10	4.								133	659	10	8
Zone 11	4.								161	714	10	9
Zone 12	4.		N/A						202		10	8

Zone 13	4.					
Zone 14	4.					
Zone 15	4.					
	LW Truncated	4.99	MW Truncated	MW Full Spectral	SW Truncated	SW Full Spectral
Total Interfe rogra m Bits	10610 x 2 = 21220	4.100	7464 x 2 = 14928	11930 x 2 =23860	2260 x 2 = 4520	4.10

	4.103 1328x2=2656	1340 x 2 = 2680	4.10	1492 x 2 = 2984	4.105	914 x 2 = 1828

	4.107 2656+14+20=2690	2680 + 14 + 20 = 2714	4.10	4.10	4.110	4.11

4.111.1.1 *Calibration Data*

The CrIS outputs Deep Space view data in APIDs 1342 through 1368 and Internal Calibration Target view data in APIDs 1369 to 1395. The SSM spends two epochs at each location so each of the APIDs above is generated twice every 8 second scan when in Operational Mode. The packet format and user data fields for these APIDs are identical to the Science Data APIDs.

The CrIS also outputs one Science/Calibration Telemetry Packet in APID 1289 every 8 second scan period. This packet contains Calibration Resistor temperatures and ICT temperatures measured during all 40 epochs of the scan. Servo pointing errors are available when the SSM points to the 30 earth FORs. Additional fields are added to the first epoch observing the ICT. The packet has a fixed length of 560 octets.

4.111.1.2 *Engineering Data*

The CrIS generates an engineering packet in APID 1290 every 30 scans (or 4 minutes). The extensive contents of this packet include tables of calibration target emissivity versus frequency, Instrument Line Shape (ILS) curve fitting parameters, calibration of the neon source wavelength, polarization change versus wavelength for the Earth Scene and Deep Space FORs, Science/Calibration Telemetry conversion coefficients and limits, field of view mapping parameters, bit trim parameters, jitter correction parameters and neon laser calibration data. The packet has a fixed length of 7730 octets.

4.111.1.3 *Diagnostic Data*

The CrIS generates high resolution interferograms when in Diagnostic Mode. Because the sampling of the interferogram is much finer, the CrIS limits its Diagnostic data output to one FOV per FOR. Operators select which FOV via command; the selection is reflected in the Diagnostic Mode Channel Select field of the Filter Status Word within the packet. Instead of 9 APIDs per band, Diagnostic data uses one APID per IR band: APIDs 1294, 1295 and 1296 for LW, MW and SW respectively. The CrIS outputs these packets 34 times per 8 second scan if the Diagnostic Test Mode bit of the band's DSP Hardware Control Settings field in the Housekeeping Packet is set to Normal. This includes 30 diagnostic Earth FORs, 2 diagnostic Deep Space FORs and 2 diagnostic ICT FORs. If the Diagnostic Test Mode bit of a band is set to Process All frames, the CrIS outputs the APID 40 times per scan. The CrIS will exceed its J1 allocated data rate if all three diagnostic packets are generated 40 times per scan in truncated spectral resolution. The J1 allocated data rates will also be exceeded for outputting diagnostic interferograms in full spectral resolution. Each of these packets has a unique fixed length, shown below.

No bit trimming is performed in Diagnostic Mode. Each interferogram sample is put into a 16-bit word, regardless of its post-processing length or A/D resolution. Thus even a sample from a 14-bit A/D is put into a 16-bit word. With every sample of uniform length, the number of samples determines the length of the packet, as seen in Table 4.2.3-4 for truncated spectral resolution and Table 4.2.3-5 for full spectral resolution.

Table 4.2.3-4 CrIS Diagnostic Interferogram Truncated Spectral Resolution Samples by IR Band

IR Band	Number of Samples	Packet Length (including headers)
LW	21038	42106
MW	10854	21738
SW	5506	11042

Table 4.2.3-5 CrIS Diagnostic Interferogram Full Spectral Resolution Samples by IR Band

IR Band	Number of Samples	Packet Length (including headers)
LW	21278	42586
MW	21294	42618
SW	21262	42554

The Diagnostic packet formats are identical to the other Interferogram packets with two exceptions. First, is one data block for the actual detector samples. Second, the "Number of I words after bit trimming" in the Operational Interferogram packet is unnecessary and not included in the Diagnostic Packet

4.111.1.4 ***Dwell Data***

Three types of dwell packets are commandable from the CrIS sensor in Diagnostic mode. All three types of packets are generated at every scan epoch (40 times per 8 second scan).

4.111.1.4.1 IM Telemetry Dwell

The Interferometer Module Telemetry Dwell provides fast sampling of seven selectable channels within the IM. Each channel is sampled 80 times with a single epoch. The CrIS outputs APID 1293 forty times per 8 second scan. The packet length is fixed at 1150 octets.

4.111.1.4.2 HK Telemetry Dwell

The Housekeeping Telemetry Dwell provides fast sampling of six selected housekeeping telemetry points. Each selection is sampled 80 times with a single epoch. The CrIS outputs APID 1291 forty times per 8 second scan. The packet length is fixed at 988 octets.

4.111.1.4.3 SSM Telemetry Dwell

The Scene Selection Module Telemetry Dwell provides fast sampling of seven selectable channels within the SSM. Each channel is sampled 80 times with a single epoch. The CrIS outputs APID 1292 forty times per 8 second scan. The packet length is fixed at 1150 octets.

4.111.1.5 ***Memory Dump***

The Memory Dump Packet (APID 1397) is initiated in response to a dump command. (Note: the instrument must be in safe mode before data can be dumped.) If the requested size of memory to dump is too large for the intended peak throughput of a single packet of (32768 bytes), then it will be sent in multiple packets at 200ms increments. The Secondary Header timestamps increase in multiple-packet dumps since each packet is stamped with the time of its generation. Dumps of the SSM and IM EEPROM are limited in size to 128 bytes; multiple requests are necessary for larger dumps. The following types of memory dumps may be requested:

- IFC SRAM
- Boot ROM
- Program EEPROM
- BAE PCI Bridge Chip
- Aux Bridge Chip
- Housekeeping CCA
- Signal Processor LW
- Signal Processor MW
- Signal Processor SW
- SpaceWire CCA
- SpaceWire CCA Error Log
- APID Table
- SSM EEPROM
- IM EEPROM
- Fault Log
- ECC Error Log

All memory dumps that include SRAM DMA buffers will contain 0xCC where the DMA buffer memory would be. If the memory type dumped is anything other than SRAM, Boot ROM, Program EEPROM or SSM/IM EEPROM, then the Start Address and Data Size fields are irrelevant and the memory dump packet is filled with static, predefined information for each module. The contents of the memory dump packet under these conditions are defined in the 472-00255 CrIS Table Description Document (TDD).

4.111.1.6 *Test Packet*

When commanded, CrIS will generate one fixed Test packet every scan until disabled by command. The Test packet consists of a packet primary header with APID 1398, a secondary header, two octets of CrIS flight software version number and instrument identification number and a fixed data pattern of 240 ‘CC’ hex characters for a total of 256 bytes.

4.112 OMPS

4.112.1 Introduction

The information in this section should be considered a high-level overview of the OMPS instrument. Please see the following OMPS reference documentation for complete details: OMPS On-Orbit Operators Manual (OOOM), OMPS Post-Delivery and On-Orbit Maintenance Manual (PDOOMM), OMPS Test, Handling and Operations Constraints Manual, OMPS Command & Telemetry Handbook (C&T), OMPS Software Users Manual (SUM).

The Ozone Mapping and Profiler Suite (OMPS) provides JPSS-1 users with data products describing the vertical, horizontal and temporal distribution of ozone in the Earth's atmosphere. On NPP, two sensors -- one nadir viewing and one limb viewing -- observe ultraviolet and visible light from 250 nm to 1000 nm. On JPSS-1, only the nadir sensor is manifested. Unlike the other JPSS-1 sensors, the OMPS does not scan across nadir. Its nadir instrument has a fixed field of view 110º x 0.3º centered at nadir. Charge-coupled devices (CCDs) within the sensor integrate the spectral and spatial distribution of radiation from 250 nm to 380 nm.

Mission data obtained from the OMPS produce the following JPSS-1 EDR:

- Ozone Total Column Ozone

The following VIIRS and CrIS EDRs are used in generating the OMPS EDRs:

- Cloud Top Pressure (CrIS)
- Temperature Profile (CrIS)
- Snow Fraction (VIIRS)
- Ice Surface Temperature (VIIRS)

The OMPS instrument has the capability of being configured via FSW table uploads to perform on-board data compression, which allows higher volumes of OMPS data to be transmitted without an increase in bandwidth allocation, enabling increased utilization of the OMPS instrument capabilities. Compressed and uncompressed data cannot be generated simultaneously. However, it is possible that they are generated sequentially within an orbit.

The OMPS instrument also has the capability to change the quantity of data that it can transfer to the spacecraft over the 1553 data bus. The JPSS-1 spacecraft polling rate is fixed at 10 Hz, and the OMPS instrument can transmit either 32, 64, or 80 64-byte buffers in a polling interval. The baseline configuration for the OMPS instrument is to transmit 80 64-byte buffers, resulting in a 409.6 kbps data rate.

4.112.2 Modes and Packet Structure

“Modes” are distinct, commandable states for the OMPS instrument. “Activities” are sequences of operations that are designed to be executed from a particular mode.

The OMPS implements the following modes.

- OFF Mode
- SURVIVAL Mode
- BOOT Mode
- SAFE-HOLD Mode

- DECON Mode
- OPERATE Mode

The normal transition from full off to full operational mode progresses through the BOOT, SAFE-HOLD, and DECON modes, where certain early orbit checkout activities occur. The SURVIVAL MODE is used for abnormal conditions. Routine science and calibration activities are performed in the OPERATE mode, including autonomous functionality. The OMPS does not have a separate calibration mode, but performs calibrations as part of OPERATE mode as discussed below. Figure 4.112-1 is the top-level mode transition diagram for the OMPS.

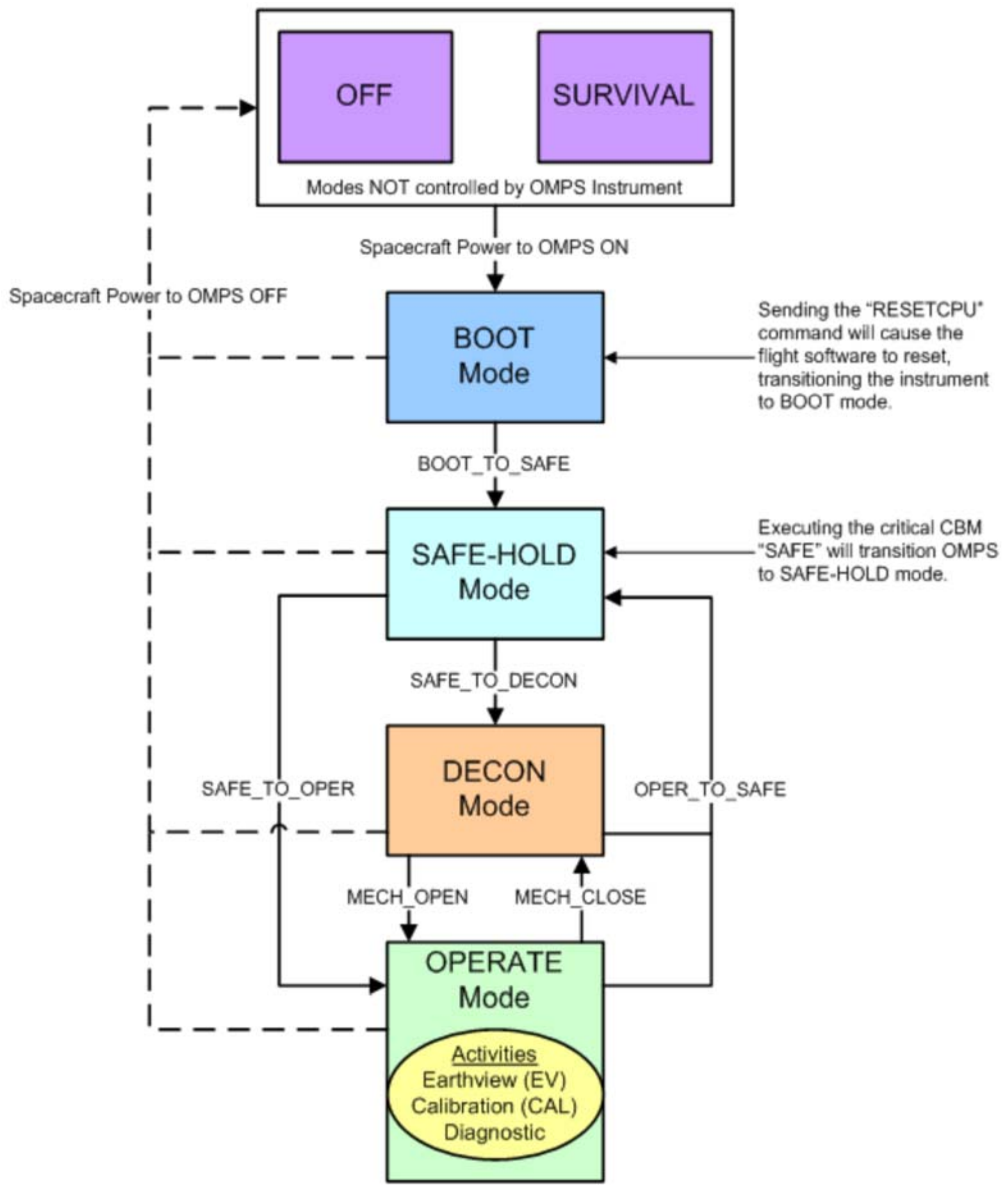

Figure 4.112-1 OMPS Modes and Mode Transitions

Table 4.112.2-1 lists all the data packets output by the OMPS.

Table 4.112.2-1 OMPS Mission Data Packet Types

Uncompressed $APID_{10}$	Compressed $APID_{10}$	Telemetry Packet Name	Data Rate (bps)		Packet Size (octets), Note 2
			Operational	Diagnostic	
544	NA	Housekeeping, Note 1	Note 1	Note 1	Note 1
545	NA	LEO&A Housekeeping, Note 1	Note 1	Note 1	Note 1
546	NA	Test	--	409.6	256
549	NA	Dwell Telemetry	--	244	244
550	NA	Diagnostic - FSW Bootup Status Frame	Note 1	Note 1	Note 1
556	NA	Table/Memory Dump	--	Varies	<= 4219288
560	616	Nadir Total Column Earth View	Varies	--	(Note 3)
561	617	Nadir Profiler Earth View	Varies	--	(Note 3)
562	619	Limb Profiler Long Exposure Earth View (Not generated on JPSS-1)	N/A for JPSS-1	--	(Note 4)
563	618	Limb Profiler Short Exposure Earth View (Not generated on JPSS-1)	N/A for JPSS-1	--	(Note 4)
564	624	Nadir Total Column Calibration RDR	Varies	--	Varies (Note 3)
565	625	Nadir Profiler Calibration	Varies	--	Varies (Note 3)
566	626	Limb Profiler Calibration (Not generated on JPSS-1)	N/A for JPSS-1	--	(Note 4)
576	620	Diagnostic Nadir Total Column Earth View	--	Varies	(Note 3)
577	621	Diagnostic Nadir Profiler Earth View	--	Varies	(Note 3)
578	623	Diagnostic Limb Long-Exposure (Not generated on JPSS-1)	--	N/A for JPSS-1	(Note 4)
579	622	Diag Limb Profiler Short Exposure (Not generated on JPSS-1)	--	N/A for JPSS-1	(Note 4)
580	627	Diagnostic Nadir Total Column Calibration	--	Varies	Varies (Note 3)

Uncompressed APID10	Compressed APID10	Telemetry Packet Name	Data Rate (bps)		Packet Size (octets), Note 2
			Operational	Diagnostic	
581	628	Diagnostic Nadir Profiler Calibration	--	Varies	Varies (Note 3)
582	629	Diagnostic Limb Profiler Calibration (Not Generated for JPSS-1)	--	(N/A for JPSS-1)	Varies (Note 4)
592	608	Reduced frame EV Nadir Total Column	Varies		Varies (Note 3)
593	609	Reduced frame EV Nadir Profiler	Varies		Varies (Note 3)
594	610	Reduced frame EV Limb Short-Exposure	(N/A for JPSS-1)		Varies (Note 4)
595	611	Reduced frame EV Limb Long-Exposure	(N/A for JPSS-1)		Varies (Note 4)
596	612	Diagnostic reduced frame Nadir Total Column	--		Varies (Note 3)
597	613	Diagnostic reduced frame Nadir Profiler	--		Varies (Note 3)
598	614	Diagnostic reduced frame Limb Short-Exposure	--	(N/A for JPSS-1)	Varies (Note 4)
599	615	Diagnostic reduced frame Limb Long-Exposure	--	(N/A for JPSS-1)	Varies (Note 4)
641	640	Nadir Total Column Both	--		Varies (Note 3 and 5)
643	642	Nadir Profiler Both	--		Varies (Note 3 and 5)
645	644	Limb Long-Exposure Both	--	(N/A for JPSS-1)	Varies (Note 3 and 5)
647	646	Limb Short-Exposure Both	--	(N/A for JPSS-1)	Varies (Note 3 and 5)

1. Documented in the JPSS-1 C&T Handbook and Database.
2. Packet sizes greater than 1024 octets are grouped packets.
3. The size of all OMPS science, calibration and diagnostic packets is configurable and not set at one value. The full available unbinned CCD requires multiple grouped packets to be sent. The maximum size of the packets including all primary and secondary headers in the multiple grouped packets is documented in the OMPS C&T and SUM. Refer to the JPSS Common Data Format Control Book - External - Volume II - RDR Formats for OMPS maximum RDR sizes.

4. The Limb sensor is not manifested on JPSS-1, and therefore the limb packets are not generated. Their heritage APID assignments are preserved for use on future missions.
5. APIDs 640 - 647 are intended for ground test diagnostics and are not expected to be used on-orbit.

4.112.2.1 *Off Mode*

In the instrument Off mode, the OMPS receives no external power. This includes primary and redundant survival heater power, and operational power. No mission data is output in Off Mode. There is no communication with the OMPS instrument in this mode. In this mode, the only OMPS telemetry (TLM) that is available comes from passive temperature sensors that pass directly to the spacecraft. The instrument is in Off mode during launch and in the worst-case spacecraft power crisis situations once on orbit.

4.112.2.2 *Survival Mode*

In this mode the OMPS Primary and Redundant survival heaters are enabled. Enabling OMPS survival heaters is a spacecraft function and does not involve sending commands to the OMPS instrument. Thermostats control the turn-on and turn-off of survival power to the survival heaters. There is no communication with the OMPS instrument in this mode. In this mode, the only OMPS TLM that is available comes from passive temperature sensors that pass directly to the spacecraft. OMPS is in this mode prior to initial power-on.

4.112.2.3 *Boot Mode*

In this mode the spacecraft supplies operational power to the OMPS instrument. Supplying operational power to the OMPS instrument is a spacecraft function and does not involve sending commands to the OMPS instrument. When OMPS operational power is initially supplied, bootstrap code executes and OMPS transitions itself to BOOT mode. Once in BOOT mode, OMPS FSW generates nominal Health and Status (HSD) telemetry and is ready to receive commands.

4.112.2.4 *Safe-Hold Mode*

SAFE-HOLD mode is the nominal protected, low-power mode for the OMPS instrument. This is the mode into which OMPS will autonomously transition itself in the event of a serious fault or limit violation – or from a spacecraft requested "safing" operation. OMPS FSW generates nominal Health and Status (HSD) telemetry in this mode, unless commanded to perform an Aliveness activity, during which Diagnostic packets are also generated.

4.112.2.5 *Decon Mode*

DECON mode is a special mode designed primarily for early-orbit operations – and for routine orbit correction events. DECON mode – short for decontamination – is identical to OMPS OPERATE mode (see below), except that the diffuser wheel assembly remains in its closed/home positions. The purpose of this mode is to configure the OMPS instrument in a safe, warm and operationally functional configuration during (1) the JPSS-1 observatory "outgassing" phase of early-orbit operations, and during (2) routine orbit correction events. In this mode OMPS is fully capable of generating internal calibration data. It is expected that OMPS will remain in this mode for approximately the first 30 days after launch. OMPS FSW generates nominal Health and Status (HSD) telemetry and Diagnostic science packets in this mode, unless commanded to perform the Functional and/or Darks activities, during which Calibration packets are also generated.

4.112.2.6 *Operate Mode*

OPERATE mode is the nominal configuration of the OMPS instrument during routine operations. In OPERATE mode, the Nadir sensor is powered on, the FPA window heaters are powered on, the FPA TECs are powered on and actively maintaining CCD temperatures at their nominal set points, and the Nadir diffuser wheel assembly is in its open position. In this mode OMPS is fully capable of generating science and calibration data.

The frequency and scheduling of OMPS routine science and calibration activities is configurable -- and under the control and management of the OMPS science and calibration teams.

4.112.3 Mission Data

The mission data products and APIDs that the OMPS instrument produces are dictated by uploadable FSW tables. OMPS produces either compressed or uncompressed nominal EV packets, diagnostic EV packets, nominal calibration packets, or diagnostic calibration packets. Additionally the nominal and diagnostic EV data can be either reduced or full frame. Reduced frame data is obtained by loading timing patterns on OMPS to select a subset of pixels from each CCD to read into FSW memory, saving CCD read-out time. Table 4.112.3-1 shows the APIDs that are produced for each of these data types.

It is expected that OMPS will produce nominally APIDs 608 and 609 (compressed and reduced frame) for the Nominal EV RDRs. The highest time stamp frequency for nominal EV RDRs is 1.25 seconds for Total Column and 7.5 seconds for Nadir Profiler.

Table 4.112.3-1 OMPS Data Type to APID Mapping

Packet Type	Uncompressed		Compressed	
	TC	NP	TC	NP
Nominal EV	560, 592	561, 593	616, 608	617, 609
Diagnostic EV	576, 596	577, 597	620, 612	621, 613
Nominal Calibration	564	565	624	625
Diagnostic Calibration	580	581	627	628

4.112.3.1 *OMPS Compression*

As previously stated, The OMPS instrument has the capability of being configured via FSW table uploads to perform on-board data compression. OMPS FSW implements lossless Rice compression algorithm (szip version 1.5). When an OMPS image profile is selected for an imaging operation, the APID associated with that profile becomes available to the OMPS FSW. This APID is used by the FSW to determine whether or not to compress the data.

Per BATC System Engineering Report IN0092SYS2-712 “JPSS-1 OMPS Data Compression Study”, the configuration parameters that OMPS uses with szip software are the following:

- 256 pixels per scanline
- 32 bits per pixel
- 32 pixels per block
- Option mask set to (NN_OPTION_MASK | MSB_OPTION_MASK) (0x110000).

OMPS image files can have an extra byte added to the end of them in order to make the whole image CCSDS packet (header & data) an even number of bytes (per the Data Format Requirements Document). Two bytes (to preserve odd/even byte count) are added to the very beginning of the compressed image file. These two bytes either contain 0xEEEE if an extra byte was added to the end of the file, or 0x0000 if an extra byte was not added. The two bytes at the beginning of the compressed image file, as well as the extra byte at the end, need to be removed before the image data file is run through the decompression utility.

4.112.3.2 *OMPS Mission Data Formatting*

The OMPS telemetry transferred via the MIL-STD-1553B bus consists of grouped packets that use the Consultative Committee for Space Data Systems (CCSDS) Path Protocol Data Unit format described in the JPSS-1 Data Formats Requirement Document (472-00244) and in section 4.0. 472-00331 JPSS-1 OMPS Mission Data Packet Structures documents the detailed packet structure and user field content.

The first packet of a group has a primary header containing three 16-bit words (one 16-bit word = 2 octets) and a secondary header containing a four-word UTC time code, a one-byte field denoting the number of packets in the group and a spare field. The OMPS formats the time of packet generation consistent with Table 4.0.1 in the secondary header. The time in the secondary header is not the time of observation for packets with CCD data; see the explanation below to derive the observation time. The middle and last packets of a group have only the three-word primary header. Because CCD images can be too large for a single group of 256 packets, the OMPS packets have an OMPS Header inside the User Data Zone of the first packet in each group to work around the CCSDS 8-bit limit on specifying the number of packets. The OMPS Header contains the version number, the number of grouped packets remaining in the CCD image (Continuation Count), and a Continuation Flag set to 0 if the packet is the first of a group and set to 1 if the first packet is not the first of a multiple packet group. The largest OMPS images require five groups of packets. For these packets, the Continuation Count in first packet of the first group is set to 4 and the Flag is set to 0. The Continuation Count in the first packet of the second group is set to 3, but the flag is set to 1. The Continuation keeps decreasing to 0 by the fifth and final first packet and the Continuation Flag remains 1 in those packets. The CCSDS packet sequence counter increments continuously, so the first packet of the second group will have a CCSDS sequence count one greater than the last packet of the first group. Since the data in multiple grouped packets belong to a single CCD image, the secondary header timestamps are identical in all of the first packets in a multiple grouped packet. Examples of how the OMPS headers are utilized for three different sized OMPS images are provided below. All fields in the OMPS data packets are big endian.

- **Primary CCSDS Headers Items (6 bytes)**
  - **APID:** indicates the packet APID. This value describes the type of RDR being generated.
    - **X** indicates the APID value for this packet
  - **Sequence:** indicates the sequence type of this packet. This value describes whether this is the first, middle or last segment of the packet sequence. A sequence type of standalone indicates a non-segmented packet.
  - **Seq. Num:** A one-up packet sequence counter, relative to the previous CCSDS packet associated with this APID. Unique counters are maintained for each APID. The sequence counters are initialized to 0 at OMPS power-on and rollover occurs based on a 14 bit value (i.e. counter range of 0 – 16383).

  - **CNT(X)** indicates the packet sequence count for each of the APIDs that have been received

- **Secondary Header Items (10 bytes)**
  - **Num. Pkts:** indicates the number segmented packets that comprise the RDR. Since this item is limited to a 1-byte value it will always be 255 or less. This value will be total number of middle and last packets for this packet sequence.
  - **N** indicates the total number of segmented packets for this RDR
  - **Spare Byte:** The 1553 IRD requires that this value is always set to 0 and is not used by the instrument.

- **Secondary Header Items – OMPS specific (4 bytes)**
  - **Cont. Count:** An OMPS specific value that aids in de-packetization of RDRs which are of the large type (i.e. case 3). This item contains a value indicating how many packet sequences or “chunks” (aka super-segmented) will follow.
    - **C** indicates the number of packet sequences that are required for the RDR
  - **Cont. Flag:** An OMPS specific value that aids in de-packetization of RDRs which are of the large type (i.e. case 3). This value indicates whether the packet is a continuation of the previous packet sequence or “chunk”.

- **Non-Header Item Definition**
  - **S** indicates the number of actual downlinked data bytes in the RDR (i.e. not including the Header data) . **Note:** Per 1553 IRD Requirement, the maximum size for CCSDS packets is 1024 bytes. The amount of actual data contained in the packet depends on which headers are included. Packets requiring all headers (i.e. Primary, Secondary and OMPS Specific) contain a maximum of 1004 bytes of actual data. Packets which require only the Primary Header contain a maximum of 1018 bytes of actual data.

First case: small RDR (of data size **S** <= 1004 bytes), with APID **X**, standalone packet. Standalone packets do not required segmentation and the header item Num Pkts does not require a value.

	Primary CCSDS Header							Secondary CCSDS Header			OMPS-Specific Sec. Header	
	Forced by CCSDS	Type	Secondary Header Flag	APID	Sequence	Seq. Num [0-16383]	Packet Length	CCSDS Time Code	Num of Pkts. (Byte #1)	Spare (Byte #2)	Cont. Count	Cont. Flag
FIRST	000	0	1	X	STANDALONE	CNT(X)	X	X	0xFF	0	0	0

Second case: medium RDR (of data size 1004 < S <= 260,594 bytes), with APID X, segmented into N packets (1 < N <= 256). Medium RDRs require packet segmentation but do not require multiple CCSDS packet sequences.

	Primary CCSDS Header							Secondary CCSDS Header			OMPS-Specific Sec. Header	
	Forced by CCSDS	Type	Secondary Header Flag	APID	Sequence	Seq. Num [0-16383]	Packet Length	CCSDS Time Code	Num of Pkts. (Byte #1)	Spare (Byte #2)	Cont. Count	Cont. Flag
Segnented	000	0	1	X	FIRST	CNT(X)	X	X	N-1	0	0	0
	000	0	0	X	MIDDLE	CNT(X)+1	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	X	MIDDLE	CNT(X)+2	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	…	…	…	X	…	…	…	…	…
	000	0	0	X	LAST	CNT(X)+(N-1)	X	N/A	N/A	N/A	N/A	N/A

Third case: large RDR (of data size S > 260,594 bytes), with APID X, segmented into N packets (N > 256). Each RDR requires a total of "C" segmented CCSDS packet sequences. Each CCSDS packet sequence is referred to as a "chunk" (aka super-segmented) for notational convenience. Large RDRs require packet segmentation and multiple CCSDS packet sequences.

	Primary CCSDS Header							Secondary CCSDS Header			OMPS-Specific Sec.	
	Forced by CCSDS	Type	Secondary Header Flag	APID	Sequence	Seq. Num [0-16383]	Packet Length	CCSDS Time Code	Num of Pkts. (Byte #1)	Spare (Byte #2)	Cont. Count	Cont. Flag
FIRST chunk	000	0	1	X	FIRST	CNT(X)	X	X	255	0	C - 1	0
	000	0	0	X	MIDDLE	CNT(X)+1	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	X	MIDDLE	CNT(X)+2	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	…	…	…	X	…	…	…	…	…
	000	0	0	X	LAST	CNT(X)+ 255	X	N/A	N/A	N/A	N/A	N/A
NEXT chunk	000	0	1	X	FIRST	CNT(X) + 256	X	X	255	0	C - 2	1
	000	0	0	X	MIDDLE	CNT(X)+ 257	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	X	MIDDLE	CNT(X)+ 258	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	…	…	…	X	…	…	…	…	…
	000	0	0	X	LAST	CNT(X)+ 511	X	N/A	N/A	N/A	N/A	N/A
NEXT	000	0	1	…	…	…	X	…	…	…	…	…
LAST chunk	000	0	1	X	FIRST	CNT(X)++	X	X	N-((C-1)*256)-1 "Number of remaining packets in the last "chunk" minus one"	0	0	1
	000	0	0	X	MIDDLE	CNT(X)++	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	X	MIDDLE	CNT(X)++	X	N/A	N/A	N/A	N/A	N/A
	000	0	0	…	…	…	X	…	…	…	…	…
	000	0	0	X	LAST	CNT(X)+ (N-1)	X	N/A	N/A	N/A	N/A	N/A

NOTE: All timestamps contained within the CCSDS secondary headers of an RDR in the Third Case example above will have the same time.

Every OMPS image comes from an image profile. The image profile number and any associated timing pattern, sample table, linearity correction table, and gain correction table are reported in OMPS image packets. The OMPS uses sample tables to bin CCD pixels into macro-pixels and to exclude bad pixels. If all the CCD pixels in a given macro-pixel go bad on orbit, the number of macro-pixels in the OMPS CCD data may be reduced, changing the size of the OMPS CCD data within any of the OMPS science, calibration, and diagnostic packets. It is also possible for the packets to contain all CCD pixels with no binning by a sample table. When a sample table is not used, the CCD data are framed in the packet by four-octet Hardware (HW) Start and End Tags, defined in Table 4.112.3-2 . The CCD images described below are those baselined by OMPS at the time of delivery for JPSS-1 integration. The size of the packets can be expected to change on-orbit due to changes in the sample table. Since calibration and diagnostic packets contain multiple types of images, each with a different size, a generic description is given for them and the size is left indefinite.

Table 4.112.3-2 OMPS Hardware Tags

Image Type	APIDs	Start Tag	End Tag
Nadir Total Column (TC)	560, 564, 576, 580, 592, 596, 608, 612, 616, 620, 624, 627	0x81000000	0xC1000000
Nadir Profiler (NP)	561, 565, 577, 581, 593, 597, 609, 613, 617, 621, 625, 628	0x82000000	0xC2000000

The information necessary to determine the precise timing of all the coadded frames in an image is a combination of the "xx_LAST_IMG_yy" mnemonic values in the header (which are the precise timestamp of when the OMPS FSW received the image from the low-level imaging electronics) and information about the specific timing pattern which was used to generate this image data. By knowing the specific timing pattern used to generate the image data, one can then use a look-up table to determine the specific time differential between when the FSW set the values in the "xx_LAST_IMG_yy" mnemonic values, and when each of the individual frames that make up the coadded image were obtained. Timing pattern details are documented in IN0092SYS2-104, OMPS-J1 Timing Pattern Definition.

4.112.3.3 *Science Data*

The JPSS-1 OMPS produces two science data packets (at a time) described below: Nadir Total Column Earth View and Nadir Profile Earth View. Each packet contains the health and status telemetry that is required to process the CCD data followed by CCD data.

4.112.3.3.1 Nadir Total Column

The Nadir TC uses both halves of the CCD. The TC image is aligned with the spectral dimension in columns (each column corresponds to a different spectral wavelength) and the spatial dimension in rows (each row corresponds to a different cross-track spatial location). The TC produces useful data from almost all of the CCD rows, but uses only about two thirds of the columns. The data is temporally co-added and binned in the spatial dimension. The number of pixels required in the spatial dimension is derived from the minimum horizontal cross-track FOV of 110 degrees. The number of pixels in the spectral dimension is based on the required spectral range, the spectral scale of the instrument, the uncertainty in the spectral scale, and the alignment of the focal plane to the spectral range. See "OMPS CCD Reference Figures" for explanation of the pixel binning and alignment.

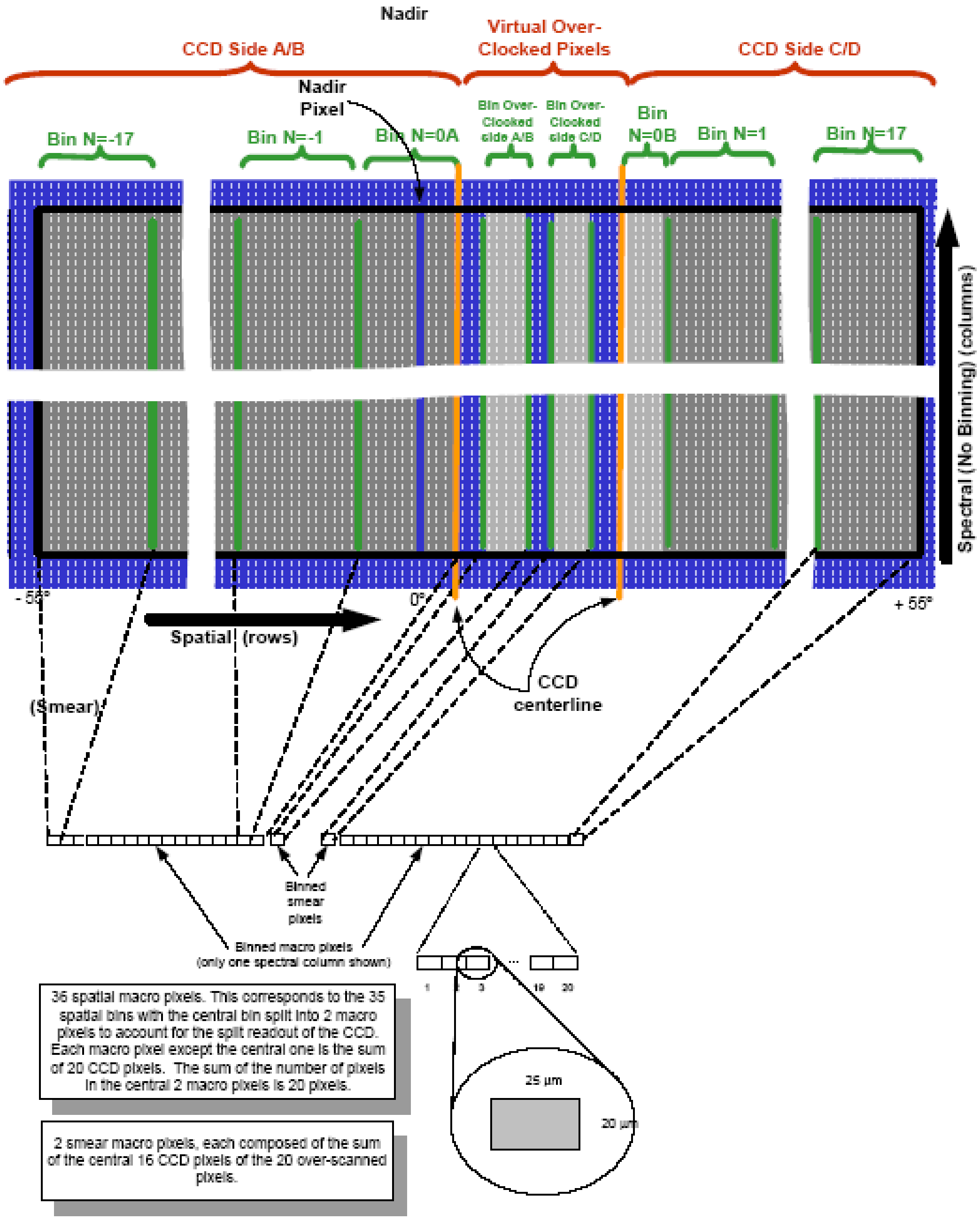

Figure 4.112-2 (For Reference Only) OMPS Total Column On-Orbit Windowing and Spatial Binning

The TC image is taken from the active area of the CCD image. Binning is performed in the spatial dimension centered about the nadir pixel column. The nadir row is determined based on instrument to spacecraft mounting alignment. There is one over- clocked bin generated for each half of the CCD. See Figure 4.112-2.

The OMPS outputs the Nadir Total Column packet (APID 560, 592, 608, or 616) in one grouped packet containing multiple 1024-byte CCSDS packets. The Nadir TC Nominal EV packet that is generated depends on the configuration of the OMPS instrument. It is expected that it will nominally be configured to generate the compressed reduced frame packet (APID 608).
The packet is generated approximately every 1.25 seconds.

4.112.3.3.2 Nadir Profiler

The Nadir Profiler (NP) only uses one half (the A/C half) of the CCD and is aligned the same way as the TC with the spectral dimension in columns and spatial dimension in rows. Each column corresponds to a different spectral wavelength and each row a different spatial location. The number of pixels that are required in the spatial dimension is derived from the 250 km swath width requirement. The number of pixels in the spectral dimension is based on the required spectral range, the spectral scale of the instrument, the uncertainty in the spectral scale, and the alignment of the focal plane to the spectral range. See "OMPS CCD Reference Figures" for explanation of the pixel binning and alignment.

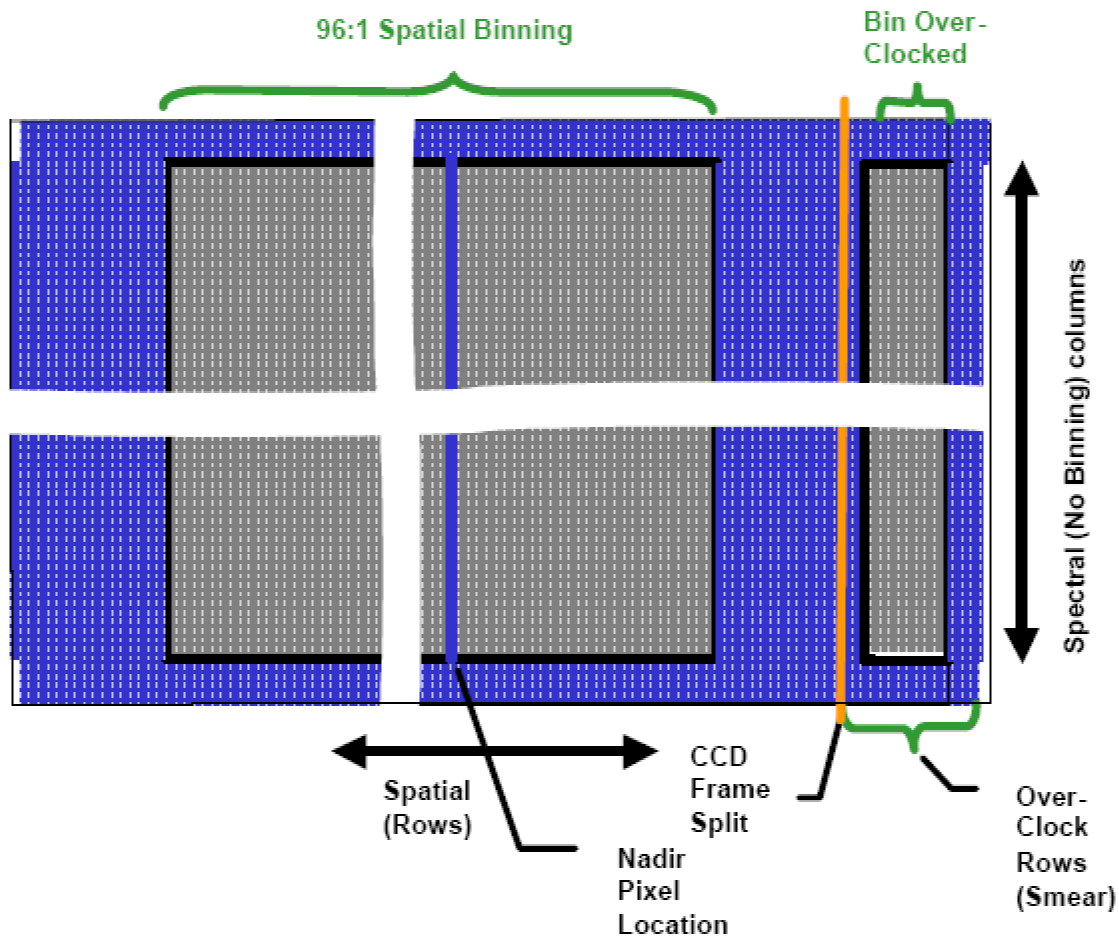

Figure 4.112-3 (For Reference Only) OMPS Nadir Profile On-orbit Windowing and Spatial Binning

The NP image data is taken from the light sensitive portion of the CCD. Binning is performed in the spatial dimension centered about the nadir pixel row. Again, the nadir row is determined based on instrument to spacecraft mounting alignment. There is no binning in the spectral dimension. There is one over-clocked bin generated for the half of the CCD in use. The center rows are binned spatially with no binning of spectral over- clocked rows. See Figure 4.112-3.

The OMPS outputs the Nadir Profiler data (APID 561, 593, 609, or 617) in one grouped packet containing multiple 1024-byte CCSDS packets. The Nadir Profiler Nominal EV packet that is generated depends on the configuration of the OMPS instrument. It is expected that it will nominally be configured to generate the compressed reduced frame packet (APID 609).
The packet is generated approximately every 7.5 seconds.

4.112.3.4 *Calibration Data*

The OMPS has three calibration packet formats, one for each CCD. Each packet produced contains a single CCD image. During calibration orbits, the OMPS produces multiple packets of each type. Solar, linearity and dark current calibration measurements are made for each CCD. The solar images measure the spectral and radiometric response of the CCD. Each type of calibration requires multiple images of varying sizes. The quantity, size and duration of the calibration images is configurable.

Because the diffuser takes up only a portion of the total Nadir Column field of view, seven overlapping images are necessary to complete the Nadir Column radiometric/spectral calibration. The Nadir Profiler radiometric/spectral calibration is obtained when the diffuser is in the middle position of the seven Nadir Column images. Dark current and two linearity images for each spectrometer/CCD follow when the OMPS is in the shadow of the Earth.

4.112.3.4.1 Nadir Total Column Calibration

The OMPS produces Nadir Total Column collects its nominal calibration data in APID 564 (uncompressed) or APID 624 (compressed). Because the solar, linearity and dark current calibrations require different image sizes, APID 564 can be a variable-sized grouped packet. . It is possible but not expected for APID 564 and APID 624 to be a single standalone packet.

4.112.3.4.2 Nadir Profiler Calibration

The OMPS produces Nadir Profiler collects its nominal calibration data in APID 565 (uncompressed) or APID 625 (compressed). Because the solar, linearity and dark current calibrations require different image sizes, APIDs 565 and 625 can be a variable-sized grouped packet. . It is possible but not expected for APIDs 565 and 625 to be a single standalone packet.
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4.112.3.5 *Diagnostic Data*

Each Science and each Calibration packet have a corresponding Diagnostic packet. These seven packets are configurable and facilitate sensor performance and calibration investigations. The Diagnostic Nadir Total Column packet is output in APID 576, 596, 612, or 620 (depending on the instrument configuration). The Diagnostic Nadir Profiler packet is output in APID 577, 597, 613, or 621 (depending on the instrument configuration). The Diagnostic Nadir Total Column Calibration packet is output in APID 580 (uncompressed) or 627 (compressed). The

Diagnostic Nadir Profiler Calibration packet is output in APID 581 (uncompressed) or 628 (compressed).

4.112.3.6 *Dwell Data*

The OMPS can be commanded to produce a packet with dwell telemetry once per second. Each dwell packet contains 16 telemetry points sampled at the same rate that engineering data are collected but output more often than engineering data. The OMPS Dwell Telemetry packet, APID 549, has a fixed length of 244 octets.

4.112.3.7 *Memory Dump*

Upon command, the OMPS outputs up to 4 Mbytes of either volatile (RAM) or non-volatile (Flash) memory (NVM). The “Packets in RDR” field in the grouped packet secondary header is an 8 bit field and therefore limits the number of CCSDS packets in a group to 256. Therefore, the maximum memory or table data that can be dumped in a grouped packet is 260594 octets. It will take 17 grouped packets (4,219,290 bytes including all headers) to dump the maximum 4,194,304 bytes of memory. For dumps large enough to require multiple grouped packets, the “Cont Count” field indicates the number of *grouped* packets (-1) remaining in the dump. The timestamp in the secondary header represents the time the first packet is generated. If multiple grouped packets are required, the first packet of each group contains a timestamp identical to the first packet. Additional detail on the OMPS memory dump content and structure is provided in 472-00256 OMPS Table Description Document (TDD).

4.112.3.8 *Test Telemetry*

When commanded, OMPS will generate one fixed Test Telemetry packet every 5 seconds until disabled by command. The Test Telemetry packet consists of a packet header with APID 546 and a fixed data pattern of 250 ‘CC’ hex characters for a total of 256 bytes.

4.113 VIIRS

4.113.1 Introduction

The VIIRS Sensor is a nadir viewing, cross-track observing, continuously operating electro-optical imaging sensor and is designed to operate in a circular sun-synchronous orbit with an inclination of approximately 98 degrees relative to the equator. It collects Earth and atmospheric scene spectral radiance in 22 channels spanning the visible through IR regions and sends these data to the JPSS-1 spacecraft for transmission to the ground. The 22 channels include 16 moderate resolution bands (of 16 detectors each), 5 imaging resolution bands (which have twice the resolution of the moderate resolution bands), and a Day Night Band (DNB). Some of the moderate channels are dual gain and are capable of measurement within two discrete ranges of radiance. The DNB obtains imagery throughout both the day and night portions of the orbit. The VIIRS flies in a sun synchronous orbit that provides the along track component of the image. The cross track scan is implemented using optics and a rotating telescope as indicated in Figure 4.113-2.

Figure 4.113-1 illustrates the VIIRS Sensor from a downward-viewing perspective showing the mounting surfaces. As shown, the Sensor consists of two modules separately mounted to the spacecraft. The Opto-Mechanical Module contains all of the optical and mechanical assemblies required to collect Earth and calibration data including scanning optics, focal planes, and calibration sources. The Electronics Module provides all of the electrical interfaces to the JPSS-1 spacecraft. In response to spacecraft commands, it controls the VIIRS configuration, operates the mechanisms in the Opto-Mechanical Module and collects and formats the data from the focal planes and transmits it to the spacecraft. The Electronics module bolts to a nadir-facing Spacecraft cold plate (not shown) and the OMM attaches to the spacecraft nadir deck via four flex-mounts seen in Figure 4.4-1.

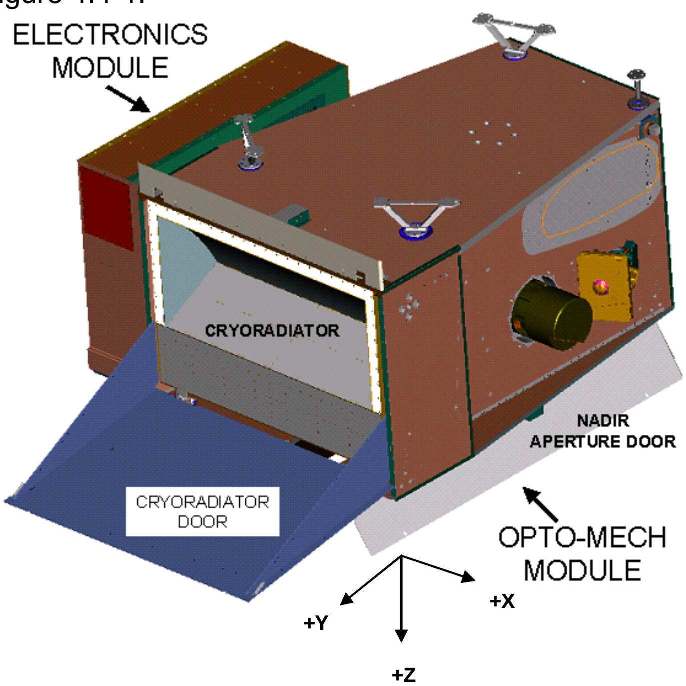

Figure 4.113-1 VIIRS Sensor ANTI-Solar/Travel-Direction Sides & OMM Interface Mounts

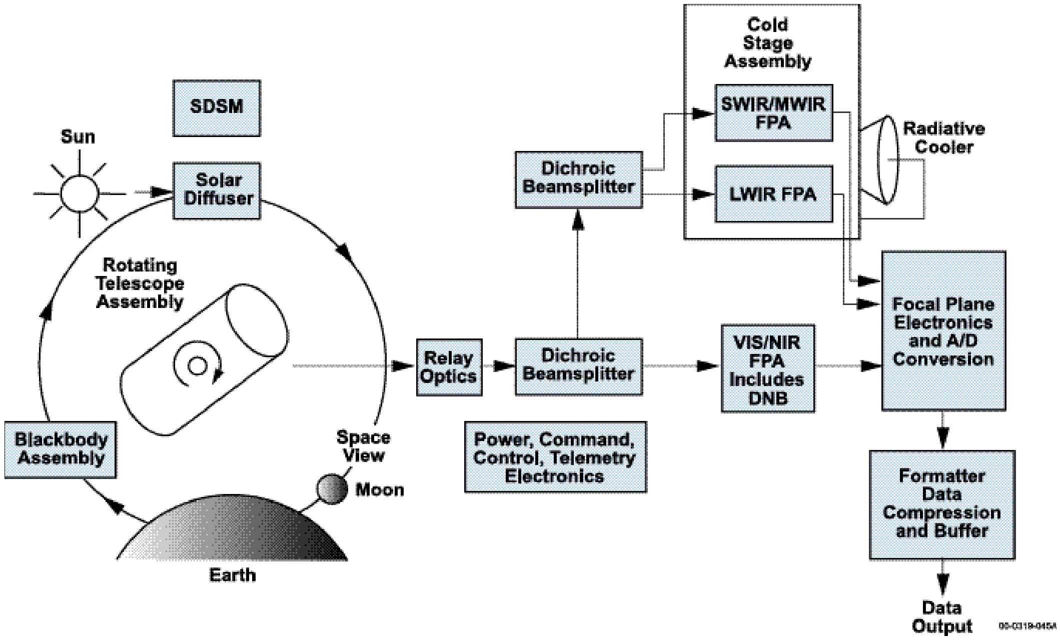

Figure 4.113-2 VIIRS Simplified Design Concept

The scanning optics sweep the linear detector over the earth collecting of 22 coincident swaths of data (one per band), 16 or 32 samples wide. The scan interval is synchronized with the spacecraft motion so that the swaths of data taken on successive scans do not leave gaps in coverage on the Earth's surface. The moderate resolution and Day Night bands have 16 detectors and the imaging bands have 32 detectors arranged in an along-track linear configuration. The nominal 1.7864 second scan interval is synchronized with the satellite motion so that the swaths of data taken on successive scans do not leave gaps in coverage on the Earth's surface.

The processed VIIRS data produce the following EDRs:

- Imagery
- Sea Surface Temperature
- Aerosol Optical Thickness
- Aerosol Particle Size
- Suspended Matter
- Cloud Base Height
- Cloud Cover/Layers
- Cloud Effective Particle Size
- Cloud Optical Thickness
- Cloud Top Height
- Cloud Top Pressure

- Cloud Top Temperature
- Surface Albedo
- Land Surface Temperature
- Sea Surface Temperature
- Vegetation Index
- Snow Cover Fraction
- Snow Cover Binary Map
- Surface Type
- Ice Surface Temperature
- Net Heat Flux
- Ocean Color/Chlorophyll
- Sea Ice Characterization

4.113.2 Modes and Packet Structure

VIIRS has 9 Sensor Modes to support JPSS-1 mission operations. The modes and most common transitions are illustrated by the Figure 4.113-3. The spacecraft controls entry and exit of the first three modes. The remaining modes are established by a single bus Mode command.

Note, “Sensor Modes” is used as the modes title instead of “Operational Modes,” in order not to cause interpretation conflict with the “OPERATIONAL DAY/NIGHT” mode.

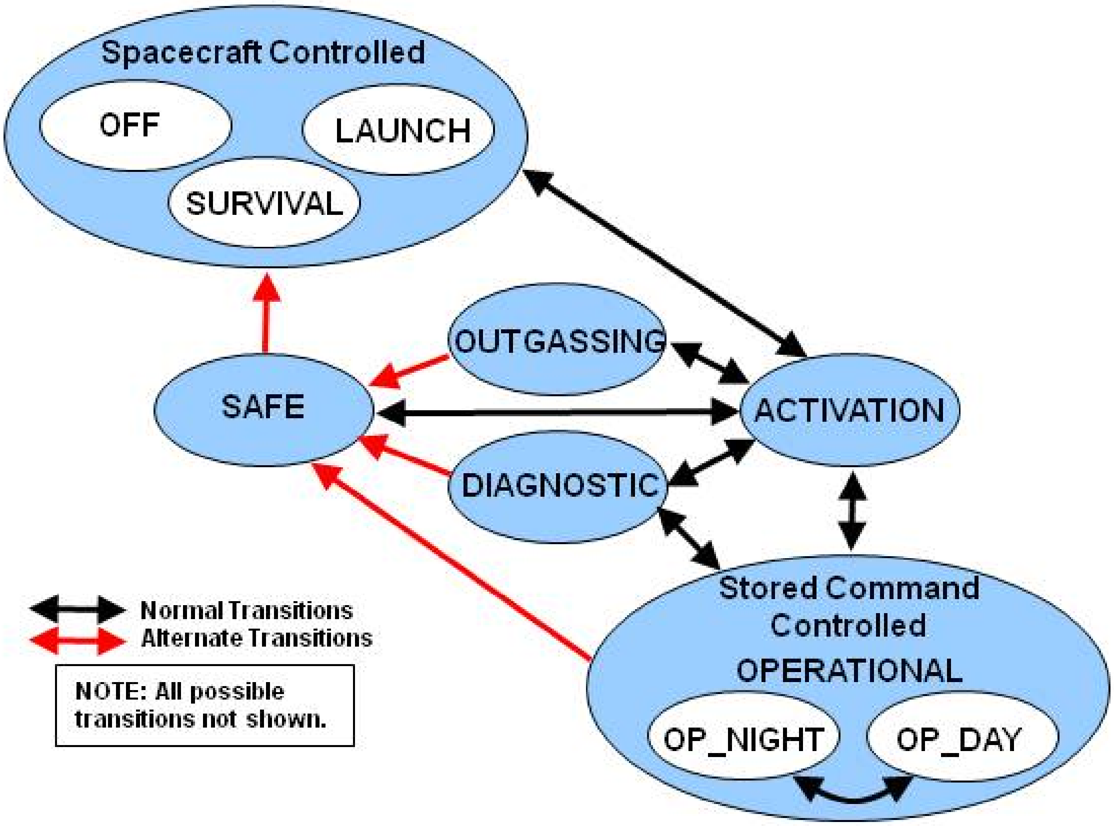

Figure 4.113-3 VIIRS Sensor Mode Transition Diagram

VIIRS outputs six types of packets unique to the X-band. Science, Calibration and Engineering packets are transmitted when in Operational Mode and Diagnostice mode with the RTA Scanning. Memory Dump packets are available in every mode including Activation, Outgassing, and Safe modes. Housekeeping telemetry is available in every mode (in diagnostic mode it is called Diagnostic Housekeeping Telemetry and has a different APID). Unique APIDs are assigned to each packet to enable them to be identified by source (instrument, ground segment, or spacecraft), instrument mode, and type of data. The contents, and in some cases the internal structure of the packets differ depending on the source and mode. Table 4.113.2-1 lists all VIIRS mission data APIDs. The packet assignment to HRD and SMD is configurable and may change throughout the mission.

1. HRD
2. Telemetry
3. Calibration
4. Engineering
5. Memory Dump
6. LEO&A
7. Test

The VIIRS packets are sent out in three different groups, and the packet order between the groups is non-deterministic. The first group is the telemetry packet group with the Housekeeping packet.

The second group is the Science data that consists of the Engineering packet, followed by HRD (band) packets, and ends with the Calibration packet. These packets are sent out in order of the DPP band processing table order. The third group is Memory Dump packets.

Table 4.113.2-1 VIIRS Mission Data Packet Types

AP ID	Telemetry Packet Name	Data Rate (bps) by Mode		Packet Size (octets), Note 8
		Operational	Diagnostic	
768	Housekeeping, Note 7	Note 7	Note 7	Note 7
769	LEO&A Housekeeping, Note 7	Note 7	Note 7	Note 7
770	Test Packet	--	1146.4	256
773	Diag Housekeeping Tlmy, Note 7	--	1997.3	446
780	Mem Dump	--		Up to 4196524
800	HRD Operational (Day Only) – M4	variable*	--	177016*
801	HRD Operational (Day Only) – M5	variable*	--	177016*
802	HRD Operational (Day Only) – M3	variable*	--	177016*
803	HRD Operational (Day Only) – M2	variable*	--	177016*
804	HRD Operational (Day Only) – M1	variable*	--	177016*
805	HRD Operational (Day Only) – M6	variable*	--	86656*
806	HRD Operational – M7	variable*	--	177016*
807	HRD Operational (Day Only) – M9	variable*	--	86656*
808	HRD Operational – M10	variable*	--	86656*
809	HRD Operational – M8	variable*	--	86656*
810	HRD Operational– M11	variable*	--	86656*
811	HRD Operational – M13	variable*	--	177016*
812	HRD Operational – M12	variable*	--	86656*
813	HRD Operational – I4	variable*	--	340412*
814	HRD Operational – M16	variable*	--	86656*
815	HRD Operational – M15	variable*	--	86656*
816	HRD Operational – M14	variable*	--	86656*
817	HRD Operational – I5	variable*	--	340412*
818	HRD Operational (Day Only) – I1	variable*	--	340412*
819	HRD Operational (Day Only) – I2	variable*	--	340412*
820	HRD Operational (Day Only) – I3	variable*	--	340412*
821	HRD Operational - DNB	variable*	--	124756*
822	HRD Operational, Note 3 – DNB MGS	Variable*	--	124756*
823	HRD Operational, Note 3 – DNB LGS	Variable*	--	124756*
824	HRD Operational Test, Note 4	Note 4	--	Note 4
825	HRD Operational Calibration	Variable*	--	188806*†
826	HRD Oper Engineering, Note 2	41,728.6	--	9318

AP ID	Telemetry Packet Name	Data Rate (bps) by Mode		Packet Size (octets), Note 8
		Operational	Diagnostic	
827	HRD Operational, Note 3 – DNB HGA	Variable*	--	124756*
828	HRD Operational, Note 3 – DNB HGB	Variable*	--	124756*
830	HRD Diagnostic – M4, Note 5	--	283655.7	46292
831	HRD Diagnostic – M5, Note 5	--	283655.7	63316
832	HRD Diagnostic – M3, Note 5	--	283655.7	63316
833	HRD Diagnostic – M2, Note 5	--	283655.7	63316
834	HRD Diagnostic – M1, Note 5	--	283655.7	63316
835	HRD Diagnostic – M6, Note 5	--	283655.7	63316
836	HRD Diagnostic – M7, Note 5	--	283655.7	63316
837	HRD Diagnostic – M9, Note 5	--	283655.7	63316
838	HRD Diagnostic – M10, Note 5	--	283655.7	63316
839	HRD Diagnostic – M8, Note 5	--	283655.7	63316
840	HRD Diagnostic – M11, Note 5	--	283655.7	63316
841	HRD Diagnostic – M13, Note 5	--	283655.7	63316
842	HRD Diagnostic – M12, Note 5	--	283655.7	63316
843	HRD Diagnostic – I4, Note 5	--	1117007.4	249332
844	HRD Diagnostic – M16, Note 5	--	283655.7	63316
845	HRD Diagnostic – M15, Note 5	--	283655.7	63316
846	HRD Diagnostic – M14, Note 5	--	283655.7	63316
847	HRD Diagnostic – I5, Note 5	--	1117007.4	249332
848	HRD Diagnostic – I1, Note 5	--	1117007.4	249332
849	HRD Diagnostic – I2, Note 5	--	1117007.4	249332
850	HRD Diagnostic – I3, Note 5	--	1117007.4	249332
851	HRD Diagnostic – DNB, Note 5	--	283655.7	63316
852	HRD Diagnostic – DNB MGS, Note 5	--	283655.7	63316
853	HRD Diagnostic – DNB LGS, Note 5	--	283655.7	63316
854	HRD Diagnostic Test, Note 4	--	Note 4	Note 4
855	HRD Diag Calibration, Note 5	--	578300.0	185782
856	HRD Diag Engineering, Note 5	--	41,728.6	9318

1. VIIRS is allocated 249 decimal integer APIDs 650 – 899. Table is by APID sequence. Presently 158 Spares. Only those APIDs unique to mission data stream are shown.
2. HRD Operational in compressed form except Engineering.
3. Packet size same as normal DNB data. DNB MGS, LGS and HGS Science Data is only transmitted in Operational-Night mode if DNB packets are set to SEND.
4. Not used and therefore is not routed to a virtual channel but is reserved. Fixed test packets upon command occur in assigned Operational & Diagnostic band packets with Header Test Flag. See VIIRS Command, Telemetry, Science & Engineering Data Description for description.

5. HRD Diagnostic not compressed. With the exception of the Diagnostic Engineering Packet, these packets sizes (and therefore the rates) are configurable via Table ID 7 upload. Sizes reflect the maximum packet size.
6. LRD Operational not on Flight 1. Compressed by Spacecraft except Engineering.
7. Documented in the JPSS-1 Command & Telemetry Database and Handbook
8. Packet sizes include all octets in a grouped packet. VIIRS Operational and Diagnostic packets are grouped by design. See the respective sections for the size of each packet within the group.

* The Operational packets sizes and data rates are variable due to compression. The table lists the size with all fields uncompressed.

† The Calibration Packet content and size changes between Day and Night Modes. The size listed in the Table is the larger Night size. In Day Mode, the group of 24 uncompressed packets is 186118 octets.

4.113.2.1 *Off Mode and Launch Mode*

The VIIRS is in Off Mode when no external power is applied. The sensor performs no functions. It is not recommended to ever place VIIRS in Off mode as this would mean that neither Operational power nor Survival power is being provided to VIIRS. Spacecraft provided Stow power would still be recommended to hold the RTA in its stowed, anti-nadir position, but will only be utilized if Stow power control had been passed to the Spacecraft (i.e. if we transitioned through Safe mode). The only telemetry that is available during Off mode is the point to point, passive telemetry.

If VIIRS enters Off mode as the result of a SC Sudden Removal of Power, then the spacecraft will enable the VIIRS Survival Heaters within 60 seconds of VIIRS Operational power removal; this activity places VIIRS in Survival mode.

From Off mode, VIIRS may transition to Survival mode (preferred), by applying Survival power, or to Activation mode by applying Operational Power. If the passive telemetry checks indicate (red) Alarms, VIIRS must first transition to Survival mode to allow the sensor to warm up.

The Launch Mode describes the state of the VIIRS with nadir aperture and cryoradiator doors latched, launch locks applied and no power applied. Once activated after Launch Mode, the VIIRS is not expected to transition to Off mode but may do so by removing all power.

4.113.2.2 *Survival Mode*

If VIIRS is being transitioned to Survival mode from Safe mode, the RTA motor winding control has already been given to the SC Stow power and the RTA will remain in its stowed, anti-nadir position. All volatile memory will be lost with the removal of Operational power; ensure all desired table or memory dumps are completed before transitioning to Survival mode.

Upon removal of Operational power and provided that Survival power is still being supplied by the Spacecraft, VIIRS enters Survival mode. If this was a sudden removal of power the RTA may not be properly stowed which could lead to a possible sun stare condition (not recommended). The only telemetry available during Survival mode is the point to point, spacecraft provided, passive telemetry.

From Survival Mode, VIIRS may transition to Activation Mode (preferred) or Off Mode (not recommended).

4.113.2.3 *Activation Mode*

The VIIRS enters Activation Mode when Operational power is applied to the sensor. VIIRS Sensor may also be commanded into Activation Mode from any other powered mode. The telescope does not rotate during Activation Mode so no Science Data is being produced. Housekeeping telemetry is output to indicate the state of the sensor. In Activation mode, the VIIRS power supply is configured so that all Operational and CFPA Heaters, thermostatic controls, and Health and Status telemetry are available. From Activation Mode, VIIRS may transition to any other mode.

4.113.2.4 *Outgassing Mode*

The VIIRS sensor is placed into Outgassing Mode from Activation Mode by a single bus mode command. This mode is used to decontaminate certain mechanical or optical elements of the sensor. Housekeeping telemetry is output but the telescope remains in a stowed position so no mission data are output. When Outgas mode is commanded, which may only be commanded from Activation mode, all Operational Heaters are off; the set points are not changed. All Health and Status telemetry is available. The outgas heaters of the VIIRS Power Supply are not automatically enabled with the transition to Outgas mode and must be enabled separately.

From Outgas Mode, VIIRS may transition to Activation Mode (preferred) or Safe Mode.

4.113.2.5 *Operational Mode*

Operational Mode is the normal operating condition for the sensor. It has two sub-modes Operational-Day and Operational-Night for the day and night portions of the orbit. All data outputs are on, scene data, engineering and calibration source data are transmitted, and telemetry is monitored and transmitted. As the spacecraft moves through its orbit, commands stored in the Stored Command Table cause the VIIRS to switch between Operational-Night and Operational-Day sub-modes at the appropriate times. This table must be updated by ground commands and table uploads weekly.

The VIIRS outputs all spectral bands in Operational-Day Mode. Operational-Night mode is identical to Operational-Day mode except that, during Operational-Night mode, VIIRS only processes and transmits HRD from 12 of its 22 spectral bands as identified in Table 4.4.3-5 are transmitted. The VIIRS is also capable of transmitting the high, medium and low gain data from Stages 2 and 3 of the Day/Night Band CCD upon command. These data will be formatted in the same manner as other DNB data but in separate APIDs (822-823 / 827-828). The normal Night mode data will continue to be transmitted.

From either Operational mode, VIIRS may transition between Operational-Day and Operational-Night, to Activation mode, Diagnostic mode, or Safe mode.

4.113.2.6 *Diagnostic Mode*

Diagnostic Mode may only be commanded from Activation mode or Operational modes. The Macro Command Table configures the VIIRS Power Supply and does not change the scan / stow status of the RTA (i.e. if transitioning from Activation mode, the RTA will be stowed; if transitioning from Operational modes, the RTA will be scanning). Science Data is not available unless the HAM and RTA are synchronized, and when available, these packets are processed differently and mapped to different APIDs than in Operational modes. All Health and Status telemetry remains available and the Operational and CFPA heaters (and their set points) remain unchanged.

Diagnostic Mode encompasses many sensor configurations necessary to support software updates. It also supports trouble shooting by allowing different sampling of telemetry. Sensor data with little post-processing are output in a distinct set of APIDs from operational mode. The normal post-processing functions can be re-activated upon command to operational mode.

Since the data format is highly varied based on the scene, test patterns can be enabled to fill the data output sequence with one or more chosen standard pixel sequences for each band, in place of the actual detector output data. The known sequence is sent along the sensor electronics, through the formatting, and on to the spacecraft. Ground analysts verify proper operation of the post-processing and formatting functions.

In the Diagnostic mode, the diagnostic housekeeping telemetry data packet replaces the normal housekeeping telemetry packet. The telemetry data is exactly the same in both normal housekeeping and diagnostic housekeeping; only the APIDs are different.

The VIIRS supports software modifications only in Diagnostic Mode with the RTA Stowed.

4.113.2.7 ***Safe Mode***

Under fault conditions sensed by the VIIRS (auto safing enabled) or the spacecraft, the VIIRS turns off collection of science data and stows the telescope within 45 seconds by a call to the Safe Mode Manager. VIIRS can be commanded into Safe mode from any powered mode, but VIIRS will only autonomously transition to Safe if auto safing is enabled and if certain conditions are met. No mission data are output though housekeeping telemetry remains enabled.

Once VIIRS is in Safe mode commanding is restricted to a reduced set of commands. All other non-Safe mode, all time-tagged, and all stored commands (even if it is an allowable safe mode command) will be dropped. In addition, In Safe mode the OBC Black Body (BB) is turned Off and, if appropriate, the setpoint of the HAM and RTA operational heaters is raised. All other heaters remain unchanged.

From Safe mode, VIIRS may transition to Activation mode, or Survival mode.

Table 4.113.2-2 provides the common APIDs received from VIIRS per mode.

Table 4.113.2-2 Common APIDs Received from VIIRS per Mode

Mode	Data Packet Type	APIDs
Activation, Outgas, or Safe	Health and Status Telemetry	768
Diagnostic	Health and Status Telemetry	773
	Engineering*	856
	HRD*	830 – 853
	Calibration*	855
Operational-Day	Health and Status Telemetry	768
	Engineering	826
	HRD	800 - 821
	Calibration	825
Operational-Night	Health and Status Telemetry	768
	Engineering	826
	HRD	800 - 805, 807, 810, 818 - 820, 822† - 823† and 827† - 828†
	Calibration	825

The following Packets are available, independent of bus mode: LEO&A Telemetry (APID 769), Memory Dump (APID 780, only when commanded), and Test (APID 770, only when commanded).

* The RTA and HAM must be synchronized (RTA scanning) for Science Data to be sent in Diagnostic mode.

† DNB packets must be commanded to SEND for these APIDs to be sent

4.113.3 Mission Data

Sensor data is collected from four views - Earth View, Space View, Solar Diffuser, and Blackbody. The VIIRS collects Earth view data in Operational Mode over a field of view that is approximately +/- 56 degrees from nadir, and a reduced FOV for Scanning Diagnostic Mode which can be modified via a Table ID7 upload. The Earth view data is processed and downlinked in the High Rate Data (HRD) packets. The Space View, Solar Diffuser View, and Blackbody View are collected to support instrument calibration and are downlinked in the Calibration Packet.

All SC-VIIRS SpaceWire bus data exchanges are via CCSDS packets. Packet formats comply with the CCSDS Standards, as tailored for JPSS use per the Data Formats Requirements Document. The secondary header timestamp is formatted consistent with Table 4.0.1. It represents the time at the start of the scan, except for Memory Dump packets where it represents the current time the memory dump was generated. All fields are big endian.

472-00335 JPSS-1 VIIRS Mission Data Packet Structures documents the detailed packet structure and user field content.

4.113.3.1 *Science Data*

Science data includes the HRD band packets, the Engineering packet and the Calibration packet and is only available if the Telescope is scanning.

The VIIRS Science Data consists of 24 unique APIDs output during Scanning Diagnostic mode and 23 for Operational mode. There is one APID for each of the five imaging and sixteen moderate resolution bands. The Day Night Band has 5 APIDs to identify three levels of gain settings. The normal DNB packet (APID 821) is the auto selected DNB Gain Stage based on Earth Scene and is output for the full orbit. The packets that output the high, mid and low gain

DNB stages (APIDs 822, 823, 827 & 828) can be enabled via command when VIIRS is in Operational Night mode.

All of the science APIDs have a common format. Each APID contains one scan of data from one band formatted into grouped packets. Each science data grouped packet consists of a First CCSDS Packet, N-1 Middle CCSDS Packets, and a Last CCSDS Packet, where N is the number of detectors associated with the band (16 for Moderate, 32 for Imaging, see Table 4.113.3-2). The First Packet contains metadata associated with the DPP that describes the collect conditions of the data. The Middle and Last Packets contain the actual Earth view detector data. The number of detectors per band is shown in Table 4.113.3-2 and is present in the Number_of_Packets parameter in the Secondary Header of the First packet.

Table 4.113.3-1 shows the instrument bands by type (e.g. visible, IR), by gain characteristics, and lists the predominant noise source for each band. A key element is the gain characteristics of each band (single or dual gain) because this defines other processing. The M16 band uses time delay integration (TDI) of two detectors, M16A and M16B. Its data are sent as a single band in the science and diagnostic packets, but sent separately in the calibration packet.

Table 4.113.3-1VIIRS Science Data Packet Band Information

	Band	λ	Δλ	Gain	Noise Source	Radiance
VIS	M1	0.412	0.020	Dual High	Photon	Reflective
		0.412	0.020	Low	Photon	
	M2	0.445	0.018	Dual High	Photon	Reflective
		0.445	0.018	Low	Photon	
	M3	0.488	0.020	Dual High	Photon	Reflective
		0.488	0.020	Low	ASP	
	M4**	0.555	0.020	Dual High	Photon	Reflective
		0.555	0.020	Low	ASP	
	I1	0.640	0.080	Single	ASP	Reflective
	M5**	0.672	0.020	Dual High	Photon	Reflective
		0.672	0.020	Low	ASP	
	M6	0.746	0.015	Single	Photon	Reflective
NIR	I2	0.865	0.039	Single	Photon	Reflective
	M7*	0.865	0.039	Dual High	Photon	Reflective
		0.865	0.039	Low	ASP	
SWIR	M8*	1.240	0.020	Single	Detector	Reflective
	M9	1.378	0.015	Single	Detector	Reflective
	I3	1.610	0.060	Single	Detector	Reflective
	M10*	1.610	0.060	Single	ASP	Reflective
	M11*	2.250	0.050	Single	Detector	Reflective
MWIR	I4*	3.740	0.380	Single	Detector	Emissive
	M12*	3.700	0.180	Single	Detector	Emissive
	M13*	4.050	0.155	Dual High	Photon	Emissive
		4.050	0.155	Low	ASP	
LWIR	M14*	8.550	0.300	Single	Detector	Emissive
	M15*	10.763	1.000	Single	ASP	Emissive
	I5*	11.450	1.900	Single	Detector	Emissive
	M16*	12.013	0.950	Single	Detector	Emissive
	DNB*	0.7	0.4	Variable	Photon	Reflective

Note: All spectral bands are collected during Operational-Day Mode.
* Indicates the bands output during Operational-Night Mode.
** M4 and M5 Calibration data can still be valid in Operational-Night Mode as long as the sun illuminates the diffuser and DNB packets are set to NOT_SEND. If DNB MGS and LGS packets are commanded to SEND, they will overwrite the M4 and M5 data.
Yellow highlights in Table 4.113.3-1 indicate Imaging bands.

The science data Middle and Last packets contain subfields specifying the location of the first pixel (or sample) in the packet and the number of pixels (or samples) in the packet. This information is not needed when the instrument is in Operational mode. However, in Diagnostic mode, each packet does not contain data corresponding to an entire scan, so the location of the first pixel and number of pixels parameters are needed for displaying and interpreting the data in a packet.

Table 4.113.3-2 VIIRS Gain, Detector, & Bit Summary for Science Data

[1] Band	[2] # of Zero Bits	[3] # of Gain Bits	[4] # of Bits for Data Number	[5] Total Number of Bits	[6] # of Gain Settings	[7] # of Dets/ Band	[8] # of Bits/ Word
M1	2	1	12	15	2	16	13
M2	2	1	12	15	2	16	13
M3	2	1	12	15	2	16	13
M4	2	1	12	15	2	16	13
M5	2	1	12	15	2	16	13
M6	3	0	12	15	1	16	12
M7	2	1	12	15	2	16	13
M8	3	0	12	15	1	16	12
M9	3	0	12	15	1	16	12
M10	3	0	12	15	1	16	12
M11	3	0	12	15	1	16	12
M12	3	0	12	15	1	16	12
M13	2	1	12	15	2	16	13
M14	3	0	12	15	1	16	12
M15	3	0	12	15	1	16	12
M16	3	0	12	15	1	16	12
I1	3	0	12	15	1	32	12
I2	3	0	12	15	1	32	12
I3	3	0	12	15	1	32	12
I4	3	0	12	15	1	32	12
I5	3	0	12	15	1	32	12
DNB (stage1) Most sensitive (low rad / high gain)	0	1 (set “0”)	14	15	NA	16	15
DNB (stage2) (med rad / med gain)	0	2 (set “10”)	13	15	NA	16	15
DNB (stage3) Least sensitive (high rad / low gain)	0	2 (set “11”)	13	15	NA	16	15
DNB MGS All data is med rad / med gain Apply Stage 2	1	0	14	15	NA	16	15

DNB LGS **All data is high rad/low gain** **Apply Stage 3**	1	0	14	15	NA	16	15
DNB HGS, A **All data is low rad/high gain** **Apply Stage 1A**	1	0	14	15	NA	16	15
DNB HGS, B **All data is low rad/high gain** **Apply Stage 1B**	1	0	14	15	NA	16	15

Notes

[1] Column 1 indicates the number of leading bits in the word that are set to 0.

[2] Column 2 indicates the number of bits used to indicate the gain state: 0 for single gain bands, 1 for dual gain bands. If column 6 indicates that there are two gain settings, column 2 must be 1 bit; and, if column 6 indicates that there is one gain setting, column 2 must be 0.

[3] The Mnemonic is the command name, and is limited to 23 characters. Some commands have an applicable selection of states or values. Character count forces the use of 2-character subsystem abbreviations. Redundancy selections are indicated by the _A or _B. Except the PS's are designated PS1 and PS2 to differentiate and emphasize their side ID with their individual power form groups. Frequently in conversations, the terms primary/redundant, Pri/Rdt, A/B or ½ are used without confusion. Values are indicated in various number systems as Binary=bbb, Decimal=ddd and Hexadecimal=hhh. In the case of dual parameters, values of each are shown in a top/bottom selection.

[4] Column 4 indicates the number of bits for the data number.

[5] Column 5 indicates the total number of bits for the band. Total Bits = Zero Bits + Gain Bits + Data Bits

[6] Column 6 indicates the number of gain settings for the band.

[7] Column 7 indicates number of detectors in each band.

[8] Column 8 indicates meaningful band bits before compression and after ground data recovery. For the dual gain bands (bold in the table), the following logic applies to the gain bit. If the gain bit = 0, this is a HIGH State. If the gain bit = 1, this is a LOW State. All DNB bands above Stage 1 are the most significant bit of the 14 bit value.

Table 4.113.3-2 summarizes the characteristics of the data words in each band. All data words are 15 bits in length, however the allocation of the bits between gain and data information depends on the band. The number of detectors in each band is also shown for reference in the table.

To meet the requirements for EDR products, accommodate S/C downlink bandwidth limitations, and compensate for artifacts arising from the scan geometry over the Earth's surface, several types of on-board processing are performed by the instrument electronics. Figure 4.113-4, shows the artifacts of the scanning geometry.

Bow Tie Deletion eliminates redundant data at the edges of successive scans to reduce the data rate. Sample aggregation, the combining of adjacent samples along a scan, reduces overall bandwidth, improves SNR, and matches the IFOV footprints of samples across the scan. Spectral and/or spatial differential encoding of the bands followed by lossless compression reduces the data rate Note: this only applies in Operational Mode. (This is not shown in Figure 4.113-4).

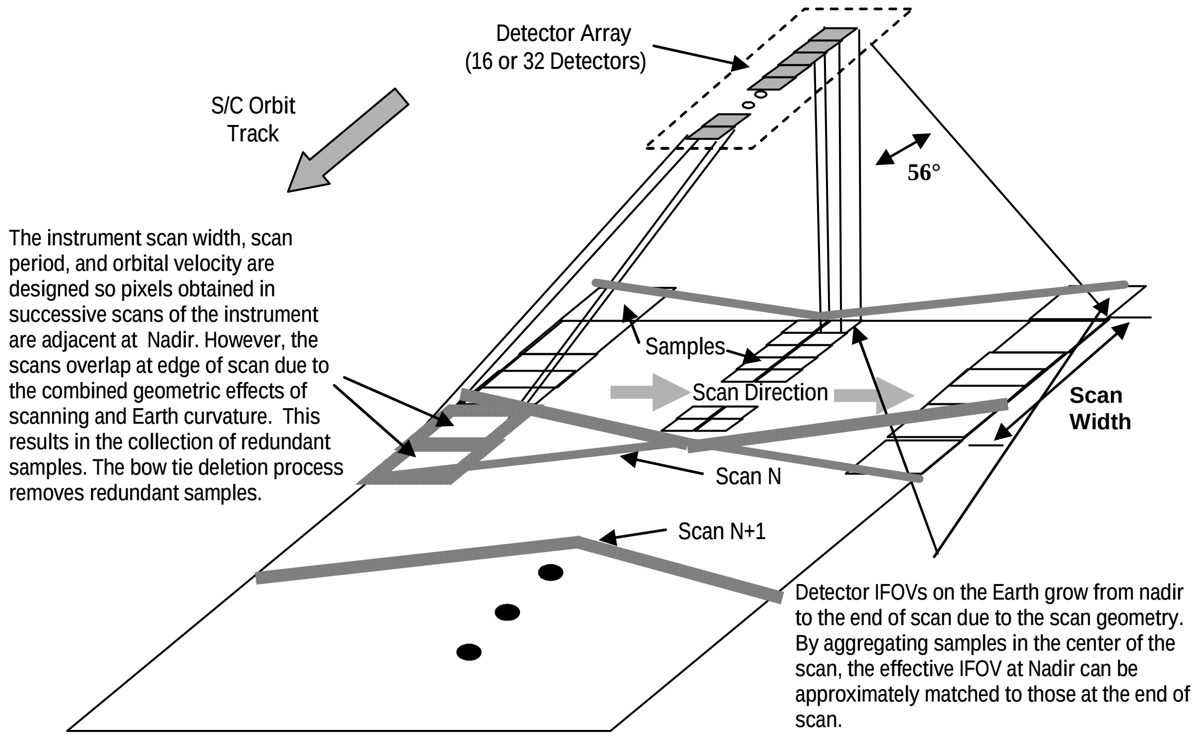

Figure 4.113-4 VIIRS Scanning Geometry for Science Data

There are two instrument modes which send scanning data - Operational and Diagnostic. In Operational Mode the instrument performs all of the processing indicated above - Bow Tie deletion, Aggregation, and Lossless Compression. In Diagnostic Mode, all of these processing functions are disabled.

The Day Night Band processing differs from that described above in several respects. The DNB Focal Plane has 672 sub-pixels in a CCD array that utilize an on-board 2-D aggregation scheme to generate 16 “pseudo-detectors” with a near constant 2-D sample size across the scan. This special DNB 2-D aggregation eliminates the need for any bow-tie deletion associated with along track sample growth at edge of scan that was discussed above for the other bands. Bow Tie Deletion is not performed for the Day Night Band in a way that is identifiable at the packet level. Rather than by post processing, the DNB inherently aggregates the CCD data on both sides of Nadir during data collection by a series of sample timing steps. At the packet level the DNB samples are organized into 6 aggregation zones, so they resemble the other bands. The DNB internal aggregation has 32 modes which vary within the 6 zones in order to maintain the near constant FOV (see Fig. 4.4-12). The aggregation within a zone for the other bands is constant, leading to a change in sample size variations in sample FOV within a zone as described in the next section. Compression is performed on the DNB data in each of the aggregation zones at the packet level.

The 32 Agg modes configuration is the flight software default for modifiable Table ID3. Via the uploadable table, for J1 only, 21 Agg modes are being used to prevent electrical crosstalk, which causes a non-linear response at low light levels at the edge of the scan FOV. Reference ENB VIIRS.02.05.074_J1 for the reduced Agg mode details and resultant DNB non-linearity summary.

The term Sample is used to denote the output of one detector taken at a given instant of time. When Samples are combined in the aggregation process the term Pixel is used to denote the result. This nomenclature is consistent at the packet level. However, it should be noted that if the data is being described at a lower level these definitions require some qualification, especially for the DNB.

A functional overview of the on-board processing performed in Operational Mode is shown in Figure 4.113-5. Moderate resolution and imaging bands undergo sample aggregation, bow tie deletion, spectral or spatial differential encoding, and compression. The VIIRS packets indicate whether aggregation, bow tie deletion, and compression are performed, and the processing order for spectral differential encoding. Arithmetic processing is performed prior to differential encoding to ensure that the differential encoding process does not result in negative numbers. For dual gain bands, additional processing is performed to incorporate data on the gain state into the data words. After unique aggregation described below in Section 4.113.3.1.6, DNB data is compressed like the other bands.

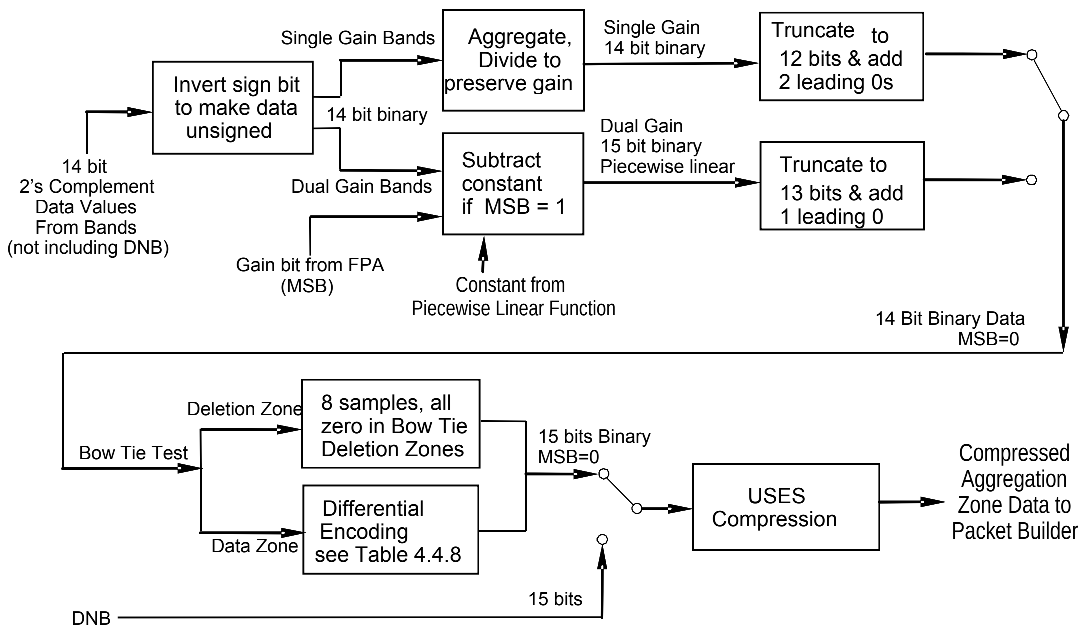

Figure 4.113-5 VIIRS Overview of Science Data Processing in Operational Mode

4.113.3.1.1 Operational Mode Aggregation

Sample aggregation is performed on the single gain bands. Samples are aggregated 3:1, 2:1, or 1:1 to form Pixels. The amount of aggregation is a function of their location in the scan, with 3:1 aggregation occurring in the middle of the scan and 1:1 (no) aggregation occurring at the edges. The regions over which aggregation is performed are called Aggregation Zones.

Figure 4.113-6 illustrates the aggregation process and the formation of aggregation zones for single gain and imaging bands. (DNB aggregation is described below in the DNB Processing section.) Although the number of detectors and pixels vary, the aggregation process is the same for the moderate resolution single gain bands and the single gain imaging bands. Figure 4.113-7 shows the boundaries and sizes of the aggregation zones and the along-scan resolution that results after aggregation of the single gain bands. Although no aggregation is actually performed on the dual gain band data, it is grouped into six "aggregation zones" for purposes of spectral differencing and compression. Thus when viewed at the packet level, the data from dual gain bands looks very similar to that from single gain bands.

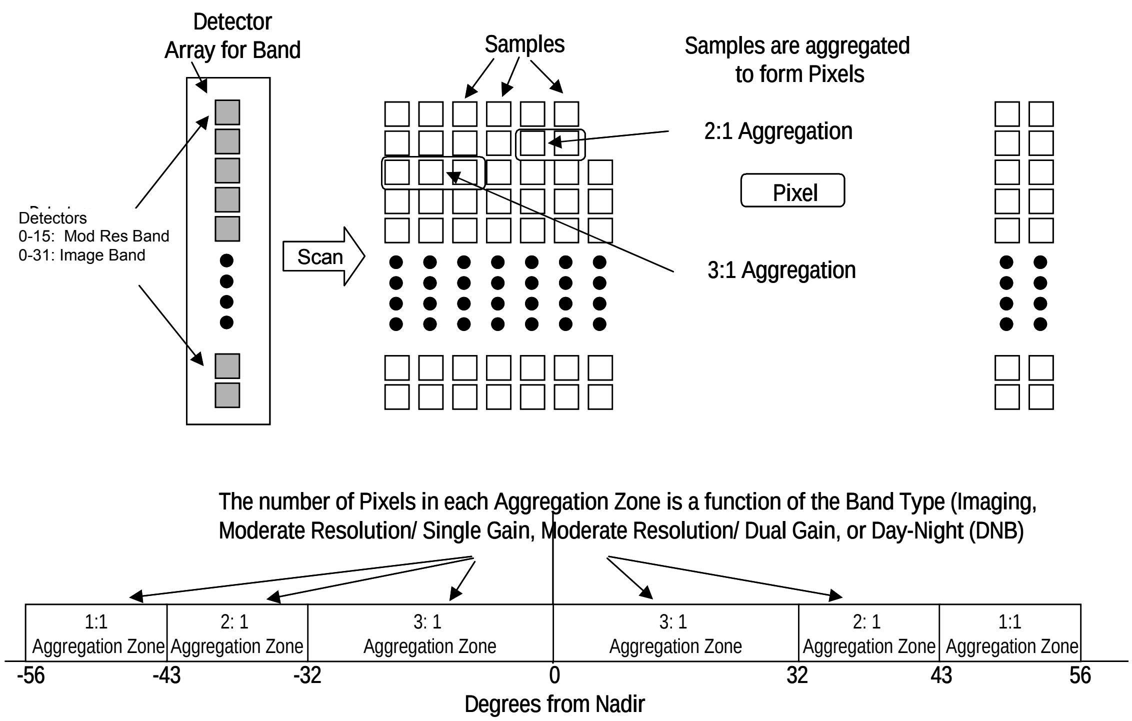

Figure 4.113-6 VIIRS Overview of Aggregation & Aggregation Zones for Single Gain/Imaging HRD – Operational Mode

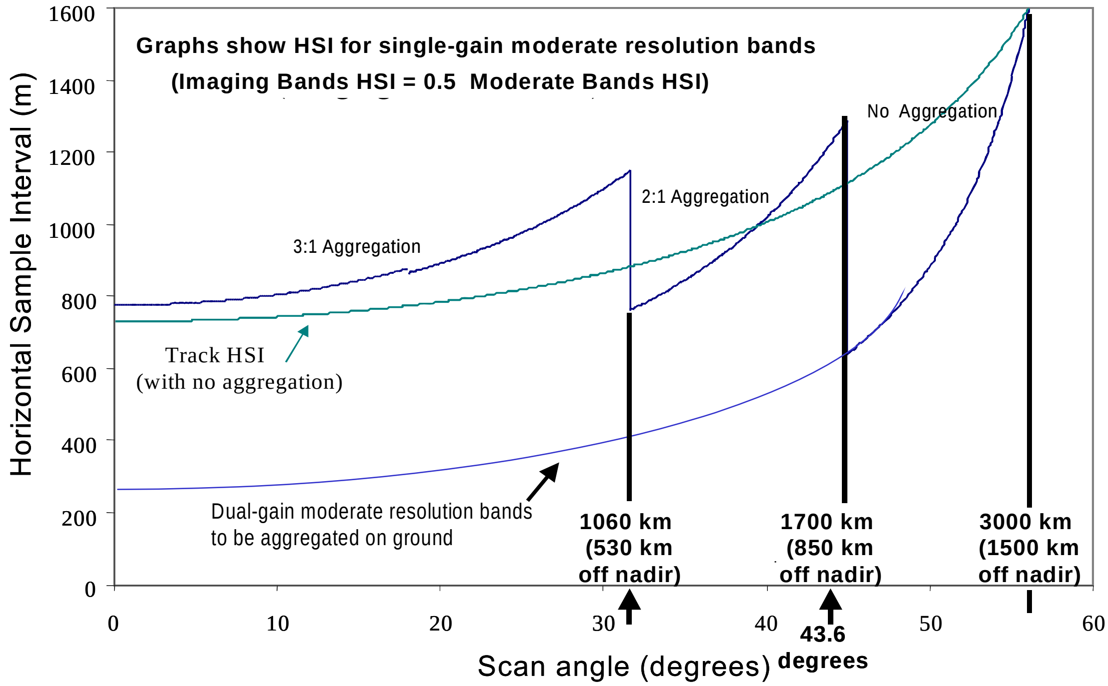

Figure 4.113-7 VIIRS Overview of Aggregation Zone Definition

4.113.3.1.2 Operational Mode Bow Tie Deletion

Bow Tie Deletion is applied to all imaging and moderate resolution bands irrespective of their gain characteristics. To simplify processing, Bow Tie Deletion is done at the aggregation zone level on a detector-by-detector basis. Although this results in some overlaps remaining between successive scans, the reduction in processing complexity and the fact that the overlaps can be calculated make it worthwhile. Bow Tie Deletion at the aggregation zone level means that some of the aggregation zones, in particular those at the corners of a scan, are of length zero. This is seen in Table 4.113.3-3 and Table 4.113.3-4. The DPP substitutes a single 4-byte block of zeros for these zones. These aggregation zones should not be processed.

Table 4.113.3-3 VIIRS Number of Pixels per Aggregation Zone for Single Gain Bands – Operational Mode

Detectors	Single Gain Moderate Resolution Bands Number of Pixels in Aggregation Zones						Total Pixels
	1	2	3	4	5	6	
0	0	0	592	592	0	0	1184
1	0	368	592	592	368	0	1920
2 through 13	640	368	592	592	368	640	3200
14	0	368	592	592	368	0	1920
15	0	0	592	592	0	0	1184
Detectors	**Single Gain Imaging Bands Number of Pixels in Aggregation Zones**						**Total Pixels**
	1	2	3	4	5	6	
0, 1	0	0	1184	1184	0	0	2368
2, 3	0	736	1184	1184	736	0	3840

4 through 27	1280	736	1184	1184	736	1280	6400
28, 29	0	736	1184	1184	736	0	3840
30, 31	0	0	1184	1184	0	0	2368

Table 4.113.3-4 VIIRS Number of Samples per Aggregation Zones for Dual Gain Bands – Operational Mode

Detectors	Dual Gain Moderate Resolution Bands Number of Pixels in Aggregation Zones						Total Pixels
	1	2	3	4	5	6	
0	0	0	1776	1776	0	0	3552
1	0	736	1776	1776	736	0	5024
2 through 13	640	736	1776	1776	736	640	6304
14	0	736	1776	1776	736	0	5024
15	0	0	1776	1776	0	0	3552

4.113.3.1.3 Operational Mode Differential Coding & Compression

Differential encoding is performed between bands prior to compression to further reduce the amount of data. The rationale for the selection and ordering of bands for differential encoding are not presented here. Table 4.113.3-5 shows the band prediction table for differentially encoding the bands. For reference, Table 4.113.3-5 also shows information about each of the bands, including whether they are collected at night, and key optical parameters. Table 4.113.3-5 also shows the actual transmission order of the bands.

Table 4.113.3-6 shows the processing functions that are implemented inside the “Processing for Differential Encoding” box in Figure 4.113-5 as a function of band. Note the relation of the A, B & C points.

Table 4.113.3-5 VIIRS Science Data Packet Band Transmission & Processing Order

Processing and Transmission Sequence	Encoded Band	Night	Wavelength (µm)	Bandwidth (µm)	Predictor Band	Wavelength (µm)	Bandwidth (µm)
1	M4	No	0.555	0.02	NONE		
2	M5	No	0.672	0.02	M4	0.555	0.02
3	M3	No	0.488	0.02	M4	0.555	0.02
4	M2	No	0.445	0.018	M3	0.488	0.02
5	M1	No	0.41	0.02	M2	0.445	0.018
6	M6	No	0.746	0.015	NONE		
7	M7	Yes	0.865	0.039	NONE		
8	M9	No	1.378	0.015	NONE		
9	M10	Yes	1.61	0.06	NONE		
10	M8	Yes	1.24	0.02	M10	1.61	0.06
11	M11	Yes	2.25	0.05	M10	1.61	0.06
12	M13	Yes	4.05	0.155	NONE		
13	M12	Yes	3.7	0.18	NONE	4.05	0.155

Processing and Transmission Sequence	Encoded Band	Night	Wavelength (µm)	Bandwidth (µm)	Predictor Band	Wavelength (µm)	Bandwidth (µm)
14	I4	Yes	3.74	0.038	M12	3.7	0.18
15	M16	Yes	12.01	0.95	NONE		
16	M15	Yes	10.7625	1.00	NONE		
17	M14	Yes	9.55	0.30	M15	10.7625	1.00
18	I5	Yes	11.45	1.90	M15	10.7625	1.00
19	I1	No	0.64	0.08	NONE		
20	I2	No	0.865	0.039	I1	0.64	0.08
21	I3	No	1.61	0.06	I2	0.865	0.039
22	DNB	Yes	0.70	0.40	NONE		

Table 4.113.3-6 VIIRS Processing Summary for Differential Encoding

Band(s)	Output (15 bits)
M16	(M16A + M16B) / 2
Without Predictor Band	Input
With Predictor Band *	Input + (2^{14}-1) - Predictor

* Predictor Bands are specified in Table 4.113.3-5, but are subject to change
The outputs relate to points in Figure 4.113-5

Lossless compression is performed on the data from all science data bands. Note that for some bands, the actual band data is compressed; for others differential data is compressed. Data is compressed by aggregation zone. Thus, since there are 6 aggregation zones per scan, there will be 6 sets of compressed data per scan for each detector. Table 4.113.3-7 shows the Universal Source Encoder for Space compression algorithm parameters that are used to process the data.

Table 4.113.3-7 VIIRS USES Compression Information

USES Parameter	Value	Units
J	8	Samples per block
N	15	Bits per sample
Mode	Nearest_neighbor	-
BlkRef	128	Blocks per reference

Figure 4.113-8 shows the flow diagram for reconstructing the bands from the transmitted differential values. For reference, VIIRS band processing flow bands processed at night are shaded. The band reconstruction process is the same for day and night however.

There is one subtlety of the reconstruction process that is not clearly shown in Figure 4.113-8. This is the processing required when a moderate resolution band is used to reconstruct an imaging band. This is accomplished by "reusing" one moderate resolution band sample to reconstruct four nearest neighbor samples of the imaging band as shown in Figure 4.113-9.

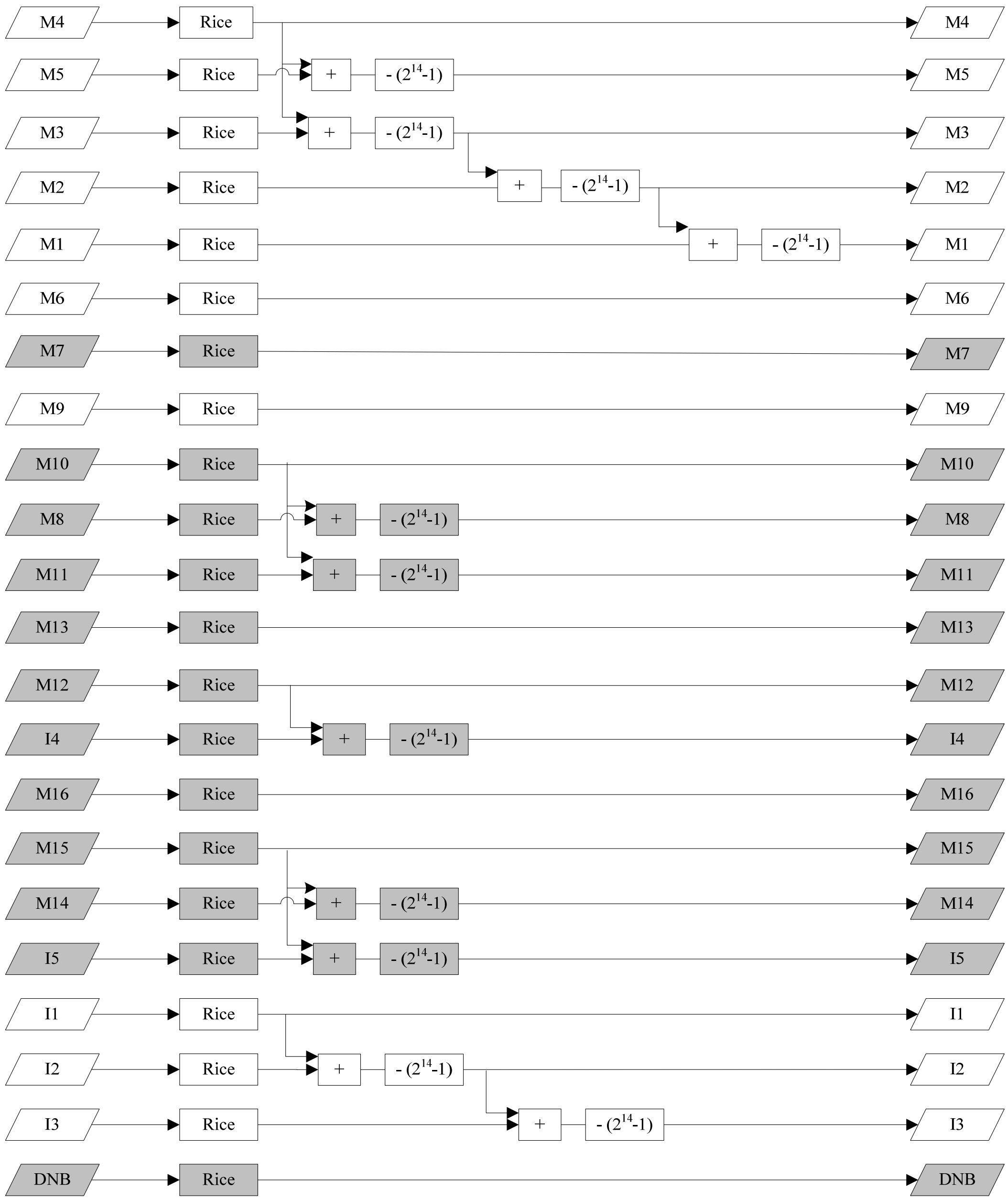

Figure 4.113-8 VIIRS Band Reconstruction Diagram

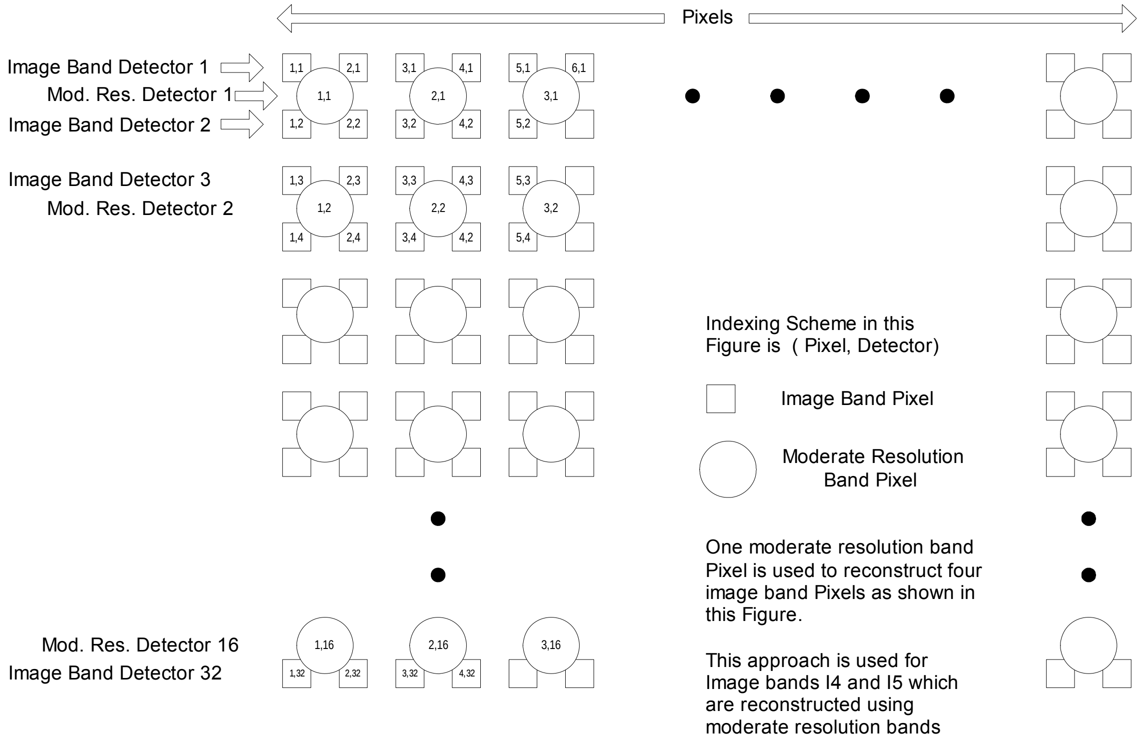

Figure 4.113-9 VIIRS Reconstruction of Imaging Bands that have Moderate Resolution Bands as Predictors

4.113.3.1.4 Operational Mode Arithmetic Operations

In addition to aggregation and bow tie deletion, Figure 4.113-5 also shows arithmetic operations associated with the processing of science data. The digital data representing single-gain spectral bands are processed differently from dual-gain band data. The first step for both types is to convert the 2’s complement numbers into 14-bit straight binary form.

After aggregation and bow tie deletion, the single gain band 16 bit words are then truncated to 12 bits and two leading-edge zeros are added, giving 14-bit binary values, which are input to the differential encoding and compression functions.

After conversion from 2’s complement form to straight binary, the data from dual-gain spectral bands are merged with the stream of “gain bits” from the focal plane array (FPA) that indicate whether each sample was taken in the high or low gain state. The gain bit is appended as a Most Significant Bit (MSB) to the beginning of each data word, yielding a 15-bit binary value. This has the effect of creating a discontinuous piecewise-linear relationship between radiance and the digital value. Because the discontinuity would reduce the efficiency of the subsequent data compression process, a constant is then subtracted from all the data words in the upper portion of the radiance range. The value subtracted for each spectral band, one of seven in the Discontinuity Offset Registers referred to in the Band Control Word of the first packet, does not totally eliminate the discontinuity, but does reduce its magnitude. This discontinuity constant is not subtracted from dual-gain detector outputs in calibration mode. The seven constant values subtracted are stored in the uploadable/downloadable DPP Register Initialization Table (VIIRS Table ID 7).

Figure 4.113-10 graphically shows the piecewise linear function that results from gain changes in the dual gain bands. The term DN (Digital Number) used in the figure refers to the binary value of the data.

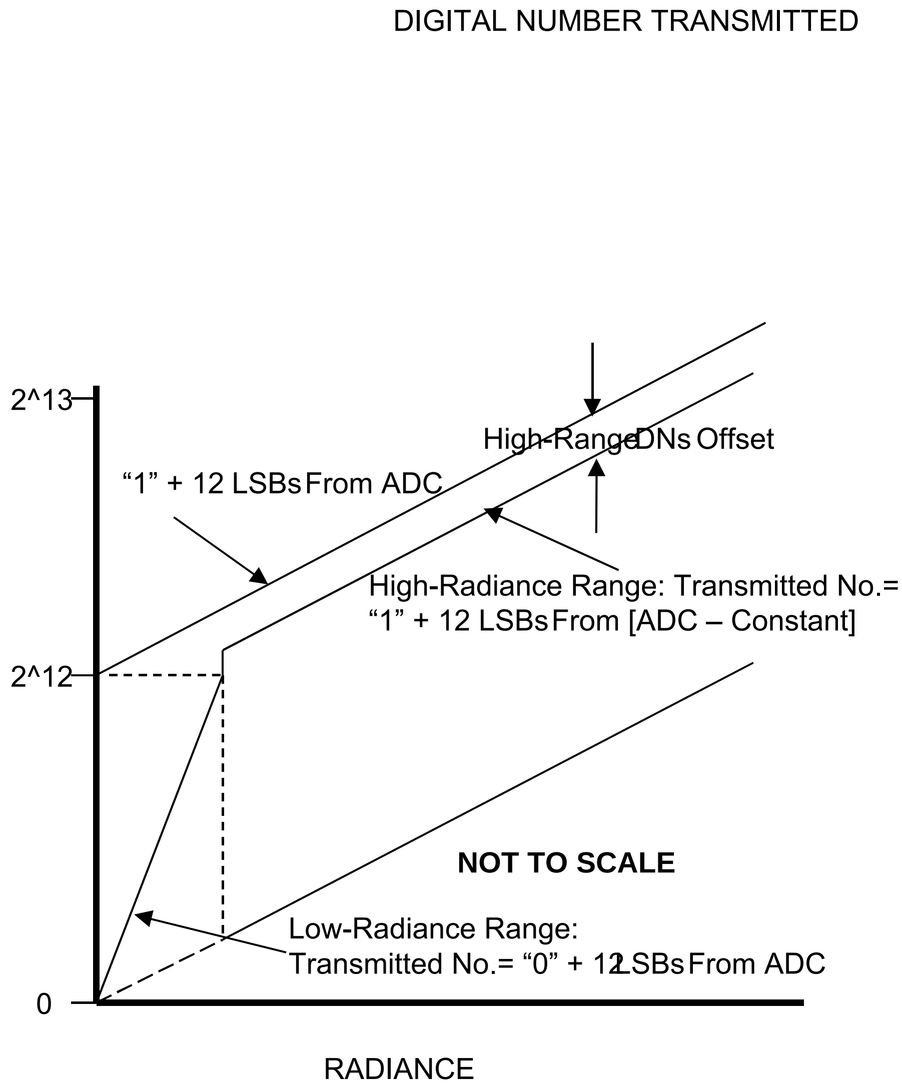

Figure 4.113-10 VIIRS Piecewise Linear Function Resulting From Dual Gain Processing & Offset Required for Correction of Data

After bow tie deletion, the 15-bit data values are then truncated to 13 bits, so that both single- and dual-gain band data is passed to the differential encoding (described above) and compression functions as 14-bit binary words.

4.113.3.1.5 Operational Mode Packet Processing

As mentioned, there is one grouped science data packet per band. The structures of the grouped packets for APIDs 800 to 823, 827 and 828 are described in 472-00335 JPSS-1 VIIRS Mission Data Packet Structures. The fields needing additional description for packet processing are discussed below.

The first CCSDS packet of the group contains meta-data characterizing the scan and band. Its Secondary header indicated the number of packet to follow, equal to the number of detectors in the band. The Middle and Last science data CCSDS packets contain 6 subfields of data each containing the compressed pixels from one of the 6 aggregation zones associated with a scan. These data subfields are denoted as “Aggr N” on the packet diagrams.

After compression, as part of the processing to build the above subfields, 1 to 31 bits having value 0 are appended to the compressed data to make the total length of the compressed “Aggr N” subfield a multiple of 32 bits. The number of bits appended can be determined by using the "Fill Data Word" in the HRD middle and last packets. Prior to decompression, the appended bits must be removed from the data or the decompression will be incorrect. The length of the “Aggr N” zone is determined by the Checksum Offset field, immediately preceding the “Aggr N” data. The Checksum field (a 32-bit XOR of the data) and fixed-pattern Sync Word field follow each “Aggr N” zone. These five fields repeat six times in each Middle and Last of the grouped science packets. The value in the checksum offset field is always equal to the length of the aggregation field in bytes, plus 4. For the special case of bowtie deletion, the checksum offset field contains the value 8, namely, the 4 bytes representing the empty aggregation field, plus 4.

The process for extracting data from the HRD packets when the instrument is in Operational Mode is shown in Figure 4.113-11.

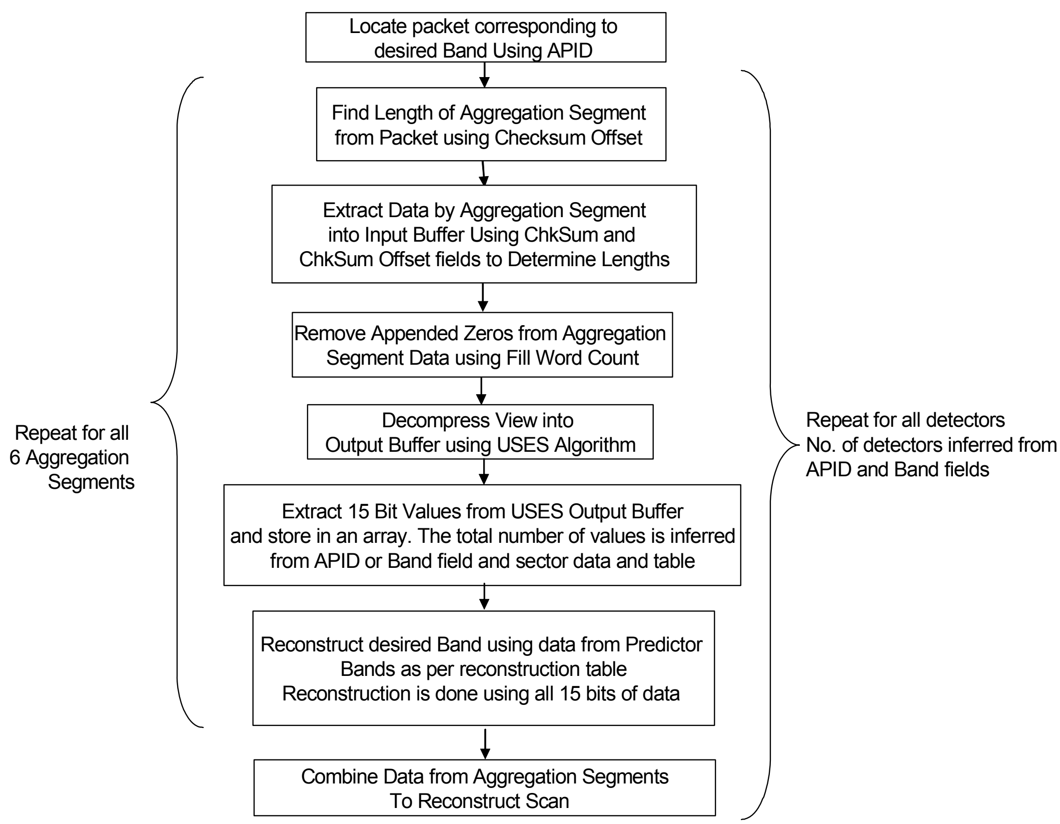

Figure 4.113-11 VIIRS Processing Flow for Extraction of Operational Mode Data from Science Data Packets

4.113.3.1.6 Day/Night Band Processing

Although there are significant differences between the DNB and the other bands at the lowest levels of the instrument (focal plane, sub pixel, and front-end electronics), at the packet level, the DNB is actually very similar to the other bands. DNB data are output in APIDs 821-823 and 827-828. APID 821 is always sent and is either the High, Mid or Low gain stage DNB which is automatically selected based on scene radiance. APIDs 822 (MGS), 823 (LGS) and 827/828 (HGS) are only sent when commanded. The output pixels from each detector corresponding to a scan are placed in a grouped packet that has the same structure as the science data packets for the other bands.

The number of DNB pixels per scan in Operational Mode is equal to 4064. A scan is broken up into six "aggregation" zones as is done for the other bands. The lengths of the aggregation zones, shown in
Figure 4.113-12, are unique to the DNB. In Operational mode, the pixels within an aggregation segment are compressed in the same manner as described for the other bands. Although it is not relevant to processing the packets, for completeness, Table 4.113.3-11 shows how the six aggregation zones are actually formed from 32 lower-level aggregation zones. The lengths of these lower level zones are determined by the geometry of the DNB focal plane array and parameters including SNR and illumination range. The data used to form the 32 lower level zones are not accessible at the packet level, but are contained in the Day Night Band Aggregation Mode Table (VIIRS Table ID 3).

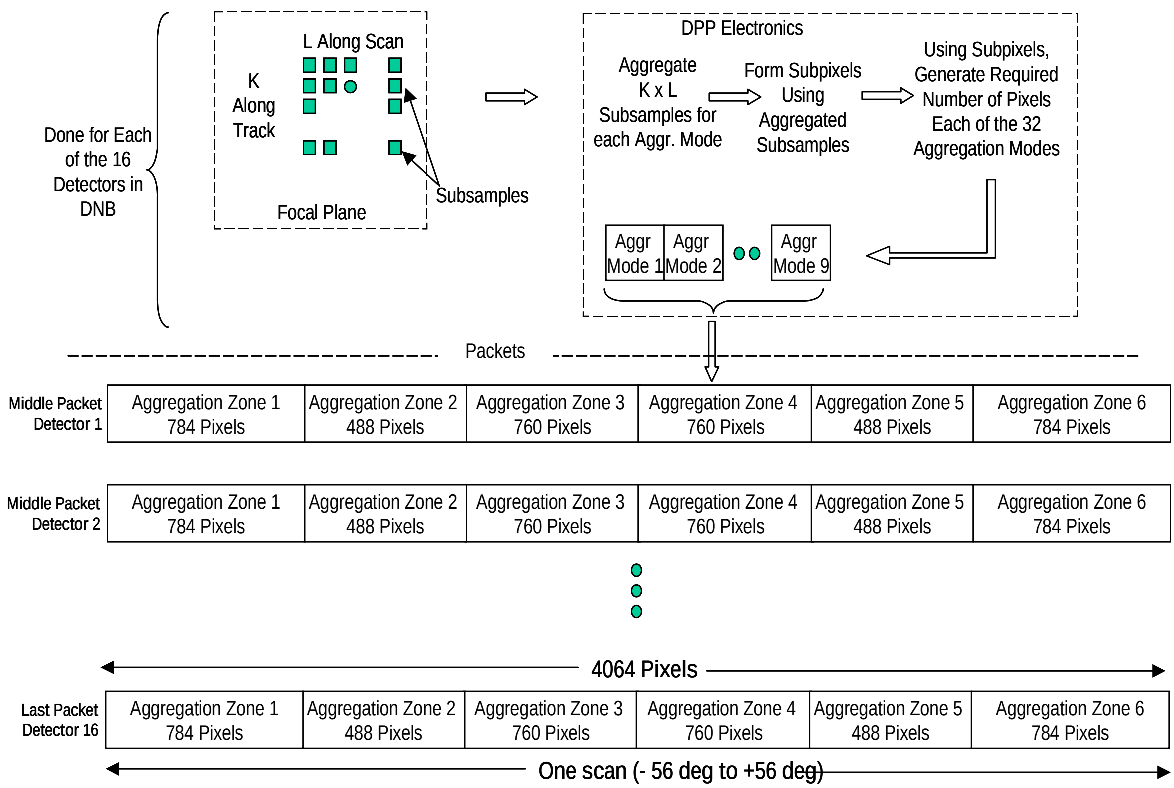

Figure 4.113-12 VIIRS Packet Structure & Definition of terms for Day Night Band (DNB) – Operational Mode

Figure 4.4-13 shows, at a top level, the processing for DNB data when the instrument is in Operational Mode.

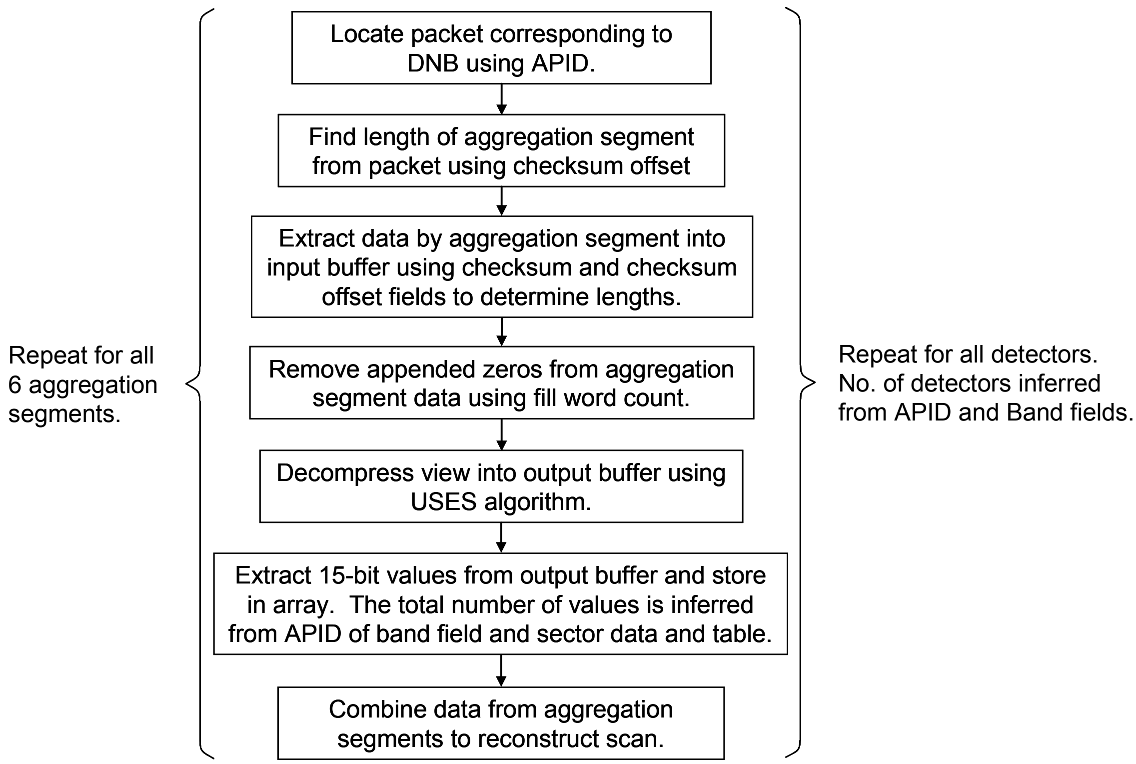

Figure 4.113-13 VIIRS DNB processing flow – Operational Mode

4.113.3.2 *Calibration Data*

The VIIRS Calibration Packet (APIDs 825 and 855) contain sensor outputs from the Space, Blackbody and Solar Diffuser Views during the VIIRS scan. Both APIDs are grouped packets containing the calibration data for all bands. VIIRS outputs one grouped packet every scan (1.7864 sec). If VIIRS is in Operational Mode it outputs APID 825 but if VIIRS is in Diagnostic Mode it outputs APID 855. The APIDs are the same, except that the data are compressed in the Operational modes and are not compressed in Diagnostic mode.

The first CCSDS packet in the grouped packet contains metadata. The 22 CCSDS packets and one Last CCSDS packet each contain the calibration data for one of the 23 bands. The packet contains data from 16 or 32 detectors per band, viewing all three calibration sources (space view, blackbody, and solar diffuser). There are two separate APIDs associated with the calibration packet, one corresponding to Operational modes, the other Diagnostic Mode. These two packets are also the same, except that the data are compressed in the Operational modes and are not compressed in Diagnostic Mode. The calibration packet format is the same in Operational Day and Operational Night modes. The band processing table determines the band order and content sent for each mode. The band processing used is defined by the Band Control Word found in each of the Middle and Last Packets. See Figure 4.4-14 for packet layouts. The only differences between day and night mode band content is that two day mode Moderate bands (M4 and M5) are replaced occasionally by command (SET_DP_DN_M_L_GAIN_PKTS) with Mid and Low Gain DNB Stages (DNBMGS and DNBLGS) and two other day mode Moderate bands (M1 and M2) are replaced occasionally by command (SET_DP_DN_H_GAIN_PKTS) with High Gain DNB Stages (DNB HGA and DNB HGB) in night mode as shown in Table 4.113.3-8. This is only recommended for night mode to avoid loss of calibration data. In both day and night modes, M16A and M16B are both transmitted as separate bands (without TDI) in the calibration packets for all operating modes. Calibration dual-gain detector data does not have the discontinuity constant subtracted.

Within a middle or last CCSDS packet the data is ordered by detector and, then by view (Space, Blackbody, or Solar Diffuser). The length of all views for moderate bands is 48 samples, imaging bands is 96. The DNB calibration data consists of 16 samples from each of the four gain stages, making a total of 64 samples in each view. The order of the DNB stages in the packet is HGA, HGB, MGS, LGS. If the DNB is in calibration Sequence Order 35 or 36, then only 4 samples are reported in each stage for a total of 16 samples per view. There is no specific telemetry point that identifies what DNB aggregation mode is being transmitted in calibration view. Aggregation modes 35 and 36 send only 16 samples of data and can be used to sync the processing to where the VIIRS system is in the aggregation mode sequence. VIIRS changes the DNB aggregation mode every two scans and cycles through all modes in 72 scans. The sample length of all views is fixed and not programmable in software. The calibration view data (SV, BB, SD) have 14 significant bits preceded by a MSB that, depending on the band, will be a zero bit or a gain bit for a total of 15 bits per sample (see Table 4.113.3-8 for more details). However, the allocation of bits between gain and data information depends on the band. The value in the checksum offset field is equal to the length of the corresponding view field in bytes, plus 4.

When the instrument is in Operational Mode, the samples representing the output from each view are compressed as individual blocks of data using the USES algorithm. The details of compression and decompression of calibration data are nearly the same as for the science data packet and are shown graphically in Figure 4.113-15. One significant difference is the discontinuity constant is not subtracted from dual-gain detector outputs in calibration mode. As shown in Figure 4.113-14 and Figure 4.113-15, compression is performed at the view level. After each view is compressed, zeros are appended to make the length of the compressed data a multiple of 32. Before decompression, these appended zeros must be removed. The Number of Fill Bits field associated with each view contains the number of zeros appended to the data after compression.

Table 4.113.3-8 VIIRS Gain, Detector, and Bit Summary for Calibration Data

[1] Band	Band Content/Mode			[2] No. Zero Bits	[3] No. Gain Bits	[4] No. Bits for Data Number	[5] Total Number of Bits	[6] No. Gain Settings	[7] No. Dets / Band	[8] No. Bits / Word
	Day	Night [9]	Diagnostic							

M1	x	x	x	0	1	14	15	2	16	15
M2	x	x	x	0	1	14	15	2	16	15
M3	x	x	x	0	1	14	15	2	16	15
M4	x	[11]	x	0	1	14	15	2	16	15
M5	x	[11]	x	0	1	14	15	2	16	15
M6	x	x	x	1	0	14	15	1	16	14
M7	x	x	x	0	1	14	15	2	16	15
M8	x	x	x	1	0	14	15	1	16	14
M9	x	x	x	1	0	14	15	1	16	14
M10	x	x	x	1	0	14	15	1	16	14
M11	x	x	x	1	0	14	15	1	16	14
M12	x	x	x	1	0	14	15	1	16	14
M13	x	x	x	0	1	14	15	2	16	15
M14	x	x	x	1	0	14	15	1	16	14
M15	x	x	x	1	0	14	15	1	16	14
M16A	x	x	x	1	0	14	15	1	16	14
M16B	x	x	x	1	0	14	15	1	16	14
I1	x	x	x	1	0	14	15	1	32	14
I2	x	x	x	1	0	14	15	1	32	14
I3	x	x	x	1	0	14	15	1	32	14
I4	x	x	x	1	0	14	15	1	32	14
I5	x	x	x	1	0	14	15	1	32	14
DNB [10] All 4 gain stages transmitted in single band packet	x	x	x	1	0	14	15	NA	16	15
DNB MGS [10] All Data is med rad/med gain		[11]	x	1	0	14	15	NA	16	15
DNB LGS [10] All data is high rad/low gain		[11]	x	1	0	14	15	NA	16	15
DNB HGA [10]		[12]	x	1	0	14	15	NA	16	15
DNB HGB [10]		[12]	x	1	0	14	15	NA	16	15

Notes

[1] The list of VIIRS Bands where I= imaging and M=Moderate
[2] The number zeros bits padded onto the calibration data to make a 15 bit word.
[3] The number of gain bits in the calibration data.
[4] Size of the calibration detector data.
[5] Total calibration data size that is packetized.
[6] Number of gain levels. 1 = Single Gain Band, 2 = Dual Gain Band
[7] The number of detectors per band.
[8] Column 8 indicates meaningful band bits before compression & after ground data recovery. For the dual gain bands (bold in the table), the following logic applies to the gain bit. If the gain bit = 0, this is a HIGH State. If the gain bit = 1, this is a LOW State. All DNB bands above Stage 1 are the most significant bit of the 14 bit value.

[9] The number of samples per view for the DNB band is 64 except for Aggregation Modes 34 and 35 when it is 16. The DNB aggregation mode in the cal view changes every 2 scans, cycling over agg. modes 1 to 36 in 72 scans. This field may also be set to zero for sensor initialization or mode transition.
[10] Due to a DNB "rise time" limitation that makes the first sample in Calibration View (CV) scans invalid, ground processing should set the first sample to 0.0 .
[11] Night mode by default sends M4/M5 calibration data, however, when commanded LGS and MGS calibration data is sent in place of M4/M5.
[12] Night mode by default sends M1/M2 calibration data, except when commanded, HGA and HGB calibration data is sent in place of M1/M2.

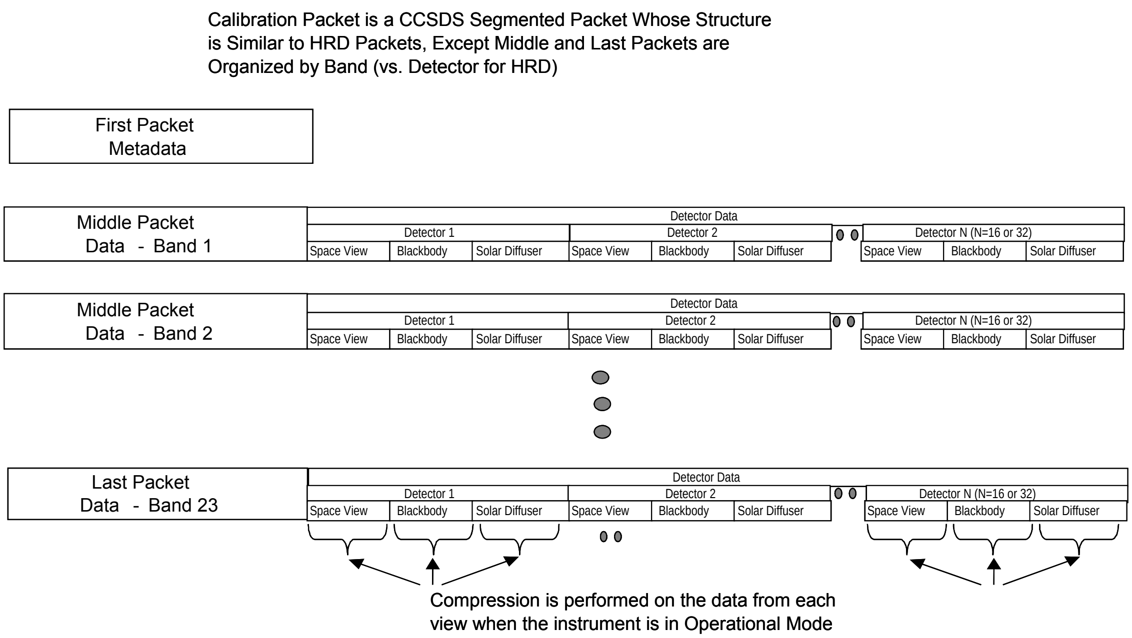

Figure 4.113-14 VIIRS Calibration Data Packet Structure

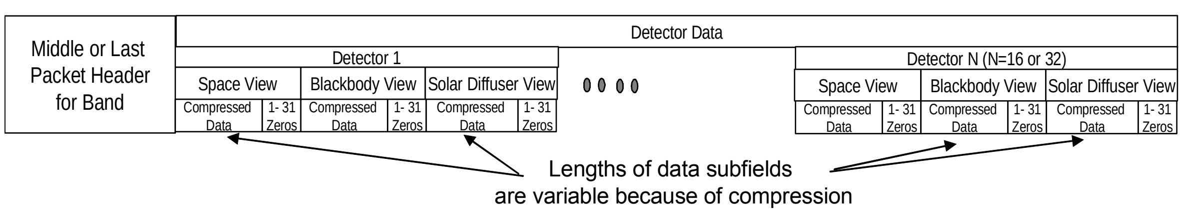

Figure 4.113-15 VIIRS Top-Level Format of Detector Field in Calibration Packet – Operational Mode

When the instrument is in Diagnostic mode, no compression is performed on the data. The length of each data word is 15 bits. The total length of the subfield containing the data from a view, in bits, is equal to 15 times the number of samples in the view. All data is packed.

The order of data is the same for Diagnostic mode as Operational Mode. Zeros are appended to the end of the data in each view to make the length of the view, in bits, a multiple of 32. The appended zeros should be removed as part of the depacketization process. The structure of the detector data field in the calibration packet for Diagnostic mode is shown in Figure 4.113-16.

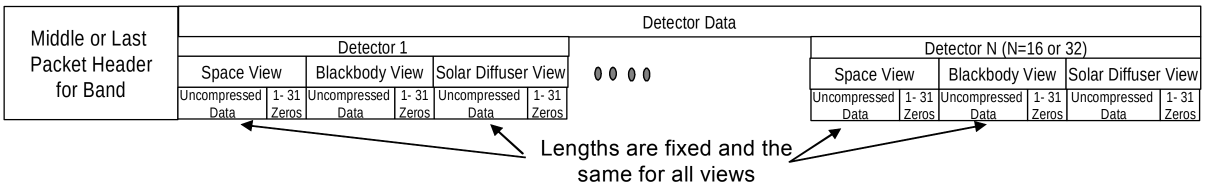

Figure 4.113-16 VIIRS Top-Level Format of Detector Data Field in Calibration Packet – Diagnostic Mode

Top level activity diagrams for processing the Calibration Packets are shown in Figure 4.113-17 and Figure 4.113-18. Figure 4.113-17 shows the processing flow for Operational Mode; Figure 4.113-18 shows the flow for Diagnostic Mode.

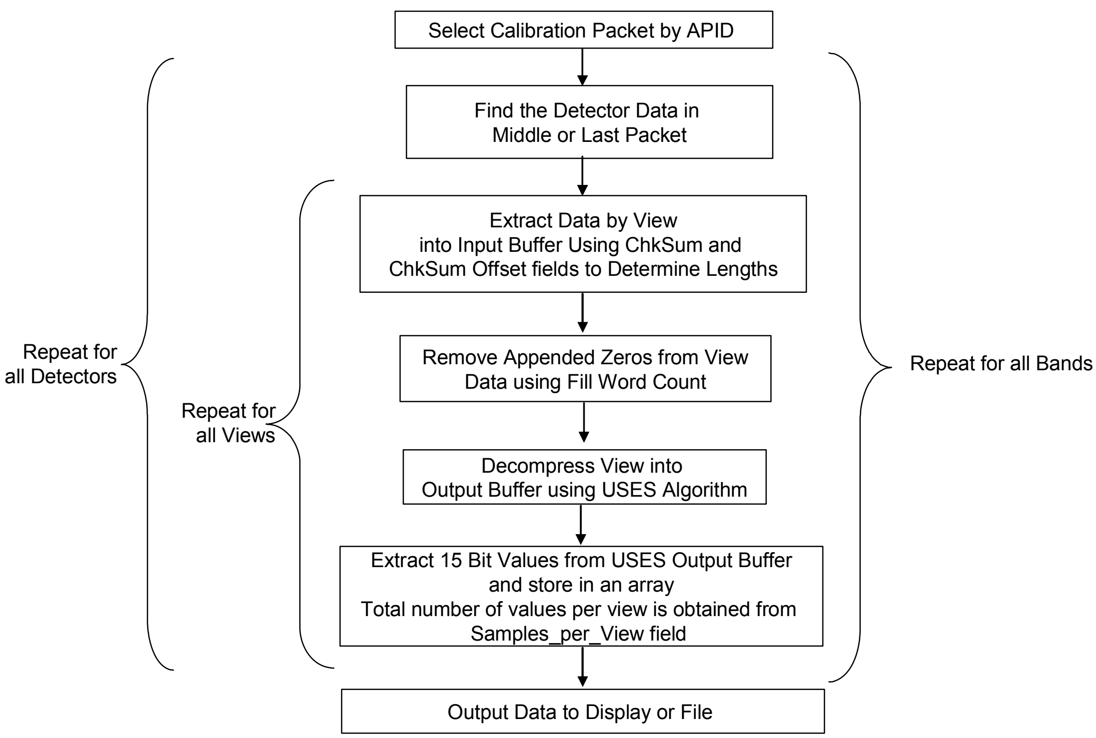

Figure 4.113-17 VIIRS Calibration Data Packet Processing – Operational Mode

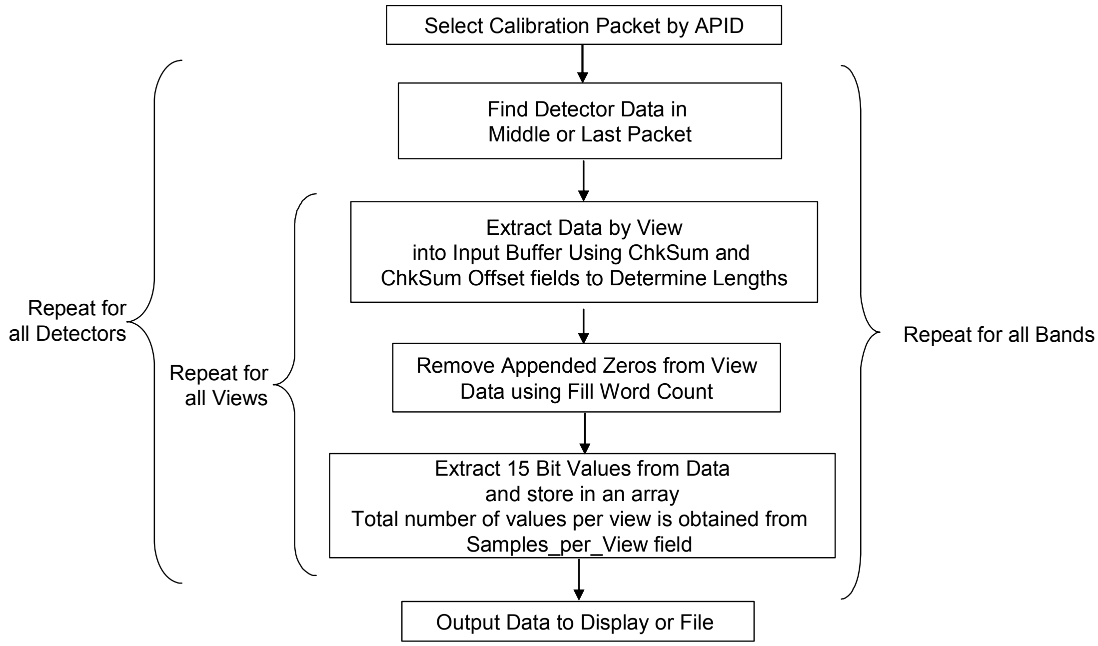

Figure 4.113-18 VIIRS Calibration Data Packet Processing – Diagnostic Mode

4.113.3.3 *Engineering Data*

The VIIRS outputs Engineering data once per scan in APIDs 826 or 856 in Operational or Diagnostic mode respectively. The two APIDs have identical formats, which are documented in 472-00335 JPSS-1 VIIRS Mission Data Packet Structures.

4.113.3.4 *Diagnostic Data*

Diagnostic mode data differs from Operational mode data in the following major ways

- The APIDs associated with the bands in Diagnostic mode are 830 to 853, different from those in Operational mode.
- No aggregation is performed on the imaging and single gain band data. To highlight this fact, the contents of the Diagnostic mode science packets are called Samples (As opposed to Pixels in Operational Mode)
- Band subtraction, compression, and bow tie deletion are not performed.
- All 22 bands are packetized at all times - there is no distinction between day and night.
- The scan width is limited to 26.38 degrees from the start of the earth view window and is not centered about Nadir.
- There is only one “aggregation sector” per packet. This sector contains all the data collected in the 26.38 degree scan by one detector.

Figure 4.113-19 summarizes the processing of data in Diagnostic Mode. Table 4.113.3-9 shows the processing functions implemented inside the “Arithmetic Processing” box in Figure 4.113-19. Note relation of the A, B & C points.

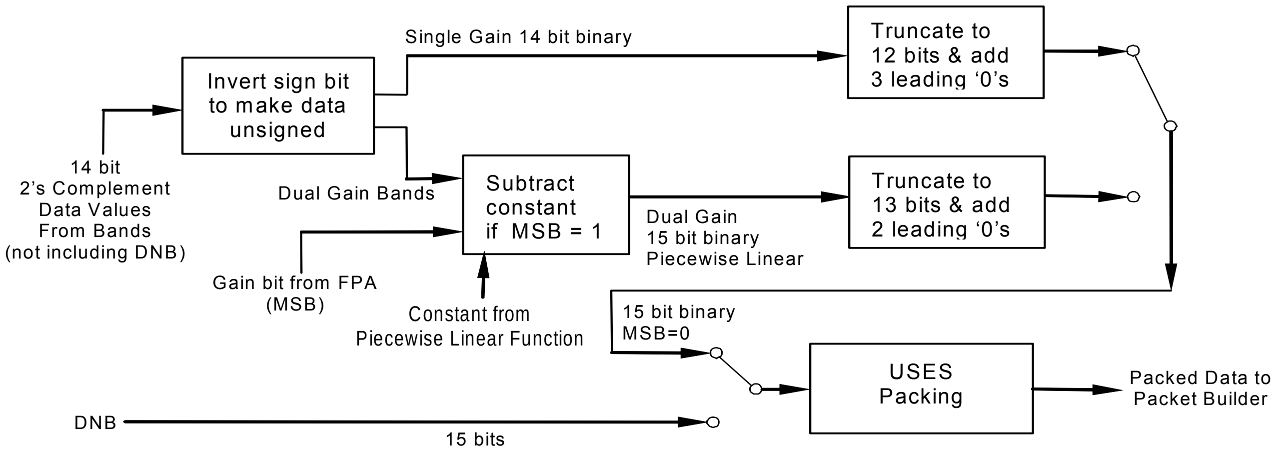

Figure 4.113-19 VIIRS Overview of Science Data Processing in Diagnostic Mode

Table 4.113.3-9 VIIRS Arithmetic Processing Summary

Band(s)	A (14 bits)	B (14 bits)	C (15 bits)
M16	M16 #1	M16 #2	C = (A + B) / 2 + (MSB=zero)
Dual gain (No Pred)	2^{13}	Data + 2^{13}	C = B – A + (MSB= zero)
Single gain (No Pred)	2^{13} (14 bits)	Data + 2^{13}	C = B – A (MSB= zero)

Although no aggregation is performed in Diagnostic Mode, samples corresponding to one scan from one detector are treated as one “aggregation zone” for the purposes of packetization. Because bow tie deletion is not performed the number of samples from each detector in a band is the same. The number of samples per scan in Diagnostic Mode is less than in Operational Mode because the scan is limited to a width of 26.38 degrees from the start of the earth view window. The overall process of data collection in Diagnostic Mode is shown in Figure 4.113-20 below.

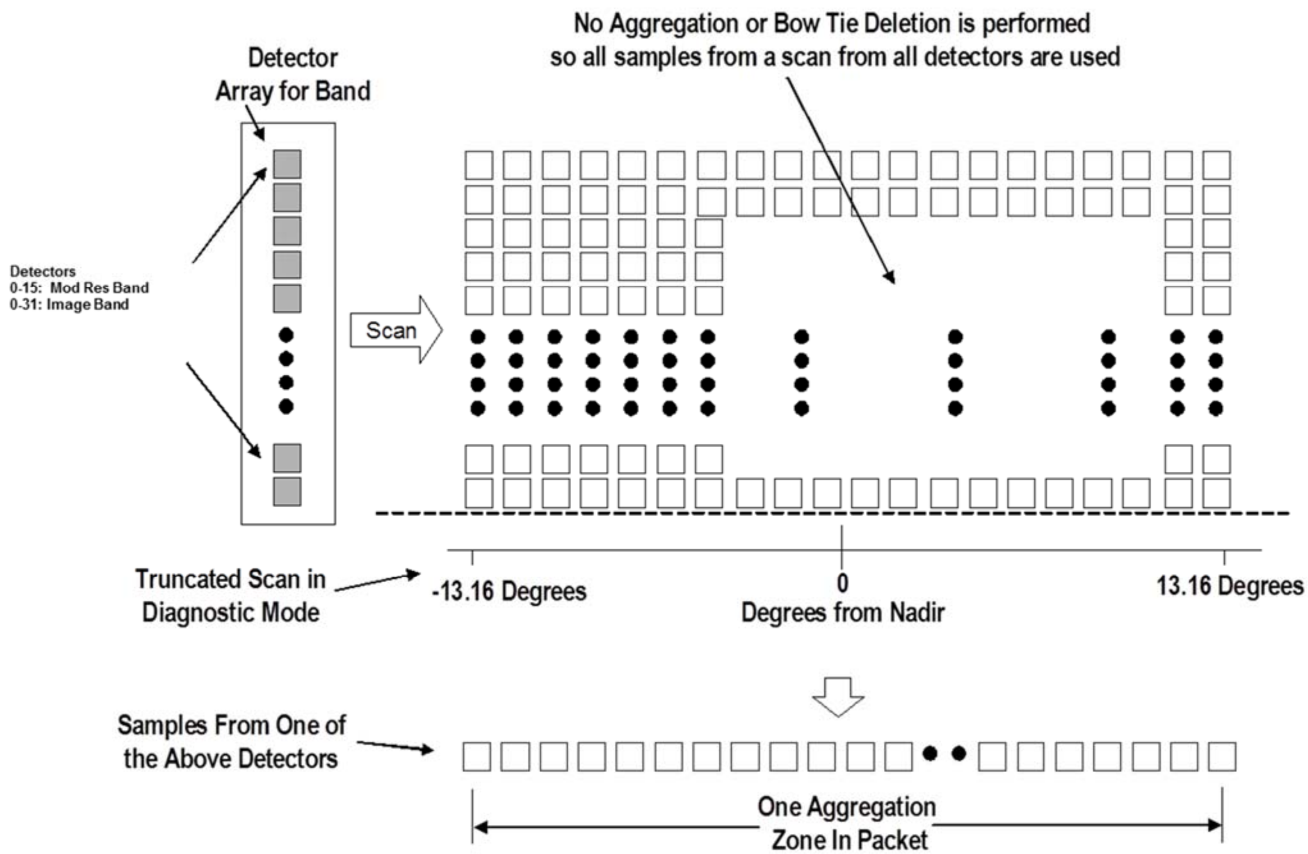

Figure 4.113-20 VIIRS Overview of Data Handling in Diagnostic Mode

Table 4.113.3-10 shows the number of samples in the “aggregation zone” by band type. All samples are 15 bits and are packed prior to be inserted into the packet.

Table 4.113.3-10 VIIRS Summary of Maximum Number of Samples in Aggregation Zone by Band Type

Detectors	Number of Samples in “Aggregation Zone” *	Total Samples
0 through 15	Moderate Resolution Bands (16 Bands) 2048	2048
0 through 31	Imaging Bands (5 Bands) 4096	4096
0 through 15	DNB (1 Band) 2048	2048

* The use of the term “aggregation zone” is for consistency with previous section and with the nomenclature used to describe packet fields. No aggregation is actually performed. Number of samples is configurable with a Table ID 7 upload.

4.113.3.4.1 Diagnostic Mode Arithmetic Processing

The arithmetic processing shown in Figure 4.113-19 is simpler than in Operational Mode because no band differencing or prediction is performed. This is reflected in the left hand side of Figure 4.113-19 by the addition of a constant 2^{13}, as opposed to the differencing operation shown earlier in Figure 4.113-5. The details of the processing in Diagnostic Mode are otherwise the same as described earlier in Operational Mode Arithmetic Operations and are not be repeated here.

4.113.3.4.2 Diagnostic Mode Packet Processing

As in Operational Mode, there is one grouped CCSDS science packet per band. Each science data grouped packet consists of a First CCSDS Packet, N-1 Middle CCSDS Packets, and a Last CCSDS Packet, where N is the number of detectors associated with the band. The Middle and Last science data CCSDS packets consist of a Packet Primary Header followed by a User Data Field. Unlike Operational Mode, in Diagnostic Mode the User Data Field contains only 1 subfield of data. This subfield contains the uncompressed samples from a detector resulting from the reduced scan. Although this data subfield is denoted as “Aggr N” on the packet diagrams, N is always equal to 1.

To build the subfield the instrument packs the 15 bit samples. As in Operational Mode, 1 to 31 bits having value 0 are appended to the resulting data to make the total length of the “Aggr 1” subfield a multiple of 32 bits. The number of bits appended is stored in the “Number of Fill Bits” subfield in the science data middle and last CCSDS packets. To correctly unpack and interpret the data in the subfield, the appended bits must first be removed.

Figure 4.113-21 shows the processing of the science data packets in Diagnostic Mode.

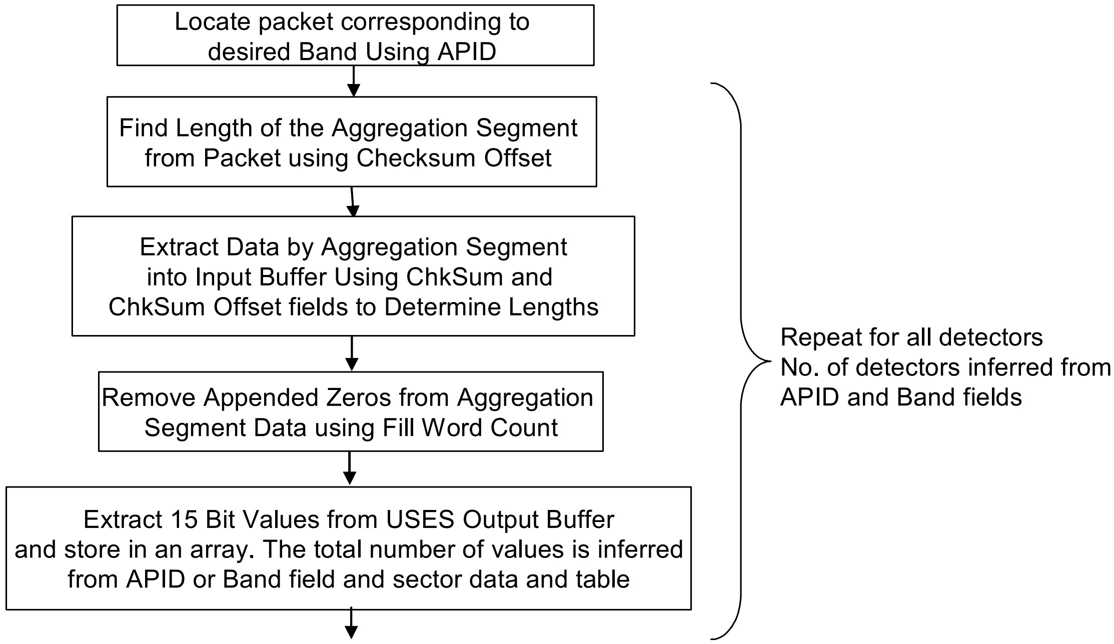

Figure 4.113-21 VIIRS Science Data Packet Processing Overview – Diagnostic Mode

4.113.3.4.3 Diagnostic Mode Day/Night Band Processing

The format of the DNB HRD packet when the instrument is in diagnostic mode is also very similar to the other bands. There is only one "aggregation zone" and the data is not compressed. In Diagnostic mode, the length of a scan is shortened to ensure that the instrument data rate is within specification. As a result, the number of samples in a scan of the DNB is 1376, as previously shown in Table 4.113.3-10. The format of the DNB data is shown schematically in Figure 4.113-22.

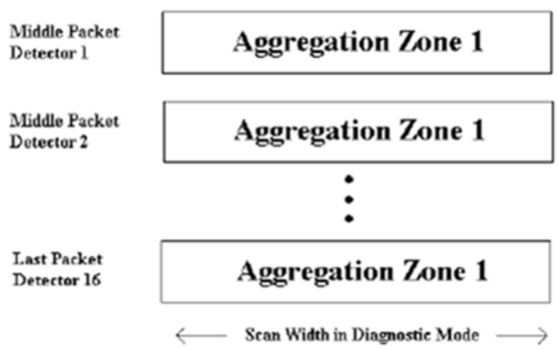

Figure 4.113-22 VIIRS Format of DNB Data when in Diagnostic Mode

Table 4.113.3-11 VIIRS DNB Reference Information

Sector in CCSDS Packet	Aggre-gation Mode	Scan Angle relative to Nadir (degrees)	Samples per Detector per scan
1	32	-55.4	80
1	31	-55.3	16
1	30	-54.7	64
1	29	-54.0	64
1	28	-53.3	64
1	27	-53.0	32
1	26	-52.7	24
1	25	-51.8	72
1	24	-51.3	40
1	23	-50.5	56
1	22	-49.9	40
1	21	-49.1	48
1	20	-48.6	32
1	19	-47.8	48
1	18	-47.2	32
1	17	-45.9	72
Total Samples in Sector 1			784
2	16	-44.5	72
2	15	-42.9	72
2	14	-41.0	80
2	13	-39.6	56
2	12	-37.4	80
2	11	-35.6	64
2	10	-33.6	64
Total Samples in Sector 2			488
3	9	-31.5	64
3	8	-29.2	64
3	7	-26.8	64
3	6	-23.9	72
3	5	-20.5	80
3	4	-17.2	72
3	3	-13.0	88
3	2	-9.4	72
3	1	0.0	184
Total Samples in Sector 3			760

Sector in CCSDS Packet	Aggre-gation Mode	Scan Angle relative to Nadir (degrees)	Pixels per Detector per scan
4	1	0.0	184
4	2	9.4	72
4	3	13.0	88
4	4	17.2	72
4	5	20.5	80
4	6	23.9	72
4	7	26.8	64
4	8	29.2	64
4	9	31.5	64
Total Samples in Sector 4			760
5	10	33.6	64
5	11	35.6	64
5	12	37.4	80
5	13	39.6	56
5	14	41.0	80
5	15	42.9	72
5	16	44.5	72
Total Samples in Sector 5			488
6	17	45.9	72
6	18	47.2	32
6	19	47.8	48
6	20	48.6	32
6	21	49.1	48
6	22	49.9	40
6	23	50.5	56
6	24	51.3	40
6	25	51.8	72
6	26	52.7	24
6	27	53.0	32
6	28	53.3	64
6	29	54.0	64
6	30	54.7	64
6	31	55.3	16
6	32	55.4	80
Total Samples in Sector 6			784

Figure 4.113-23 shows, at a top level, the processing for DNB data when the instrument is in Diagnostic Mode. Note that although the above discussion treats the number of samples per scan in Diagnostic Mode as a constant, the number of samples is stored in the packet. Thus, if a command changes the scan length, the correct number of samples can be determined from this variable.

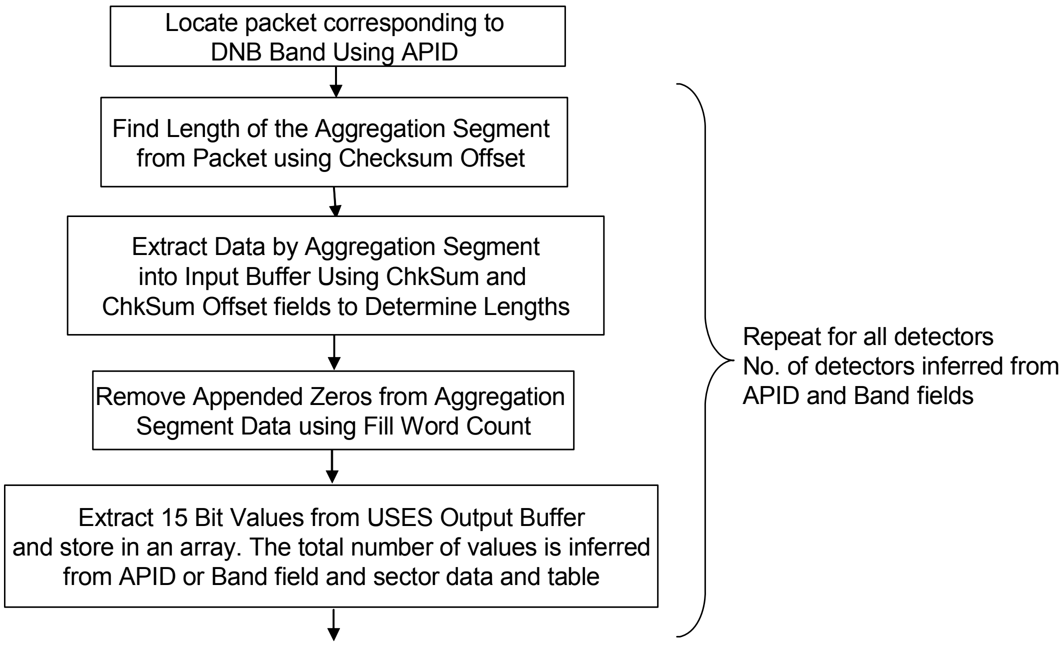

Figure 4.113-23 VIIRS DNB Processing Flow – Diagnostic Mode

Because the Diagnostic Data is uncompressed, the grouped packets have fixed lengths.

4.113.3.5 *Housekeeping Data*

Diagnostic Mode telemetry (APID 773) is identical in structure and format to the normal health and status telemetry (APID 768). The format of APID 768 is documented in the JPSS-1 Spacecraft C&T Database and Handbook. As these telemetry packets are housekeeping data and not mission data, the formats will not be provided in this document.

4.113.3.6 *Memory Dump*

The Memory Dump Packet (APID 780) is initiated in response to a dump command. The dump packet structure parallels the memory load packet structure and contains a Format Header, Memory Dump Header, Memory Dump Data, and Checksum. Dump Packets are grouped packets and are restricted to 65,506 octets per CCSDS packet. There is a maximum of 256 CCSDS packets per packet group.

The Format Header contains the VIIRS sequence count, the packet time, the software version, the instrument number, and 16 spare bits.

The Memory Dump Header contains the memory address, the amount of memory dumped, the type of memory dumped, and 8 spare bits. There are three types of memory that can be dumped: RAM, EEPROM, and Tables. The MEM Select indicates the type of memory selected for the dump: 0 - RAM, 1 - EEPROM, and 2 - Table. There are two16-bit MEM Address subfields. For RAM and EEPROM dumps, they are the memory target address most significant word (MSW) and least significant word (LSW). The target address is the start address for the memory dumped. For tables they indicate the Table ID (TID) and offset in words (OIW) of where the data was read. The MEM Data Size field reflects the number of octets remaining to be dumped in the current and any following packets of the same grouped packet. This field is an even number of octets and does not include the checksum. The MEM Data field contains the actual memory or table data and is an even number of octets.

Finally, there is a User Check Sum, which is an arithmetic check sum of octets in the User Data Field (modulo 65536).

The VIIRS uses either grouped or ungrouped packets depending on the size of the memory dump. The largest memory area possible to dump, 4 MB, requires a group of 65 packets. The timestamp in the Secondary Header represents the time the memory is captured. Additional detail about the VIIRS memory dump content and structure is provided in 472-00254 VIIRS Table Description Document (TDD).

4.113.3.7 *Test Packet*

If necessary to assess VIIRS to spacecraft communication, VIIRS can be commanded to generate fixed Test Packets which would be sent continuously, one per scan, until disabled by command. Test Packets would be transmitted via the unique APID 770, independent of mode, and would have no impact to ongoing Telemetry or Science Data collection. The Test Packet consists of a packet header and a fixed data pattern of 250 ‘CC’ hex characters. This packet is only transmitted between VIIRS and the Spacecraft and is not intended to be transmitted to the ground station.

4.114 CERES

4.114.1 Introduction

The Clouds and the Earth's Radiant Energy System (CERES) instrument measures solar-reflected and Earth-emitted radiation from the top of the atmosphere to the Earth's surface in order to trend the Earth's radiation budget. In combination with other JPSS-1 instruments, it contributes to determining cloud properties. The CERES instrument provides radiometric measurements of the Earth's atmosphere from three broadband bolometer sensor channels: a shortwave channel (0.3 μm – 5.0 μm), a total channel (0.3 μm - 100 μm), and an infrared longwave channel (5.0 μm – 50.0 μm). The instrument can scan the sensors in two axes, azimuth and elevation. The CERES instrument will scan primarily in an elevation plane orthogonal to the JPSS-1 satellite forward velocity. This normal cross-track scan takes 6.6 seconds, starting at a view of space beyond the Earth's limb, scanning 140 degrees across nadir and beyond the opposite Earth limb to a space view, continuing to an internal calibration system, and returning again. A view of the CERES is in Figure 4.5-1

Figure 4.114-1 CERES Instrument

Processed CERES data produce Outgoing Longwave Radiation and Reflected Solar Radiation EDRs. The CERES data also produces Climate Data Records of Earth's radiative fluxes.

4.114.2 Modes and Packet Structure

The CERES has the following modes of operation described below:

- Off/Launch
- Survival
- Safe

- Diagnostic
- Science

Figure 4.114-2 is a simplified diagram showing the CERES mode transitions. The CERES FM6 Instrument Operations Manual comprehensively describes all CERES modes and scan types. The instrument proceeds through an Initialization mode to Safe mode when first activated. After commanded to the Standby/Hold Science mode, internal sequences of commands then determine the Science sub-mode. As long as the internal sequences are used to configure the CERES instrument, the telemetry parameter ISEQMODE indicates the mode of the instrument. If individual commands are used, the ISEQMODE parameter will not necessarily reflect the instrument mode. The instrument can transition autonomously to Safe mode via internal sequence from any mode.

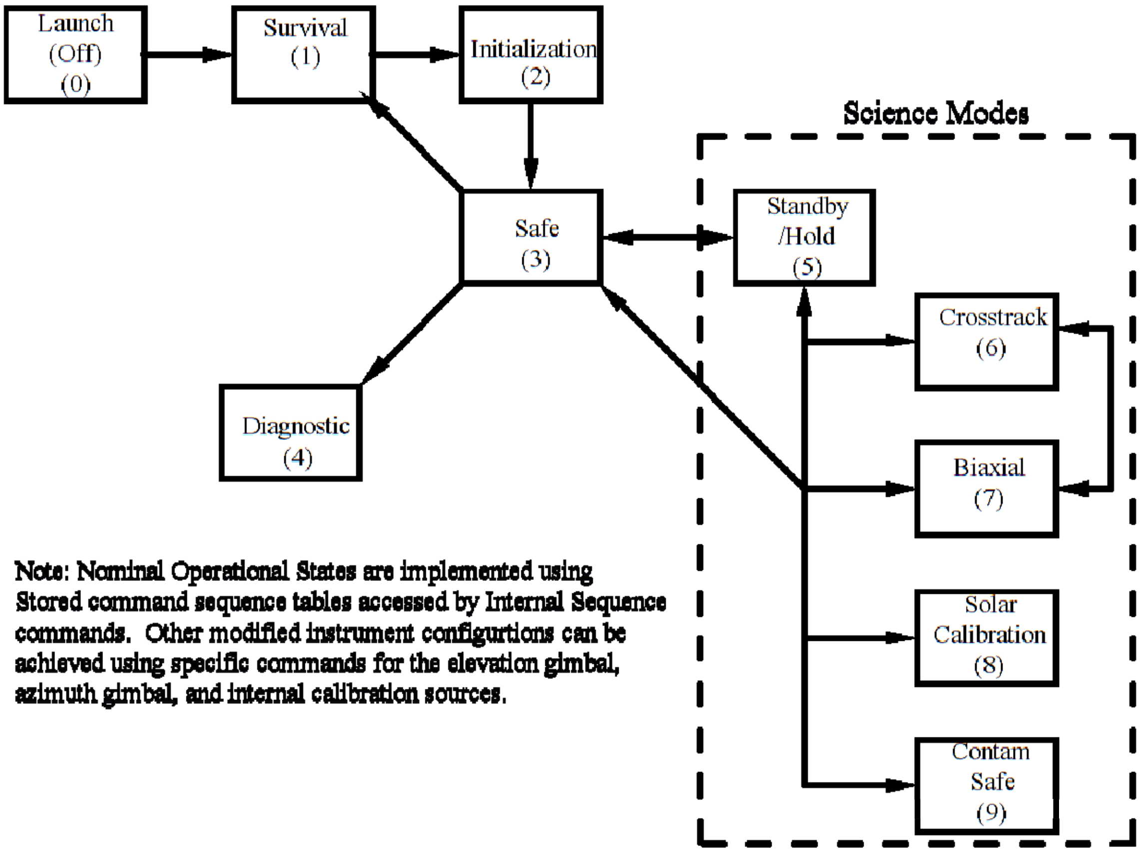

Figure 4.114-2 CERES Simplified Mode Diagram

The CERES instrument collects a single set of telemetry and formats it into two streams: science telemetry and housekeeping telemetry. The housekeeping telemetry is a subset of the science telemetry. All data found in the housekeeping telemetry may be found in the science telemetry. The instrument generates housekeeping telemetry at a rate of 2048 bits every 6.6 seconds. Science data is generated at a rate of 1 packet every 6.6 seconds.

The CERES data packets, their size and data rates are listed in Table 4.114.2-1. The packets output by the CERES depend on the internal sequence used to configure the instrument and any individual commands overriding the internal sequence. Because individual commands allow any of these packets to be output in any mode, Table 4.114.2-1 does not distinguish the packet data rates by mode.

Table 4.114.2-1 CERES Mission Data Packet Types

	$APID_{10}$	**Telemetry Packet Name**	**Data Rate (bps) by Mode**			**Packet Size (octets)**
			Operational or Diagnostic			
	146	Housekeeping Packet	Note 1			Note 1
	147	Calibration	8477.6			6994
	148	Fixed Pattern	8477.6			6994
	149	Science	8477.6			6994
	150	Diagnostic (Note 2)	8477.6			6994
	155	LEO&A	Note 1			Note 1

1. Documented in the JPSS-1 Command & Telemetry Handbook and Database
2. The Diagnostic Packet may contain sensor data, memory dump data, gimbal data, or execution time data depending on what is commanded into it. The format is the same, only the content of the fields changes.

Table 4.114.2-2 indicates the Mission Data packet type for a given instrument mode when commanded by internal sequence. Whenever the CERES instrument is powered it outputs one of four types of Mission Data packets – Science packets, Calibration packets, Diagnostic packets or Fixed Pattern packets. Fixed Pattern packets will not be used on orbit and are not described in this document. CERES packets also use an 'internal data indicator' flag to further identify the data as science, calibration, or one of several types of diagnostic data. Packet content as a result of the CERES internal sequences are described for each mode in the sections below.

Table 4.114.2-2 CERES Mission Data Packets by Internal Sequence

Mode ID	Mode	Mission Data Packet Type
0	Launch (Off)	None
1	Survival	None
2	Initialization	N/A
3	Safe	Diagnostic
4	Diagnostic	Diagnostic
5	Standby/Hold	Diagnostic
6	Cross-Track	Science
7	Biaxial	Science
8	Solar Calibration	Calibration
9	Contamination Safe	Diagnostic

4.114.2.1 *Off, Launch and Survival Modes*

At launch, the CERES instrument has operational power and survival heater power removed. In Survival mode, only survival heater power is applied. No data are output in any of these modes.

Survival mode instrument temperatures are monitored by means of passive temperature sensors via spacecraft telemetry.

4.114.2.2 *Safe Mode*

The Safe mode allows the instrument to be put into a configuration that will prevent damage to the instrument in the event of a loss of spacecraft operational power or attitude control. The transition to Safe Mode can be executed at any time. The motion of both axes is stopped, the elevation is stowed, and the azimuth brake is applied. The instrument outputs the Diagnostic, Housekeeping and LEO&A packets. Since the telescope is stowed, the science packet data indicator in the Diagnostic packet is set to 'No_Archive_Data'.

4.114.2.3 *Diagnostic Mode*

Diagnostic mode is meant for CERES table loads, troubleshooting and instrument configuration changes not allowed in the other modes. Loads of the scan table, the internal sequence command table, unique parameters, and memory will occur when the CERES instrument is in real-time contact with the ground. Housekeeping, LEO&A and Diagnostic packets are active with Diagnostic packets having the data indicator flag set to 'No_Archive_Data'. Other Diagnostic, Science or Calibration packets can be enabled by command.

4.114.2.4 *Science Modes*

Brief descriptions of the sub-modes within Science Mode are given below. The sub-mode determines whether Science or Calibration packets are generated and what type of data is in the Science packet, unless the internal sequence configuration is overridden by ground commands.

4.114.2.4.1 Cross-track Scan Mode

In the Cross-track Scan mode, the elevation gimbal performs either a normal-Earth, short-Earth, nadir, or double nadir scan while the azimuth gimbal holds its position fixed. The normal-Earth scan elevation profile shown in Figure 4.114-3 will be used as the primary science mode for JPSS-1. It starts with the sensors viewing Space, scans across Earth, pauses at a space view, proceeds to dwell on the internal calibration source and then reverses itself. Science packets are produced once per scan, every 6.6 seconds. The CERES instrument continues to output the Housekeeping and LEO&A packets.

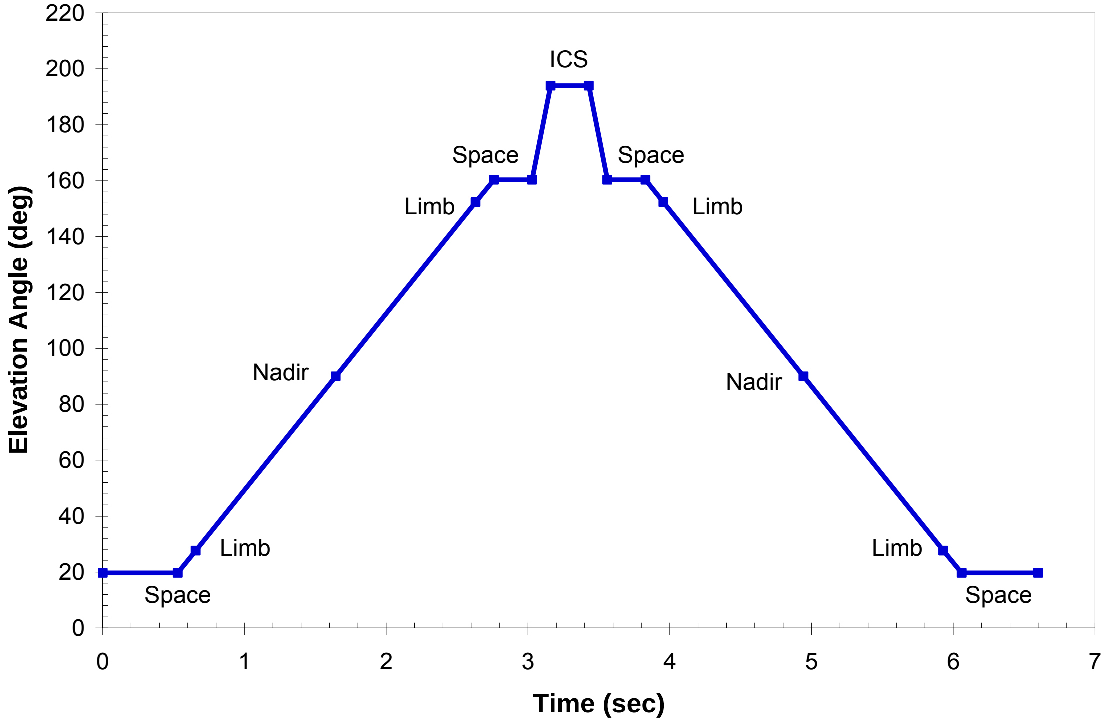

Figure 4.114-3 CERES Normal Earth Scan Elevation Profile

4.114.2.4.2 Biaxial Scan Mode

Both the azimuth and elevation gimbals are active in this mode. The elevation drive typically executes a normal-Earth scan. It can switch to a short-Earth scan depending on the orientation of the Sun relative to the spacecraft. The azimuth gimbal rotates back and forth 180 degrees between 90 degrees and 270 degrees. The Biaxial Scan mode is not intended to be used on JPSS-1.

4.114.2.4.3 Solar Calibration Mode

Solar calibrations are performed approximately every two weeks in one of two ways. First, in the legacy solar calibration approach, the azimuth gimbal is positioned so solar radiation is incident of the Mirror Attenuator Mosaic (MAM) surface as the Sun sets. The elevation drive switches between solar, MAM assembly and Instrument Calibration Source (ICS) views, as shown in Figure 4.114-4. Alternately, in the solar raster scan, the azimuth gimbal scans the MAM baffle from space across the sun to space and back as the Sun sets while the elevation gimbal positions the sensors to maintain a constant view of the MAM. This scanning continues while the sun sets through the MAM baffle field-of-view. In addition to Housekeeping and LEO&A packets, the CERES instrument also produces the Calibration packet while in this mode using either the legacy or sun raster scan method. Science packets are not produced when the internal sequence is used.

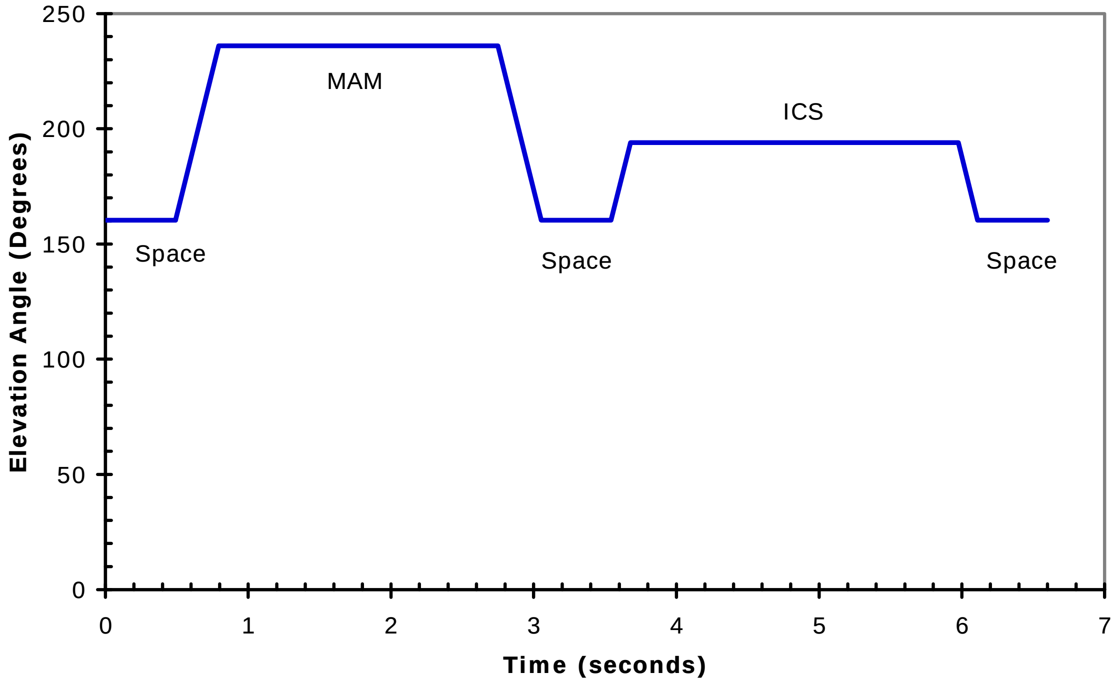

Figure 4.114-4 CERES Solar Calibration Scan Elevation Profile

4.114.2.4.4 Contamination Safe Mode

The CERES instrument stows the elevation gimbal, rotates the azimuth drive to a contamination-safe position of 180 degrees (Crosstrack) and turns off all calibration sources in Contamination Safe mode. The instrument remains in this mode for 10 minutes unless interrupted by internal command sequence to go to Safe or Standby Mode or to reenter Contamination Safe Mode. Upon expiration of the waiting period, the instrument will transition to Standby Mode. While in Contamination Safe, the Diagnostic, Housekeeping and LEO&A packets are output. The data indicator in the Diagnostic packet is set to 'No_Archive_Data'.

4.114.2.4.5 Standby/Hold Mode

The Standby/Hold Mode is used to transition the CERES instrument between Science modes and from Safe to Science Mode. The instrument is operationally ready in this mode, though the elevation gimbal is stowed. It outputs the Diagnostic, Housekeeping and LEO&A packets. The data indicator in the Diagnostic packet is set to 'No_Archive_Data'.

4.114.3 Mission Data

The CERES instrument transfers its CCSDS-formatted data to the spacecraft over the 1553B bus. The Science, Calibration, and Diagnostic packets all have the same basic format with slight customizations for each. All packets start with a 6 byte primary header and an 8-byte secondary header. The timestamp in the secondary header represents the time at the beginning of each 6.6-second scan. The timestamp is in the standard UTC format in Table 4.0.1.

Because the CERES instrument was built before JPSS-1 and NPP, its mission data packets differ from the other instruments in two significant ways. First, the CERES instrument does not have a separate engineering packet. Secondly, it does not exclude housekeeping telemetry from its mission data packets. Instead, housekeeping and engineering data are contained in each of the mission data packets. Engineering data is multiplexed with the detector data. The instrument outputs one engineering value every sample period, for a total of 660 engineering values every scan. The sampling is the same for all mission data packets. All fields in the CERES data packets are big endian.

472-00332 JPSS-1 CERES Mission Data Packet Structures documents the detailed packet structure and user field content.

4.114.3.1 *Science Data*

The CERES instrument generates one science data packet (APID 149) every 6.6 second scan cycle when none of the other Mission Data packets are active. Each packet begins with identification fields, contains 660 samples of engineering, sensor, and gimbal data, and ends with instrument housekeeping data. For each 10 msec sample period, the instrument reports one of 75 engineering data variables, the outputs of the shortwave, longwave and total channel sensors, and the elevation and the azimuth position. The 75 engineering data variables are not reported at equal intervals. Their order of occurrence repeats three times over the 6.6 second scan. The first 220 engineering data entries are listed separately in 472-00332 JPSS-1 CERES Mission Data Packet Structures. These same fields are repeated in samples 220 to 439 and 440 to 659.

The CERES Science Data packet is 6994 bytes in length. When it is output, the average data rate is 8477.6 bps. The secondary header contains the timestamp marking the beginning of the CERES scan. Its format is the standard UTC day segmented time code format in Table 4.0.1.

4.114.3.2 *Calibration Data*

The CERES instrument will generate one calibration data packet (APID 147) every 6.6 second scan cycle if the packet type is calibration. The packet format and user data field content is identical to the Science Data packet. Only the APID and the values in the packet identification fields will differ from the Science Data packet. Since the CERES instrument performs a 6.6 second scan, the same engineering, sensor and gimbal fields are repeated 660 times.

4.114.3.3 *Diagnostic Data*

The CERES instrument generates a diagnostic packet (APID 150) every 6.6 seconds when the packet type is commanded to one of four values indicated in the Science Data Packet Indicator Field – No Archive, Memory Dump, Gimbal, or Execution Time Data. No Archive Data is commanded when the instrument enters a Safe, Standby/Hold, Contamination Safe, or Diagnostic mode or when the packet type is commanded to NoArch. The Diagnostic packet has the same basic format of the Science Data packet, except the science packet's sensor outputs are replaced by Memory Dump, Gimbal, or Execution Time data or NoArch sensor outputs for each of the science packet's 660 samples. The diagnostic data consists of NoArch sensor data not intended for science processing, the Data Acquisition Processor (DAP) and the Instrument Control Assembly (ICA) Control Processor (ICP) memory data, azimuth and elevation gimbal error, or DAP and ICP execution time data sets, respectively. The packet begins with identification fields, contains 660 samples of engineering values, the selected diagnostic type, and gimbal positions, and ends with instrument status data.

The CERES Diagnostic Data packet is 6994 bytes in length and has an average data rate of 8477.6 bps. The secondary header, formatted according to Table 4.0.1, contains the timestamp marking the beginning of the CERES scan.

4.115 Spacecraft

4.115.1 Introduction

Generally, the data the Spacecraft bus generates is not considered mission data. Its housekeeping telemetry is transmitted over the narrowband data link. Thus it is documented in the C&T Handbook and not here in the MDFCB. There are two exceptions.

One exception is a fill packet the spacecraft generates to ensure that small instrument memory dumps are transmitted completely and expeditiously. This packet with fixed content can be commanded into APIDs 100 to 131, one at any given time. A combination of factors makes this packet necessary. Because only complete frames are transmitted and because packets can span frames, it is possible for the end of a packet to be in an incomplete frame. For packet types output frequently, the next packet generated will fill the frame and make it ready for transmission. But since memory dumps occur infrequently, the end of memory dump packet may remain in an incomplete frame for a significant time. The same is true of other packet types. The spacecraft fill packet fixes this. Each virtual channel has a fill packet with a unique APID to fill its incomplete frames.

The second spacecraft packet included in the MDFCB is the Attitude and Ephemeris packet whose data are required to geolocate the science data. A description of the science data is incomplete and meaningless if the attitude and ephemeris data are not included.

4.115.2 Modes and Packet Structure

The modes of the spacecraft and observatory are described in Section 3.2. Table 4.6.2-1 is similar to the tables in previous sections, showing the fill packet APID, data rate and packet size. In this case, the data rate is listed by instrument mode, not the spacecraft mode.

Table 4.115.2-1 Spacecraft Mission Data Packet Types

$APID_{10}$	Telemetry Packet Name	Data Rate (bps) by Mode	Packet Size (octets)
		Operational or Diagnostic	
11	Ephemeris/Attitude Message	568	71
100	S/C Test / Fill Packet	164,400	2055
101	S/C Test / Fill Packet	164,400	2055
102	S/C Test / Fill Packet	164,400	2055
103	S/C Test / Fill Packet	164,400	2055
104	S/C Test / Fill Packet	164,400	2055
105	S/C Test / Fill Packet	164,400	2055
106	S/C Test / Fill Packet	164,400	2055
107	S/C Test / Fill Packet	164,400	2055
108	S/C Test / Fill Packet	164,400	2055
109	S/C Test / Fill Packet	164,400	2055
110	S/C Test / Fill Packet	164,400	2055
111	S/C Test / Fill Packet	164,400	2055
112	S/C Test / Fill Packet	164,400	2055
113	S/C Test / Fill Packet	164,400	2055
114	S/C Test / Fill Packet	164,400	2055
115	S/C Test / Fill Packet	164,400	2055
116	S/C Test / Fill Packet	164,400	2055
117	S/C Test / Fill Packet	164,400	2055
118	S/C Test / Fill Packet	164,400	2055
119	S/C Test / Fill Packet	164,400	2055
120	S/C Test / Fill Packet	164,400	2055
121	S/C Test / Fill Packet	164,400	2055
122	S/C Test / Fill Packet	164,400	2055
123	S/C Test / Fill Packet	164,400	2055
124	S/C Test / Fill Packet	164,400	2055
125	S/C Test / Fill Packet	164,400	2055
126	S/C Test / Fill Packet	164,400	2055
127	S/C Test / Fill Packet	164,400	2055
128	S/C Test / Fill Packet	164,400	2055
129	S/C Test / Fill Packet	164,400	2055
130	S/C Test / Fill Packet	164,400	2055
131	S/C Test / Fill Packet	164,400	2055

4.115.3 Mission Data

All fields in the spacecraft mission data packets documented below are big endian.

4.115.3.1 *Test / Fill Packet*

The spacecraft generates Test / Fill packets (APID 100-131) at a 10 Hz rate when enabled. A command to the satellite is necessary to enable or disable generation of a given Test/Fill packet. Only one Test/Fill packet (i.e. single APID) can be enabled at a time. APID 121 is expected to be enabled during instrument memory dumps. The packet size is 2055 bytes. The structure of APIDs 100-131 are identical and are shown in Figure 4.6-1. Since the content of the Test / Fill packet is a fixed pattern that does not need to be interpreted, there is no User Data Field Table. Test / Fill packet header and user field structure is also attached in an XML formatted file in Appendix B.

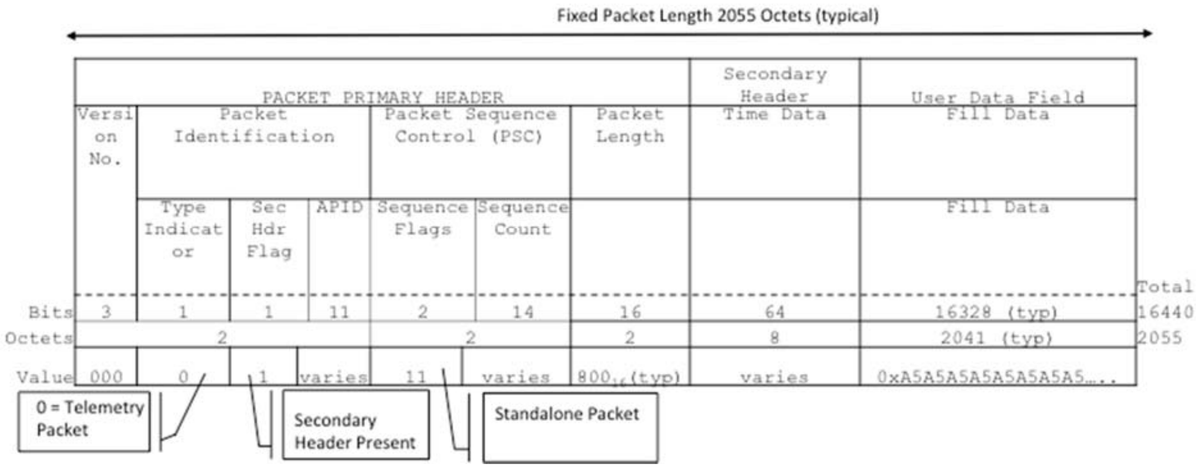

Figure 4.6-1 Spacecraft Test / Fill Packet Format

4.115.3.2 *Attitude and Ephemeris Packet*

The spacecraft generates one Attitude and Ephemeris packet (APID 11) every second. Each packet contains a time field for position and velocity, the position and velocity coordinates of the satellite, a time field for attitude, and attitude quaternions of the satellite. The position and velocity coordinates are in GPS Earth Centered Earth Fixed (ECEF) coordinates. The Control Frame Attitude Quaternions are relative to J2000, The quaternion Q is defined as Q = Q1i + Q2j + Q3k + Q4. The quantity Q4 is the scalar part of the quaternion and Q1i + Q2j + Q3k is the vector part. The packets are 71 bytes fixed length. The Attitude and Ephemeris packet header and user field structure is attached in an XML formatted file in Appendix B.

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Appendix A. Acronyms and Abbreviations

μsec	microsecond
-A-	
A/D	Analog to Digital
ACA	Azimuth Control Assembly
ADC	Analog to Digital Converter
ADC	Analog-to-digital Converter
ADCS	Attitude Determination and Control System
APID	Application Process Identifier
ASP	Analog Signal Processor
ATMS	Advanced Technology Microwave Sounder
A-to-D	Analog to Digital
-B-	
BATC	Ball Aerospace & Technologies Corp.
BB	Black Body
BCP	Ball Commercial Platform
bps	Bits per seconds
Bps	Bytes per Second
BSA	Biaxial Scan Assembly
-C-	
C&T	Command and Telemetry
C3S	Command, Control and Communications Segment
CADU	Channel Access Data Unit
CBIT	Continuous Built-In Test
CCA	Circuit Card Assembly
CCD	Charged Coupled Device
CCSDS	Consultative Committee for Space Data Systems
CDP	Command and Data Processor
CDRL	Contract Data Requirements List
CERES	Clouds and Earth's Radiant Energy System
CMD	Command
CMLB	Ceramic Multi-Layered Board
CONOPS	Concept of Operations
cPCI	Compact Peripheral Component Interface
CPU	Central Processing Unit
CrIMSS	Cross-track Infrared and Microwave Sounding Suite
CrIS	Cross-track Infrared Sounder
CSO	Cavity Stabilized Oscillator
CSS	Coarse Sun Sensor
CVCDU	Coded Virtual Channel Data Unit
-D-	
DA	Dynamic Alignment
DAA	Data Acquisition Assembly
DAP	Data Acquisition Processor

DPGD	Data Product Generation Database
DCA	Data Acquisition Converter Assembly
Dec	Decimal (base 10)
DF	Data Format
DFB	Distributed Feedback
DID	Data Item Description
DMA	Direct Memory Access
DMP	Dump
DN	Digital Number
DNB	Day Night Band
DOY	Day of Year
DPLX	Duplex
DPP	Digital Preprocessor
DSP	Digital Signal Processor
DTU	Digital Telemetry Unit
DWL	Dwell

-E-

ECA	Elevation Control Assembly
ECEF	Earth Centered Earth Fixed
EDR	Environmental Data Record
EEPROM	Electronically Erasable Programmable Read Only Memory
EMI	Electromagnetic Interference
Engr	Engineering
EOS	Earth Observing System
EPM	Earth-Pointing Mode

-F-

FIR	Finite Impulse Response
FOR	Field of Regard
FOV	Field of View
FPA	Focal Plane Array
FPGA	Field Programmable Gate Array
FSW	Flight Software
FTS	Fourier Transform Spectrometer

-G-

GDO	Gunn Diode Oscillator
GHz	gigahertz
GPS	Global Positioning System
GSFC	Goddard Space Flight Center

-H-

Hex	Hexadecimal (base 16)
HgCdTe	Mercury Cadmium Telluride
HK	Housekeeping
HKPG	Housekeeping
HOP	High Output Paraffin
HRD	High-Rate Data

HSK, Hskp	Housekeeping
HW	Hardware
Hz	Hertz (not the rental cars)

-I-

I/O	Input/Output
IBIT	Initiated Built-in Test
ICD	Interface Control Document
ICM	Instrument Calibration Module
ICP	Instrument Control Processor
ICSBB	Internal Calibration Source Blackbody
ICT	Internal Calibration Target
ID	Identifier
IDPS	Interface Data Processing Segment
IE	Interferometer Electronics
IF	Interface
IFC	Instrument Flight Computer
IFOV	Instrument Field of View or Image Field of View
ILS	Instrument Line Shape
IM	Interferometer Module
IOC	In-orbit Checkout
IPO	Integrated Program Office
IR	Infrared
IRD	Interface Requirements Document
IRU	Inertial Reference Unit

-J-

JFET	Junction Field Effect Transistor

-K-

KAV	Ka and V Bands
KAV_WL	Ka and V Bands Warm Load (Calibration Target)
kb	kilobit
kB	kilobyte
kib	decimal kilobit (1000 bits)
Kib/s	kilobits per second
km	kilometer

-L-

LED	Light Emitting Diode
LEO&A	Launch, Early Orbit & Acquisition
LEO&A	Launch, Early Orbit & Anomaly
LGS	Low Gain Setting
LPC	Limb Profiler Calibration
LPL	Limb Profiler Long
LPS	Limb Profiler Short
LRD	Low-Rate Data
LSB	Least Significant Byte
LSW	Least Significant Word

LVDS	Low Voltage Differential Signaling
LW	Longwave
LWIR	Long Wave Infrared

-M-

M_PDU	Multiplexing Protocol Data Unit
MAM	Mirror Attenuator Mosaic
Mb	Megabit
Mbps	Megabits per second
MBps	Megabytes per second
MBytes	Megabytes
MCT	Mercury Cadmium Telluride
MDF	Mission Data Formatter
MEB	Main Electronics Box
MGS	Medium Gain Setting
MHz	Megahertz
MLI	Multilayer Insulation
MMC	Mission Management Center
MPD	Maximum Path Difference
MPM	Mission-Pointing Mode
MSB	Most Significant Byte (or bit)
msec	millisecond
MSW	Most Significant Word
MUX	Multiplexer
MWIR	Mid-wave Infrared

-N-

N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NEdT	Noise Equivalent Spectral Radiance
NGES	Northrop-Grumman Electronic Systems
NGST	Northrop-Grumman Space Technology
nm	Nanometers
NP	Nadir Profile
NPC	Nadir Profiler Calibration
NPOESS	National Polar-Orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NRZ-L	Non-Return to Zero - Level
NRZ-M	Non-Return to Zero - Mark
NTC	Nadir Total Column
NVM	Non-volatile Memory

-O-

OCD	Operational Concept Description
OCXO	Oven Controlled Crystal Oscillator
OIW	Offset in Words
OMA	Opto-Mechanical Assembly
OMPS	Ozone Mapping Profiling Suite
OPD	Optical Path Difference

-P-

P/A	Preamp
PAM	Passive Analog Monitor
PAT	Passive Analog Temperature
PCA	Power Converter Assembly
PCE	Processing and Control Electronics
PGA	Programmable Gain Amplifier
pkt	Packet
PLB	Payload Bus
PRT	Platinum Resistance Temperature
PS	Porchswing

-Q-

QPSK	Quadrature Phase Shift Key

-R-

R/T	Real-Time
RAD	Radiation
RAM	Random Access Memory
RDR	Raw Data Record
RF	Radio Frequency
RFE	Receiver Front Ends
RPS	Receiver Power Supply
R-S	Reed-Solomon
R/T	Real-Time

-S-

S/C	Spacecraft
SAW	Surface Acoustic Wave
SBRS	Santa Barbara Remote Sensing (Raytheon SAS)
SCC	Spacecraft Control Computer
SCIF	Spacecraft Interface board
SD	Solar Diffuser
SDE	Scan Drive Electronics
SDM	Scan Drive Mechanism
SDR	Sensor Data Record
SDSM	Solar Diffuser Stability Monitor
SMA	Sensor Module Assembly
SMCA	Survival Mode Configuration Assembly
SMD	Stored Mission Data
SNR	Signal to Noise Ratio
SOC	State-of-Charge
SPA	Signal Processing Assembly
SPM	Sun-Pointing Mode
SPS	Solar Presence Sensors
SQPSK	Staggered Quadrature Phase Shift Key
SS	Space Segment
SSA	Sensor Scan Assembly

SSM	Scene Selection Module
SSR	Solid State Recorder
SV	Space View
SW	Shortwave
SWICS	Shortwave Internal Calibration Source
SWIR	Shortwave Infrared

-T-

TBD	To be determined
TBS	To be supplied
TBR	To be resolved
TC	Total Column, Total Channel
TCC	Total Column Calibration
TDD	Table Description Document
TDRSS	Tracking Data Relay Satellite System
TEC	Thermal Electric Cooler
TID	Table Identifier
TLM	Telemetry
Tlmy	Telemetry
TPG	Timing Pattern Generator

-U-

UART	Universal Asynchronous Receiver/Transmitter
UP	Uninterruptible Power
UPS	Uninterruptible Power Supply
UTC	Coordinated Universal Time

-V-

VC	Virtual Channel
VCDU	Virtual Channel Data Unit
VCID	Virtual Channel Identifier
VD	Video Digitizer
VIIRS	Visible Infrared Imaging Radiometer Suite

-W-

WG	W and G Bands
WG_WL	W and G Band Warm Load (Calibration target)

-XYZ-

XML	Extensible Markup Language
ZnSe	Zinc Selenium
ZPD	Zero Path Difference

Appendix B Spacecraft Mission Data Packet Structure XML Files

The Spacecraft Mission Data Packet Structure XML files can be extracted from the attached file, 472-00251_AppendixB-Spacecraft_Packet_XMLs.zip.

The Ground Project provided JPSS CGS Application Packet Schema (474-00629) was used to generate the application packet structure XMLs. The Ground Project also provided an excel template and macro that was used to generate these VIIRS XMLs. These excel files are also included in 472-00251_AppendixB-Spacecraft_Packet_XMLs.zip.