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OPERATIONAL LAND IMAGER (OLI) / NATIONAL POLAR OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) 2130 SPACECRAFT INTERFACE REQUIREMENTS

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National Aeronautics and Space Administration

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Greenbelt, Maryland

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Sheet: 1 of 1

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TABLE OF CONTENTS

Page

1 OLI / NPOESS GIID Compliance 1-1
2 OLI / NPOESS Mass, Volume, and Power Accommodation 2-1
3 OLI / NPOESS Field of View Accommodation 3-3
3.1 Nadir Field of View 3-3
3.1.1 Unobstructed Field of View 3-3
3.1.2 Glint-Free Field of View 3-3
3.2 Solar Calibration Field of View 3-4
3.2.1 Unobstructed Field of View 3-4
3.2.2 Glint-Free Field of View 3-4
4 NPOESS 2130 Orbit Requirements for OLI 4-5
4.1 Orbit Parameters 4-5
4.2 Cross-Track Repeat Cycle Variability 4-5
5 NPOESS OLI Stored Mission Data Interface 5-1
5.1 Operational Concept 5-1
5.2 OLI Stored Mission Data Interface Circuit 5-1
5.3 Mission Data Transfer Timing 5-2
5.4 OLI Mission Data Transfer Interface Data Format 5-3
5.4.1 OLI Mission Data Packet Format 5-4
6 OLI Command, Telemetry, Time and Ancillary Data Interfaces 6-1
6.1 Command and Telemetry Interfaces 6-1
6.1.1 Telemetry Formatting 6-1
6.1.2 Number of Functionally Distinct Instrument Remote Terminals 6-1
6.1.3 RT Physical Address Assignment 6-1
6.1.4 OLI Combined Data Bus Rates 6-1
6.2 OLI Auxiliary Data Input from NPOESS Spacecraft 6-2
6.3 OLI Time of Day Input from NPOESS Spacecraft 6-2
7 Telemetry and Command Requirements 7-1
7.1 Command Uploads 7-1
7.2 OLI Non-operational Point to Point Telemetry Interfaces 7-1
7.3 Realtime Monitoring and Autonomous Fault Detection and Correction 7-1
8 NPOESS Disturbance environment at oli instrument interface 8-1
8.1 RBS Alignment Knowledge Uncertainty between Spacecraft Attitude Determination Frame and the RBS Instrument Interface Reference – Absolute 8-1
8.2 Alignment Knowledge Uncertainty between S/C Attitude Determination Frame and the RBS Interface Reference (over a 17day Orbital Cycle) 8-1
8.3 Alignment Knowledge Uncertainty between S/C Attitude Determination Frame and the RBS Instrument Interface Reference (over a 30 sec along track interval) 8-1
8.4 Disturbance Spectra at the Spacecraft-Instrument Interface 8-1
8.4.1 Spacecraft Rotational Disturbance Environment 8-1
8.4.2 Spacecraft Linear Disturbance Environment 8-3
9 OLI Point to Point CMD/TLM Interfaces 9-1

9.1 Pulse Commands 9-1
10 OLI –NPOESS Thermal Interface RequirementS 10-1
10.1 Thermal Fields of View 10-1
Appendix A: Disturbance Sensitivity Curves 1

LIST OF FIGURES

Figure Page

LIST OF TABLES

Table Page

Table 2-1 OLI Mass / Volume / Power NTE Envelopes 2-1

Table 6-1 NPOESS Spacecraft Ancillary Data Update Rate and Accuracy for OLI Interface ... 6-2

OLI / NPOESS 2130 SPACECRAFT INTERFACE REQUIREMENTS

1 OLI / NPOESS GIID COMPLIANCE

Unless otherwise stated in the sections below, the OLI shall comply with all current requirements in the NPOESS General Instrument Interface Document (GIID), Doc. No. D31418 Rev. B (in bidders' library)

2 OLI / NPOESS MASS, VOLUME, AND POWER ACCOMMODATION

The NPOESS 2130 Spacecraft shall accommodate an OLI that meets the not-to-exceed (NTE) mass, volume, and power interface envelopes for those values specified in Table 2-1 (volume envelopes illustrated in Figure 2-1) and in the candidate location indicated in Figure 2-2.

Calibration deployed volume shall occur no more than 20 (TBR) continuous minutes in duration nominally once per week. Shorter duration temporary exceedences of the stowed / operational volume shall be negotiated between the OLI and NPOESS contractors on a case-by-case basis.

The stowed volume does not preclude placement of other OLI subsystems (e.g. DSAP) within the NPOESS 2130 spacecraft if feasible (to be negotiated with IPO/ NGST).

	Mass	Stowed / Operational Volume	Calibration Deployed Volume (TBC)	Average Orbital Power	Peak Power
OLI Total	400kg **(TBC)**	1.5m (z) **(TBC)** by 1.2m (x) by 1.2m (y) (see figures 2-2 and 2-3 below)	2.0m (z) by 1.2m (x) by 1.2m (y)	425 Watts	510 Watts

Table 2-1 OLI Mass / Volume / Power NTE Envelope

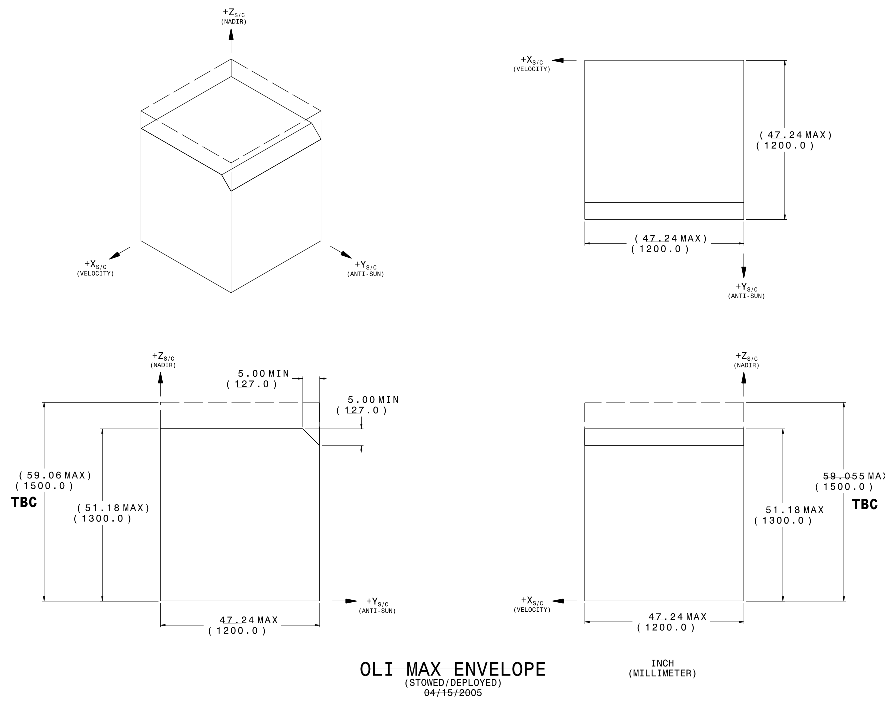

Figure 2-1 Illustration of OLI Stowed / Deployed Volume Envelopes

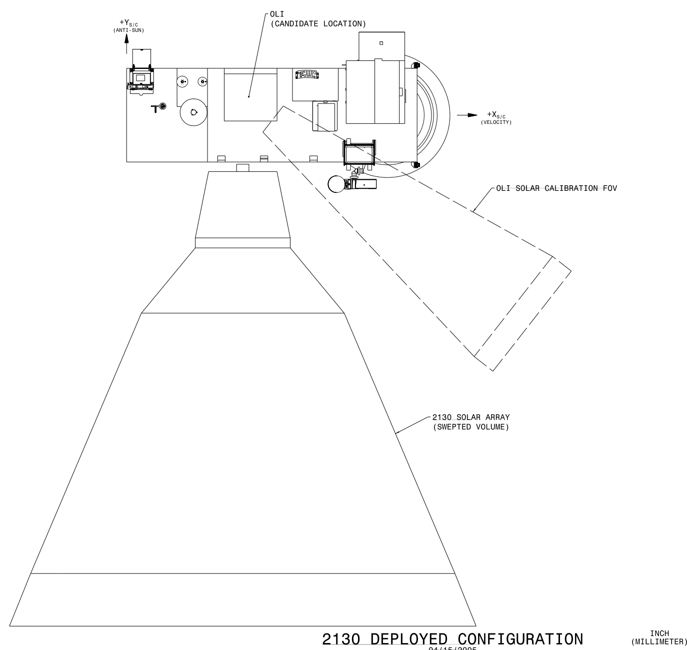

Figure 2-2 Candidate Location for OLI on NPOESS 2130 Spacecraft

3 OLI / NPOESS FIELD OF VIEW ACCOMMODATION

3.1 Nadir Field of View

3.1.1 Unobstructed Field of View

The NPOESS 2130 Spacecraft shall provide an unobstructed minimum nadir field of view for OLI which provides a 12.9 degree cross track width by at least 1.7 degree along track length. (Figure 3-1, left)

3.1.2 Glint-Free Field of View

The NPOESS 2130 Spacecraft shall provide the OLI an unobstructed FOV within a conical **25° (TBC)** half angle of optical nadir to minimize collection of scattered energy. The cone's circular intersection on the +Z face shall envelope the oval-shaped nadir port aperture. (Figure 3-1, right).

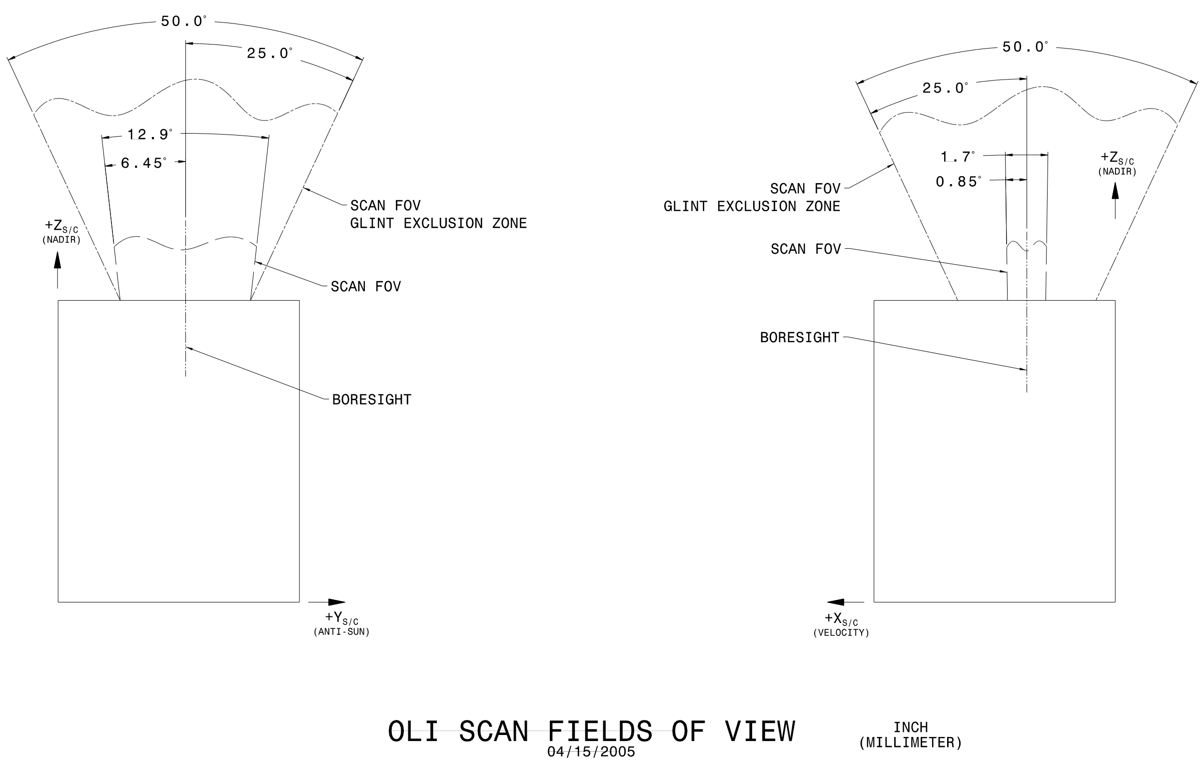

Figure 3-1 OLI Unobstructed (Left) and Glint-Free (Right) Nadir Fields of View

3.2 Solar Calibration Field of View

3.2.1 Unobstructed Field of View

The NPOESS 2130 Spacecraft shall provide the OLI with a solar calibration field of view unobstructed by spacecraft structures for any time of the year across a range of solar elevation angles from **-15° to -25° (TBC)** relative to the local horizontal for either the post eclipse exit portion of the orbit (for a forward facing solar diffuser) or the pre eclipse entrance portion of the orbit (for an aft facing solar diffuser). To cover the seasonal variation in the solar azimuthal position, the clear solar calibration field of view for the indicated solar elevation range shall be **38°± 8° (TBC)** in azimuth towards the sun side from the velocity vector or anti-velocity vector, respectively, for the post eclipse exit or pre-eclipse entrance portions of the orbit. (Figure 3-2, left)

3.2.2 Glint-Free Field of View

The NPOESS 2130 Spacecraft shall provide the OLI an unobstructed FOV within a region bounded by **–10 to –30° (TBC)** in elevation and **38°± 60° (TBC)** in azimuth (towards the sun side) from the edges of the solar calibration port. The bounding surface of this region's intersection with the instrument shall envelope the rectangular shaped solar calibration aperture. (Figure 3-2, right).

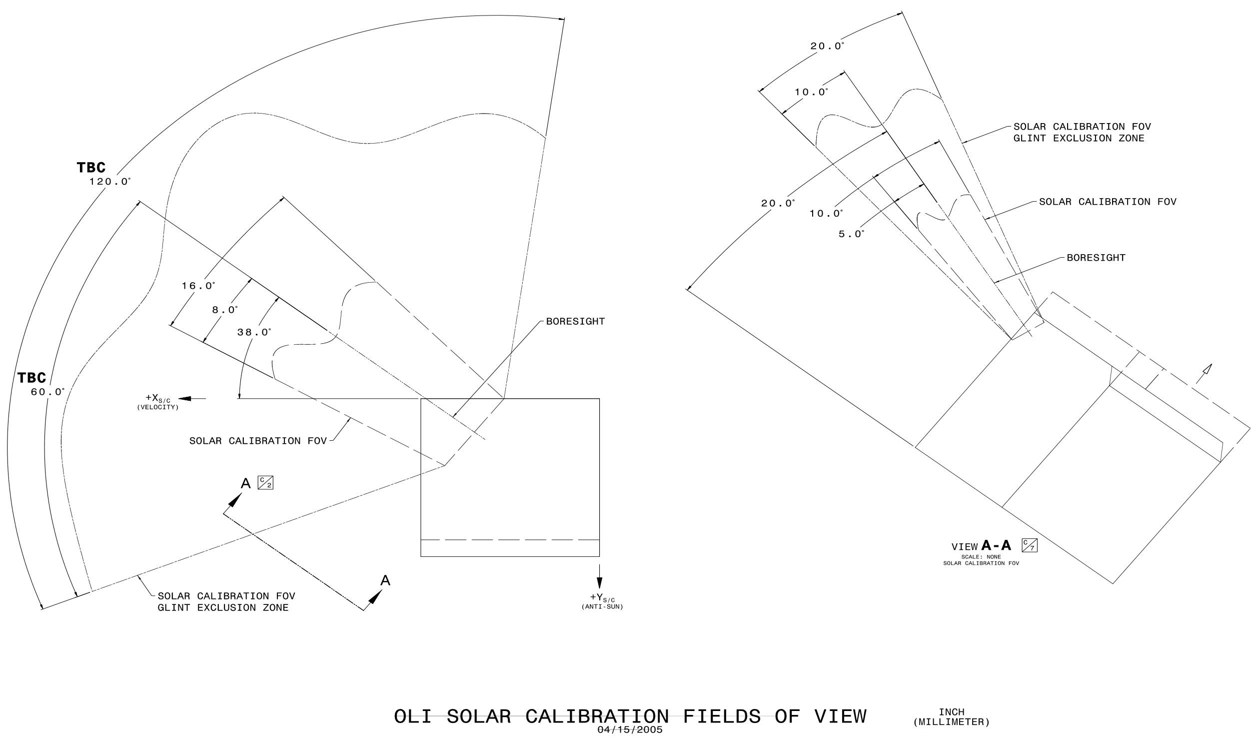

Figure 3-2 OLI Unobstructed (Left) and Glint-Free (Right) Solar Calibration Fields of View

4 NPOESS 2130 ORBIT REQUIREMENTS FOR OLI

4.1 Orbit Parameters

The NPOESS 2130 Spacecraft shall operate the OLI in a geodetically pointed 828km +/- 12km near circular sun synchronous orbit with a 17 day, 241-path repeatable ground track orbit inclined by 98.7 degrees with an equatorial ascending node crossing time of 2130hrs (+/- 10 minutes).

4.2 Cross-Track Repeat Cycle Variability

The NPOESS 2130 orbit cross-track repeat variability for the orbit defined in section 4.1 above shall not exceed +/-5 km per 17 day cycle.

5 NPOESS OLI STORED MISSION DATA INTERFACE

5.1 Operational Concept

NPOESS 2130 S/C transmits Stored Mission Data via a Ka-Band downlink to globally distributed ground receptor sites during the course of an orbit. The ground periodically uploads an SMD contact schedule (providing start times and durations for NPOESS and OLI access to the SMD downlink) good for 48 hours into the future. OLI access to the SMD downlink will be scheduled such that it will see an average transmission rate (over a 24-hour period) no less than 23 Mbps.

When it is OLI's turn to transmit SMD, as directed by the onboard contact schedule, a command will be sent by the S/C via the 1553B data bus activating the OLI Stored Mission Data Interface. Once activated, OLI monitors the state of a hardwired Ready signal (RCV_RDY, see below) and transfers a block of data each time the Ready signal transitions to a true state.

The OLI Stored Mission Data interface protocol is designed to allow transmission at a continuous 150 Mbps. Should OLI not respond to the Ready signal in a timely enough fashion, the S/C will insert a fill block into the downlink so as to maintain link data continuity. OLI's next transmission opportunity will occur following transmission of the fill block. At the end of the scheduled OLI SMD contact period, the S/C will no longer activate the Ready signal thus inhibiting further data transfer. A command will be sent by the S/C to OLI via the 1553B data bus deactivating the OLI Stored Mission Data interface.

5.2 OLI Stored Mission Data Interface Circuit

The OLI Mission Data Interface circuits shall comply with Low Voltage Differential Signal (LVDS).

The OLI Mission Data Interface configuration shall be as depicted in Figure 5-1.

The OLI Mission Data Interface signals shall consist of prime and redundant signals designated as RCV_RDY_X/, DATA(7:0)_X, DATA_CLK_X and ENABLE_X/ where the X in each signal name corresponds to either A or B depending upon the primary or redundant signal designation.

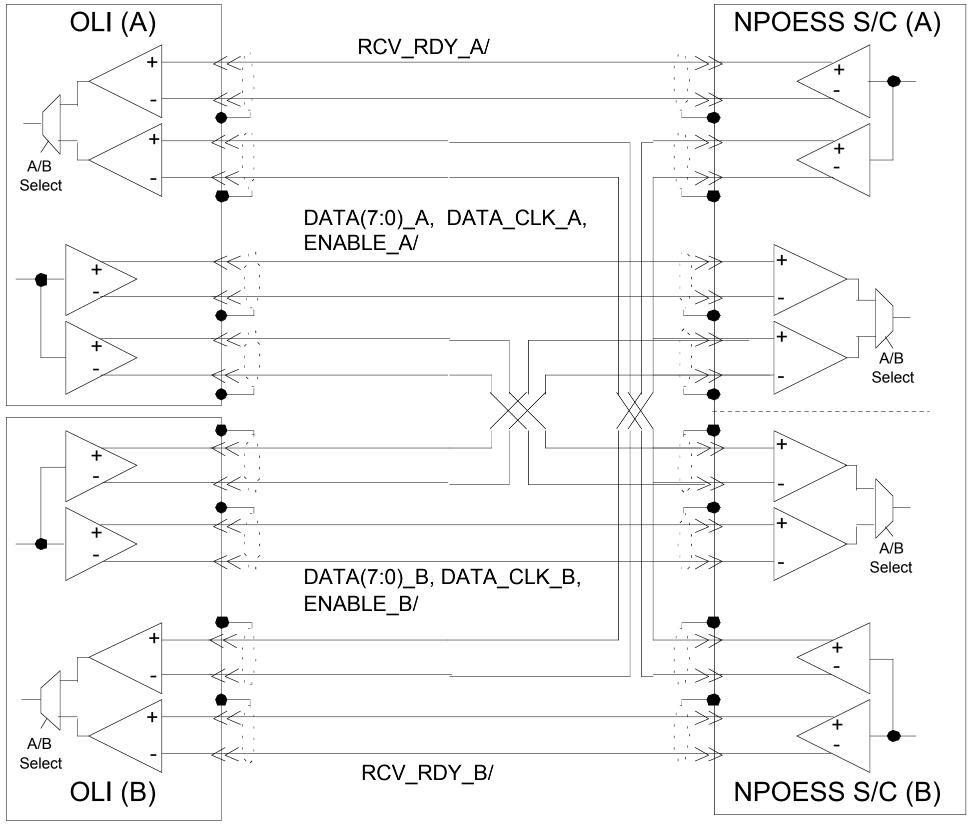

Figure 5-1 OLI Mission Data Interface Circuits

5.3 Mission Data Transfer Timing

Activation and deactivation of OLI Mission Data transfer shall be commanded via the 1553B data bus interface.

OLI Mission Data interface activation and deactivation commands shall be processed in OLI such that data transfers start and stop on block boundaries.

When OLI Mission Data Transfer is activated, data shall be transferred as a 1024 byte block, 8-bits (DATA(7:0)) per DATA_CLK, enveloped by the ENABLE signal for each inactive to active RCV_RDY transition. Note: The RCV_RDY may transition true prior to completion of the current block transfer.

The DATA_CLK signal shall be a 50% duty cycle square wave at 20 MHz.

OLI Mission Data Transfer Timing shall be as depicted in Figure 5-2.

The Delay from activation of RCV_RDY_X/ to start of data transmission shall be 1 us or less. Delays greater than 1us may result in the insertion of a fill block into the SMD downlink. Inserted fill blocks are considered part of the 23 Mbps rate allocation.

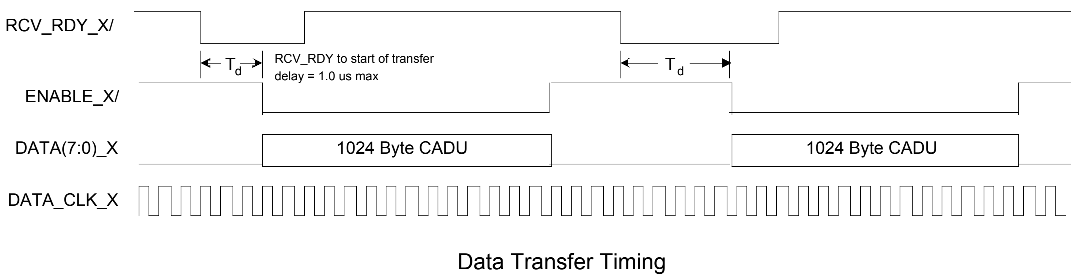

Figure 5-2 OLI Mission Data Transfer Timing

5.4 OLI Mission Data Transfer Interface Data Format

Each 1024 byte Data Block transferred via the OLI Mission Data interface shall be formatted as depicted in Figure 5-3.

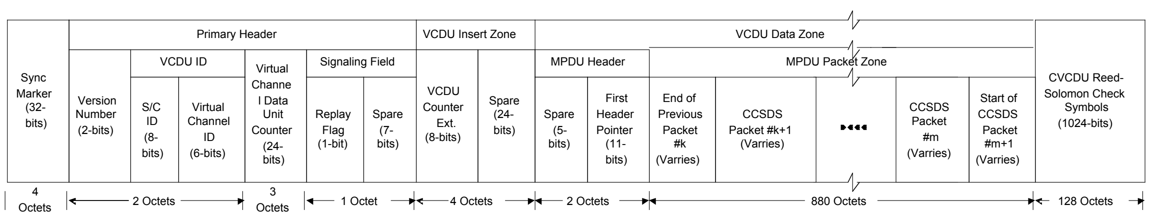

Figure 5-3 OLI Mission Data Interface Data Format

The fields within the format depicted in Figure 5-3 shall be correspond to an Interleave Depth 4, CCSDS Channel Access Data Unit as specified in CCSDS 701.0-B-2, Advanced Orbiting Systems, Networks and Data Links, except as noted below.

The S/C ID field shall be as specified in NPOESS Reference Document D35853, NPOESS Data Mapping APID, VCID, Downlink and Uplink.

The Virtual Channel ID field shall be as specified in NPOESS Reference Document D35853, NPOESS Data Mapping APID, VCID, Downlink and Uplink.

OLI shall be capable of modifying the assigned S/C ID and VCID values without disassembly.

The 24-bit Virtual Channel Data Unit Counter field shall be lengthened by eight bits using the VCDU Counter Extension field resident in the Insert zone.

The VCDU Counter Extension field shall form the MSBs of the total 32-bit Virtual Channel Data Unit Counter.

The Replay Flag shall not be used and set to ‘0’.

Spare fields shall be set to ‘0’s.

The First Header Pointer field shall be set per CCSDS 701.0-B-2, Advanced Orbiting Systems, Networks and Data Links.

The MPDU Packet zone shall contain multiplexed OLI Mission Data Packets.

5.4.1 OLI Mission Data Packet Format

The OLI Mission Data Packet shall be formatted per CCSDS 701.0-B-2 and 301.0-B-2 using the CCSDS path Protocol Data Unit (CP_PDU) format (also known as Version 1 Source Packet.

OLI Mission Data Packet size shall be limited to no more than 65,507 bytes including all headers.

OLI Mission Data Packets shall be formatted with an Application Process ID value(s) of TBD.

6 OLI COMMAND, TELEMETRY, TIME AND ANCILLARY DATA INTERFACES

6.1 Command and Telemetry Interfaces

The NPOESS / OLI Command and Telemetry interface shall be MIL-STD-1553B interface in compliance with the requirements in NPOESS reference document D34470, NPOESS 1553 Interface Requirements Document except as tailored in the subsections below.

6.1.1 Telemetry Formatting

The 1553B interface shall be utilized for the transfer of Test, Memory Dump, Dwell, Housekeeping, LEO&A and Telemetry Monitor packets types (if utilized) specified in D34470, NPOESS 1553 Interface Requirements Document.

Engineering, Calibration, Diagnostic and Science packet types shall not be transferred via 1553B.

6.1.2 Number of Functionally Distinct Instrument Remote Terminals

OLI shall have no more than two dual redundant RT interfaces coupled to the data bus.

6.1.3 RT Physical Address Assignment

OLI's RT physical addresses shall be assigned as TBD.

6.1.4 OLI Combined Data Bus Rates

Peak data rates for OLI to S/C data transfers on the 1553B data bus shall not exceed 2.048 kbps.

Should there be higher rate data transfers required, those higher rate data types will be transferred via the OLI Stored Mission Data Interface.

Peak data rates on the 1553B bus for S/C to OLI data transfers (Commands, Time of Day, Ancillary and Uploads) shall not exceed TBD bps.

It is recommended that OLI be designed to accept an input rate up to 128 kbps for commands and uploads. This rate assumes that the entire uplink rate in a given uplink contact period is dedicated to OLI. The actual input rate will be a function of how much of an uplink contact is allocated to OLI versus NPOESS.

6.2 OLI Auxiliary Data Input from NPOESS Spacecraft

The NPOESS 2130 spacecraft Command and Data Handling System shall provide the OLI with periodic auxiliary data at the specified update in Table 6-1. Detailed auxiliary data contents and formatting shall be defined in the OLI-NPOESS 2130 ICD.

Spacecraft Parameter	Minimum Update Rate	Accuracy 3 sigma	Accuracy of Time Correlation to GPS Time, 3 sigma
Measured attitude with respect to body frame	5.0Hz	15 arc-sec	48 microsec
Individual gyro axis rate data	32hz	2.25 arc-sec over 30 sec window	48 microsec
RT Ephemeris Calculation	1.0 Hz	30m	48 microsec

Table 6-1 NPOESS Spacecraft Ancillary Data Update Rate and Accuracy for OLI Interface

6.3 OLI Time of Day Input from NPOESS Spacecraft

The NPOESS / OLI Time of Day interface shall be as specified in NPOESS reference document D34470, NPOESS 1553 Interface Requirements Document except as tailored below.

The Time of Day sent in the TOD packet shall correspond to international standard UTC time at the occurrence of the TOD pulse +/- 200 us TBD.

7 TELEMETRY AND COMMAND REQUIREMENTS

7.1 Command Uploads

The OLI-NPOESS spacecraft command interface shall support daily command uploads from the of NPOESS MOC command sequences which provide autonomous operations of the OLI for 48hour periods

7.2 OLI Non-operational Point to Point Telemetry Interfaces

The OLI-NPOESS Spacecraft interface shall provide real-time monitoring of critical OLI instrument health and safety parameters during periods where the instrument is non-operational (powered off)

7.3 Realtime Monitoring and Autonomous Fault Detection and Correction

The NPOESS 2130 spacecraft shall provide real-time monitoring and autonomous fault detection and correction of critical OLI health and safety telemetry of the OLI whether operationally powered on or powered off.

OLI shall provide to the S/C all monitor points requiring real-time monitoring in a standalone TMON Packet.

OLI shall provide to the S/C the autonomous fault response algorithm for each TMON monitor point.

8 NPOESS DISTURBANCE ENVIRONMENT AT OLI INSTRUMENT INTERFACE

8.1 RBS Alignment Knowledge Uncertainty between Spacecraft Attitude Determination Frame and the RBS Instrument Interface Reference – Absolute

The NPOESS / OLI interface shall ensure that the alignment between the NPOESS 2130 spacecraft attitude determination frame and the RBS instrument interface shall be known to an accuracy of 75 arc-sec (3-sigma), or less. Prelaunch alignment knowledge data shall be provided by the spacecraft contractor.

8.2 Alignment Knowledge Uncertainty between S/C Attitude Determination Frame and the RBS Interface Reference (over a 17day Orbital Cycle)

The NPOESS / OLI interface shall ensure that the alignment between the NPOESS 2130 spacecraft attitude determination frame and the RBS instrument interface shall be known to within 40 arc-sec (3-sigma) or less over a period of 17 days.

8.3 Alignment Knowledge Uncertainty between S/C Attitude Determination Frame and the RBS Instrument Interface Reference (over a 30 sec along track interval)

The NPOESS / OLI interface shall be such that the alignment between the NPOESS 2130 spacecraft attitude determination frame and the RBS instrument interface, including the effects of jitter, shall be stable to within 40 arc-sec (3-sigma) or less over a period of 30 seconds.

8.4 Disturbance Spectra at the Spacecraft-Instrument Interface (TBC)

This section provides sensitivity functions that relate the disturbance imparted by the spacecraft at the spacecraft-instrument interface, to the instrument data quality metrics of image smear and row-to-row sampling error.

8.4.1 Spacecraft Rotational Disturbance Environment (TBC)

The combined effects of rotational and linear (see section 8.4.2) disturbances in all axes from the NPOESS 2130 spacecraft shall contribute an RSS of less than 7.2 microradians in each axis after multiplication by the transfer functions of Figure 8-1 and Figure 8-2. This RSS is computed by weighting the spacecraft rotational and linear disturbance spectra between 0.01 Hz and 1000 Hz by the instrument sensitivity transfer functions and integrating.

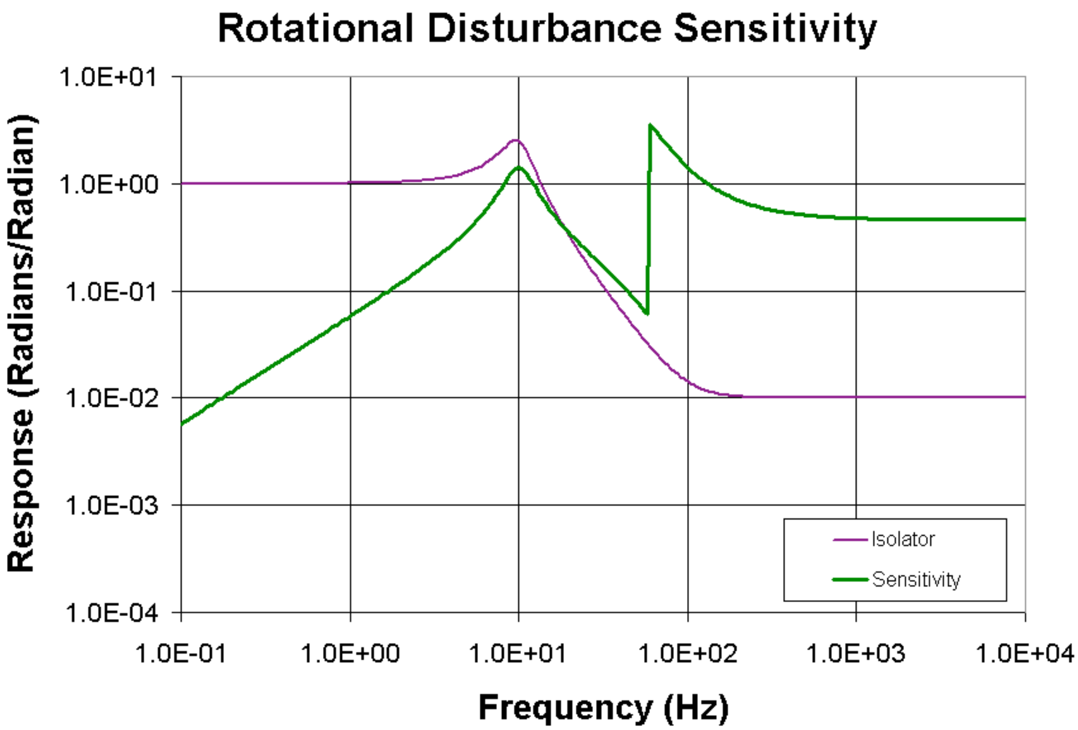

Figure 8-1 Sensitivity to the Spacecraft Rotational Disturbance Environment (TBC)

8.4.2 Spacecraft Linear Disturbance Environment (TBC)

The combined effects of rotational (see section 8.4.1) and linear disturbances in all axes from the NPOESS 2130 spacecraft shall contribute an RSS of less than 7.2 microradians in each axis after multiplication by the transfer functions of Figure 8-1 and Figure 8-2. This RSS is computed by weighting the spacecraft rotational and linear disturbance spectra between 0.01 Hz and 1000 Hz by the instrument sensitivity transfer functions and integrating.

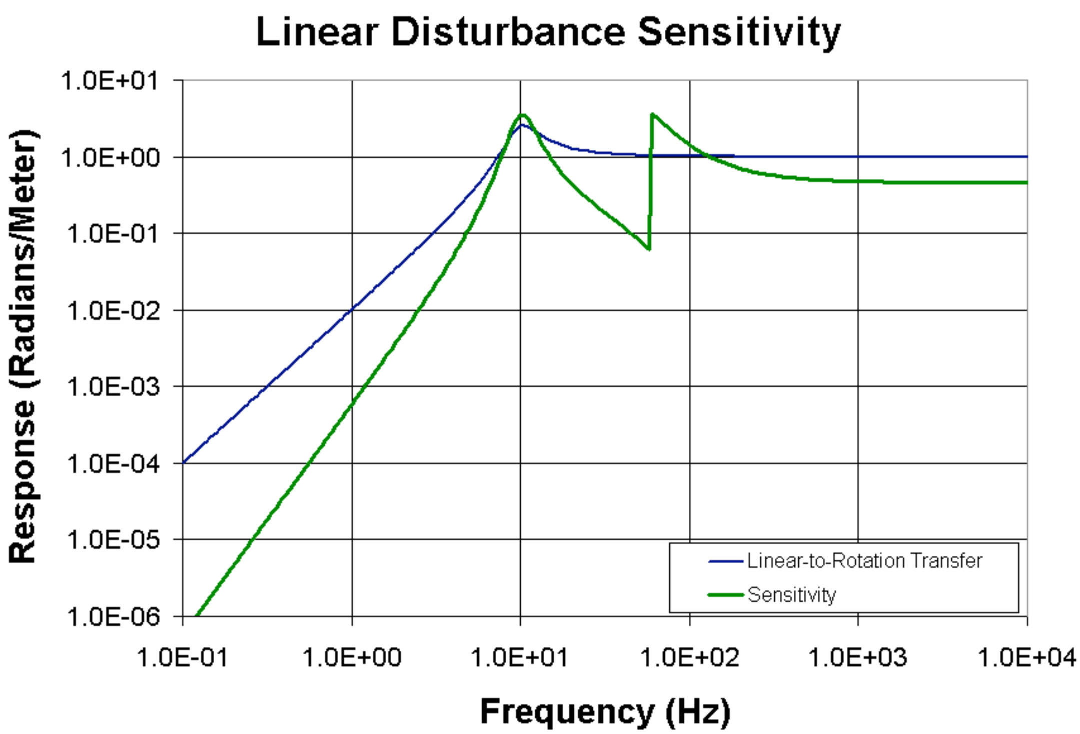

Figure 8-2 Sensitivity to the Spacecraft Linear Disturbance Environment (TBC)

9 OLI POINT TO POINT CMD/TLM INTERFACES

The NPOESS / OLI Command and Telemetry point to point interfaces shall comply with the requirements in NPOESS reference document D31418, NPOESS General Instrument Interface Document except as tailored in the subsections below.

9.1 Pulse Commands

OLI shall require no more than 6 (six) pulse command interfaces.

The Logic one state pulse command voltage shall be 20V min @350 mA load sink current.

10 OLI –NPOESS THERMAL INTERFACE REQUIREMENTS

10.1 Thermal Fields of View

The NPOESS 2130 spacecraft shall provide accommodation not to exceed TBD square meters of OLI Thermal radiators as mutually agreed to by the OLI and NPOESS 2130 Spacecraft Contractors. This area shall be located 1) as close as possible to the +Y (cold) edge of the spacecraft structure and 2) in the spacecraft X-Z plane. This area shall have a minimally obstructed (TBR) hemispherical FOV. Actual area shall be negotiate

Thermal analysis shall verify the heat transfer adequacy of the final mounting location. Details of adjacent hardware within the OLI thermal FOV shall be provided by the spacecraft to a mutually agreed upon level of fidelity.

Appendix A: Disturbance Sensitivity Curves

The sensitivity curves shown in section 8.4 were derived by combining an assumed isolation system transfer function, $\mathbf{G}_{isolator}(\omega)$, with image quality sensitivity functions, $\mathbf{G}_{sensitivity}(\omega)$, based on assumed instrument characteristics. This is shown in figure A-1.

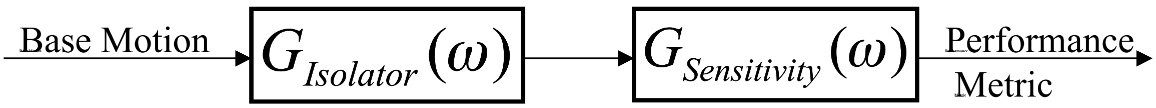

Figure A-1 Relating Disturbance Input to Performance Metrics

The isolator model used for the curves in section 8.4 is:

$$G_{isolator}(s) = (s^2/\omega_2^2 + 2\zeta_2 s/\omega_2 + 1)/(s^2/\omega_1^2 + 2\zeta_1 s/\omega_1 + 1)$$

with:

$\omega_1 = 2\pi * 10$
$\omega_2 = 2\pi * 100$
$\zeta_1 = 0.2$
$\zeta_2 = 0.707$

The sensitivity function for image smear is:

$$G_{smear}(\omega) = \sqrt{(1 - Sinc(\omega t_i))/2} \qquad \omega \le 3/2 \cdot \pi / t_i$$
$$= \sqrt{(1 + 1/(\omega t_i))/2} \qquad \omega > 3/2 \cdot \pi / t_i$$

with:

t_i = 0.0045 seconds (integration time).

The sensitivity function for row-to-row sampling shift is:

$$G_{shift}(\omega) = 2 Sinc(\omega t_i / 2) \cdot \sin(\omega t_{sh} / 2) \qquad \omega \le \pi / t_{sh}$$
$$= 2 Sinc(\omega t_i / 2) \qquad \pi / t_{sh} < \omega \le \pi / t_i$$
$$= 2/(\omega t_i / 2) \qquad \omega > \pi / t_i$$

with:

t_{sh} = 0.0090 seconds (even-odd detector row delay).

The sensitivity is amplified by internal resonance in the RBS structure. The model for this is:

$$G_{resonance}(\omega) = 1 \qquad \omega < \omega_0$$
$$= Q_r \cdot L_o \qquad \omega \geq \omega_0$$

with:

$\omega_0 = 2\pi * 50$ = resonant frequency
$Q_r = 50$ = mechanical Q of resonance
$L_o = 1.296$ = optical lever

The combined sensitivity function is the root-sum-square of the smear and shift sensitivities with the resonance function applied. The rotational disturbance sensitivity function used in section 8.4.1 is thus:

$$G_{sensitivity}(\omega) = G_{resonance}(\omega)\sqrt{\left(G_{smear}(\omega)\right)^2 + \left(G_{shift}(\omega)\right)^2}$$

The parameter values used here are nominal. Both the functions and the parameter values must be adjusted to reflect the actual OLI design.