CCR Number: 0005R1	CRITICALITY: ROUTINE	DUE:05/01/98

DISTRIBUTION SHEET

EO-1 LEVEL II CCB

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NEW MILLENNIUM PROJECT CONFIGURATION CHANGE REQUEST

PROGRAM EO-1 CCR NO. 0005R1 DATE INITIATED 04/14/98	TITLE BASELINE EO-1 S/C TO GPS NAVIGATION SENSOR ICD-025 ORIGINATOR GSFC Code 712 ORIGINATOR'S CHG. NO. EO-1 ICD-025 SPONSOR/CODE N. Speciale/EO-1 Mission Tech PHONE x8704

EFFECTIVITY

ITEM: GPS
S / N
ITEM:
S / N
ITEM:
S / N

CHANGE CLASS

	I	II
PRELIMINARY	☐	☐
FORMAL	☐	☐

TYPE OF CHANGE

MILESTONE	☐	INTERFACE	☒	SOFTWARE	☐
DOCUMENT	☒	POWER	☐	OTHER	☐
COST ____	☐	WEIGHT	☐	____	☐

DOCUMENTS OR SOFTWARE AFFECTED

EO-1 ICD-025

PROBLEM

The attached revised draft version of EO1-ICD-025, Earth Orbiter -1 (EO-1) Global Positioning System (GPS) Navigation Sensor Interface Control Document (ICD) requires baselining. The document defines the functional, physical and electrical characteristics of the GPS that impacts the EO-1 spacecraft on which it will be integrated.

The original CCR 0005 has had significant changes to warrant an R1 to this document.

PROPOSED SOLUTION

Approve the attached revised draft version of EO-1 ICD-025, EO-1 to GPS ICD, by the EO-1 Level II Configuration Control Board (CCB). This draft issue will be formally released after CCB approval. Future changes will be initiated by submittal of Configuration Change Requests (CCRs) and Preliminary Interface Revision Notices (PIRNs) for CCB approval. This document is maintained by the EO-1 Configuration Management Office (CMO).

BOARD ACTION
- APPROVE ☑
- APPROVE WITH CHANGE ☐
- DISAPPROVE ☐
- WITHDRAW ☐

APPROVAL LEVEL REQUIRED
- LEVEL I HQS ☐
- LEVEL II GSFC ☒
- LEVEL III ☐

CRITICALITY LEVEL
- EMERGENCY ☐
- URGENT ☐
- ROUTINE ☒

PROCUREMENT CHANGE ORDER CLASSIFICATION

ROUTINE		URGENT		EMERGENCY ☐
OPTION 1	☐	OPTION 1	☐	
OPTION 2	☐	OPTION 2	☐	

COMMENTS

Deleted Approval signatures review process and my signature here covers. Approve to baseline ICD-25

CHAIRPERSON [signature] DATE 7 MAY 98

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April 9, 1998

EO-1 Spacecraft to Global Positioning System (GPS) Navigation Sensor (ICD)

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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April 9, 1998

Goddard Space Flight Center

NASA/Goddard Space Flight Center
Code 573
Guidance, Navigation and Control Branch
Greenbelt, MD 20771

New Millenium Project
Earth Orbiter-1 (EO-1) Mission

EO-1 Spacecraft to GPS Navigation Sensor Interface Control Document

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1. Introduction

The Goddard Space Flight Center (GSFC) Earth Orbiter-1 (EO-1) spacecraft is being developed as part of the National Aeronautics and Space Administration's (NASA's) New Millennium Program (NMP). A Global Positioning System (GPS) capability has been baselined for the EO-1 mission to provide on-board real-time output of precise timing & navigation information for use by the Attitude Control System (ACS). From this point forward, the term Global Positioning System (GPS), will be employed when referring to the entire system comprised of the following subassemblies:

- One Power Conditioning Unit (PCU)
- One Receiver Processor Unit (RPU) with resident Flight Software
- One four-channel Preamplifier/Splitter Assembly
- Four GPS patch antennas (L1 frequency)
- Wire Harnessing & RF Cables connecting all subassemblies

The Global Positioning System (GPS) Receiver Processor Unit (RPU) manufactured by Space Systems/Loral, is the receiver selected for the EO-1 mission and from this point forward will herein be referred to by its product name; the Tensor™. The Tensor is a Standard Positioning Service (SPS) receiver that offers 13 real-time output states of precise time information, navigation position and velocity, and attitude angles and rates.

The GPS utilizes four antennas to achieve maximum coverage for an Earth pointing vehicle. The GPS is to be turned on after orbital injection and remain on throughout the one year design life of the EO-1 spacecraft (and throughout any subsequent 'extended operations'). The primary function of the GPS is to provide the EO-1 spacecraft with precise real-time navigation and timing information. Position and velocity vectors obtained from the GPS are to be used to define the primary spacecraft attitude reference frame while the digital time obtained from the GPS, in conjunction with the discrete pulse train, may be employed to update the spacecraft oscillator. Secondary functions of the GPS are intended to demonstrate the receiver as a new technology under the New Millennium Program. These demonstrations include Autonomous Orbit Control and an Enhanced Formation Flying experiment using GPS data.

1.1 Purpose and Scope

The purpose of this Interface Control Document (ICD) is to ensure successful integration of the GPS onto the EO-1 spacecraft by documenting form, fit and function interfaces required to achieve installation, checkout and orbital mission objectives. This ICD delineates the responsibilities of Swales and Litton as the spacecraft integration contractors, and GSFC as the GPS provider, by defining criteria for mechanical, structural, mass property, electrical, thermal, command, telemetry, and power interfaces. Also included are requirements for GPS integration and testing, and operational requirements that relate to the above interfaces.

This ICD shall be approved and signed by the authorized representatives of GSFC, Swales and Litton to indicate agreement with the provisions contained herein. The approved document shall then become effective immediately and binding on the participating organizations until a mutually agreed to revision is released.

Approval of this document by the responsible signatories will certify that:

- This ICD establishes the controlled spacecraft to GPS interface requirements.
- The GPS and the EO-1 spacecraft will meet the design and fabrication requirements of this ICD.
- The GPS and the EO-1 spacecraft will meet the integration, testing and operations requirements and constraints specified.

1.2 Applicable Documents

Table 1: Applicable Specifications and Publications

Document No.	TITLE	Date
SAI-SPEC-158	Verification Plan Specification for the NMP EO-1	
ANSI/ASQC 9001	Quality Management and Quality Assurance Standards Guideline for Selection and Use	8/91
NHB 5300.4(3L)	Requirements for Electrostatic Discharge (ESD) Control	8/93
MIL-STD-1246C	Product Cleanliness Levels and Contamination Control Program	12/94
MIL-STD-810E	Environmental Test Methods Standard	12/95
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics Test Methods Standard	12/95
Loral E101050	GPSAODS and GPSODS Performance Specification	7/97
Loral E101027	GLOBALSTAR GPS Tensor System Proto/FlightQualification/Acceptance Test Procedure	1/97
Loral E034580	Receiver Processor Unit (RPU) Interface Control Drawing	3/95
Loral E034811	Four-Channel Preamplifier/Splitter Assembly Interface Control Drawing	3/95
Loral E123167	GPS Antenna Interface Control Drawing	10/96
Loral E123168	GPS Antenna Interface Control Drawing	10/96
Loral E123169	GPS Antenna Interface Control Drawing	10/96
Loral E123170	GPS Antenna Interface Control Drawing	10/96
AM-149-C620(155)	EO-1 System Level Electrical Requirements	6/97

1.3 ICD Revision

Revisions to this ICD shall be proposed sing the EO-1 project level configuration management system.

1.4 ICD Requirement Status

The following acronyms are used in this ICD to identify parameters and/or requirements that have not yet been finalized:

- TBD: To Be Determined — Requirements that have not been sufficiently defined at this time.
- TBR: To Be Resolved — Parameter values followed by TBR in parenthesis (e.g. 75 Volts (TBR)) are preliminary and should not be used for design purposes. If a statement (phrase, sentence or paragraph) is to be labeled TBR, then that statement will be enclosed in brackets {} followed by (TBR).

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2. Physical Characterisitcs

The GPS Source Control Drawings (PCU, RPU, Preamplifier/Splitter Assembly and GPS antenna) defines the system's size, weight and mounting specifications. The descriptive information that follows is for reference only.

2.1 Power Conditioning Unit (PCU)

The PCU (Figure 1) contains one circuit board which converts the input voltage provided by the spacecraft bus (28±7 VDC) to that which is required by the RPU (29±3 VDC). The function of the PCU is to isolate, modify, and optimize the spacecraft power, thus providing usable power to the RPU. The optimizing parameters are line/load regulation, efficiency, power dissipation, inrush current limitation, output ripple voltage, and input voltage range. The dimensions of the PCU are 169 x 133 x 48 mm (6.66 x 5.25 x 1.875 in), and the weight is 0.97 kg (2.15 lb).

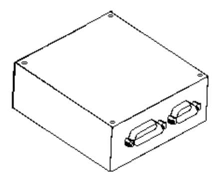

Figure 1: EO-1 GPS Power Conditioning Unit

2.2 Receiver Processor Unit (RPU)

The RPU (Figure 2) contains three circuit boards: DC/DC Converter Board, RF Down Converter Board and Digital Board. The DC/DC Converter Board converts the input voltage to the desired levels needed to power the remaining two boards. The RF Down Converter Board down converts the L_1 C/A code signal (1575.52 MHz) to an intermediate frequency of 4 MHz. A digital signal processing chip and a RISC computer on the Digital Board performs carrier tracking, code tracking, navigation data recovery, and navigation and attitude calculations. The dimensions of the RPU are 279 x 38 x 178 mm (11 x 1.5 x 7 in.), and the weight is 2.3 kg (5 lbs).

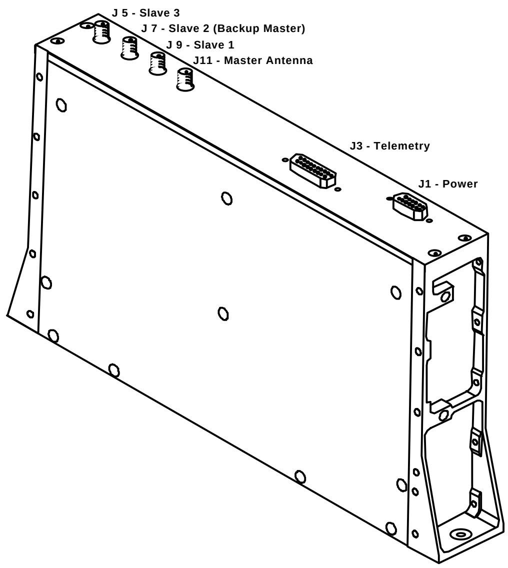

Figure 2: EO-1 GPS Receiver Processor Unit

2.3 Preamplifier / Splitter Assembly

The Preamplifier/Splitter Assembly (Figure 3) is capable of accepting input signals from four separate antennas. It amplifies these signals by a gain of approximately 45 dB and splits each amplified signal into two signals. The splitting capability allows an antenna signal to be routed to two separate input ports of one or more RPUs. The dimensions of the Preamplifier/Splitter Assembly are 152 x 51 x 76 mm (6 x 2 x 3 in.), and the weight is 0.5 kg (1 lb).

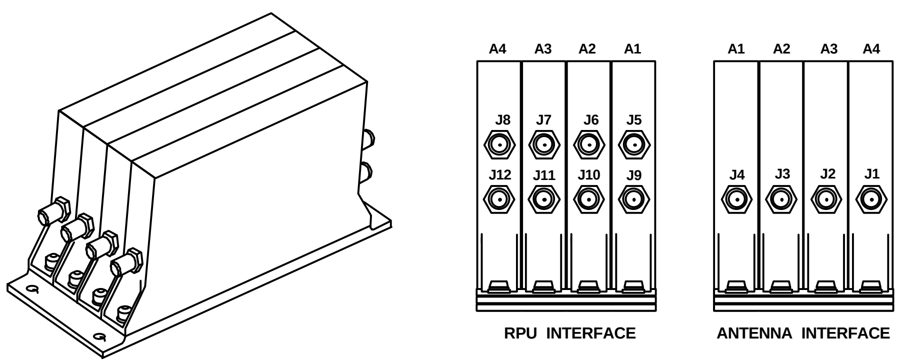

Figure 3: EO-1 GPS Preamplfier / Splitter Assembly

2.4 GPS Antenna

Each of the passive antennas (Figure 4) are made of a ceramic patch substrate that receive L_1 GPS satellite navigation signals at the center frequency of 1575.42 MHz. The L_1 signal levels at the antennas are in the range of -150 dBW to -161 dBW. The dimensions of the antenna are 76 x 76 x 8 mm (3 x 3 x 0.3 in.), and the weight is 0.14 kg (0.3 lb).

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The dimensions given exclude the connector on the bottom of the patch antenna. The connector extends approximately 0.4 in. from the offset center of the base of the antenna.

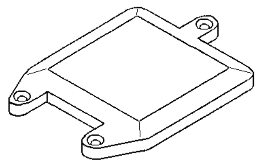

Figure 4: EO-1 GPS Antenna

Table 2: Specifications for the EO-1 GPS Antenna

Frequency	1573.4 - 1577.4 MHz
Polarization	Right-hand Circular
Gain	4.5 dBi
Azimuth Coverage	Omnidirectional
Elevation Coverage	Hemispherical

2.5 Total Weight

The estimated total weight of the GPS (one PCU, one RPU, one Four-Channel Preamplifier/Splitter Assembly and four GPS Antennas) is 4.33 kg (9.54 lbs). This weight excludes any brackets, harnessing or RF cabling.

3. Electrical Characteristics

A diagram showing GPS and spacecraft connections is given in Figure 5 below.

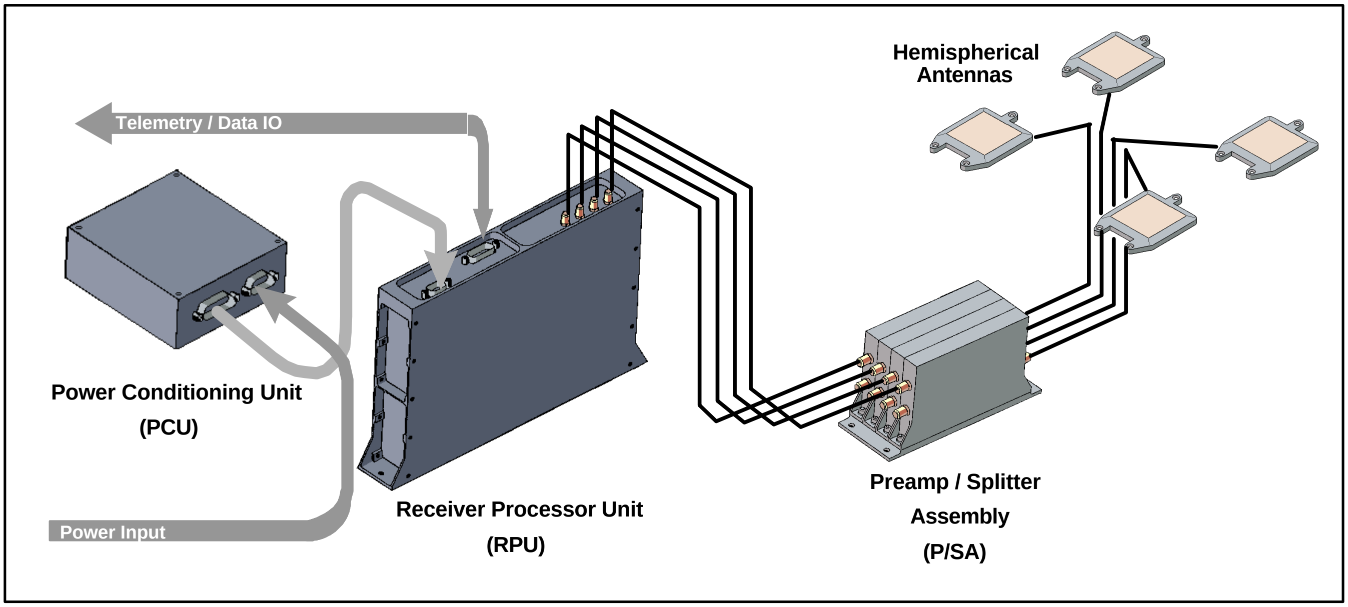

Figure 5: EO-1 GPS System

3.1 Power Consumption / Dissipation

3.1.1 Power Conditioning Unit

At the orbital average 10 W output level, the PCU will dissipate 2 W. At the maximum 16 W output level (at system power up), the PCU will dissipate 3.2 W.

3.1.1.1 PCU Line Load Regulation

The PCU shall operate effectively from an input voltage range of 21 VDC to 35 VDC.

3.1.2 Receiver Processor Unit

The power consumption of the RPU is 10 W, orbital average, and 16 W, maximum. Included in this is the 1 W necessary to power the Preamplifier/Splitter The RPU dissipates 9 W orbital average, and 15 W maximum.

3.1.3 Preamplifier/Splitter Assembly

The Preamplifier/Splitter Assembly does not require an external power source since it receives approximately 1 W from the RPU through RF cabling.

3.1.4 GPS Antenna

The GPS antennas are passive devices which do not consume or dissipate any power.

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3.1.5 Total Power Consumption

The estimated total power consumption of the GPS (one PCU, one RPU, one four-channel Preamplifier/Splitter Assembly and four GPS antennas) from the spacecraft bus is 12 W (orbital average) and 19 W, maximum.

3.2 Electrical Interface

The GPS shall meet all electrical interface requirements as stated in the EO-1 System Level Electrical Requirements Document.

3.2.1 Power Conditioning Unit

The connectors on the PCU are shown in Figure 6 below. Connector J1 is the power input connector, a 9-pin, low-density subminiature "D", male connector (P/N 311P407-1P-B-15). J2 is the power output connector, a 15-pin, low-density, subminiature "D" female connector (P/N 311P407-2S-B-15).

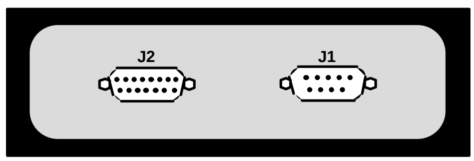

Figure 6: PCU Electrical Interface

Table 3: PCU Input Connector (J1) Signal Definition

Pin	Signal name	Signal Definition
01	+28 VDC (+/-7 VDC)	Main Power Input from Spacecraft Bus
02	+28 VDC (+/-7 VDC)	Main Power Input from Spacecraft Bus
03	Spare	
04	Return	Main Power Return to Spacecraft Bus
05	Return	Main Power Return to Spacecraft Bus
06	Spare	
07	Spare	
08	Spare	
09	Spare	

Table 4: PCU Output Connector (J2) Signal Definition

Pin	Signal name	Signal Definition
01	(Neg) Temperature	
02	Telemetry	
03	Telemetry Return	
04	Return	Main Power Return from RPU
05	Return	Main Power Return from RPU
06	Spare	
07	+30 VDC (+/-1 VDC)	Main Power Output to RPU
08	+30 VDC (+/-1 VDC)	Main Power Output to RPU
09	(Pos) Temperature	
10	Spare	
11	Spare	
12	Return	Main Power Return from RPU
13	Spare	

14	Spare	
15	+30 VDC (+/-1 VDC)	Main Power Output to RPU

3.2.2 Receiver Processor Unit

The connectors on the RPU are shown in Figure 7 below. Connector J1 is the power connector, a 15-pin, high-density subminiature “D”, male connector (Positronics Industries, P/N DD15M4B300S). J3 is the RS-422 data connector, a 26-pin, high-density, subminiature “D” female connector (Positronics Industries, P/N DD26F4B300S). Connectors J5, J7, J9 and J11 are the RF inputs into the RPU; they are female SMA connectors (MA-COM, P/N 2064-5038-94).

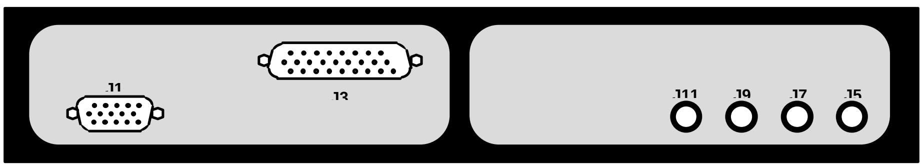

Figure 7: RPU Electical Interface

3.2.2.1 RPU Data Connector

The RPU data connector incorporates a dual (primary and secondary) RS-422 interface that is an asynchronous, bi-directional, standard serial port which operates at RS-422 differential signal levels, but which carries an RS-232 serial byte stream. The serial stream is sent least significant-bit first at 19.2 KBaud, 8 data bits, odd parity, and 1 stop bit. The dual RS-422 design allows interfacing to two separate computers, if desired. The "packetized data" output on both RS-422 outputs are identical. The data port is connected to the EO-1 Houskeeping RSN, which converts the data to 1773 protocol for communication with the EO-1 on-board computer (Mongoose V). The RPU also has two (primary and secondary) discrete one-pulse-per-second outputs that are connected directly to the EO-1 Houskeeping RSN. The RPU provides precise time to the spacecraft in a "The time at the tone will be" format. Digital time in packetized format is sent to the S/C Houskeeping RSN through the RS-422 interface followed by the Pulse-per-Second, UTC-synchronous discrete signal which is sent directly from the receiver to the Houskeeping RSN processor. This message pair is sent to the Houskeeping RSN once every second. The Houskeeping RSN then calculates the correct UTC for use in the EO-1 on-board computer. The Pulse-per-Second waveform is a 1 msec wide, 5 volt, differential pulse signal that is synchronous with the UTC on its rising edge. The digital time precedes the pulse by 875 ms. The pin and signal definitions of the RS-422 data connector are given in Table 5.

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Table 5: RS-422 Data Connector (J3) Signal Definition

Pin	Signal Name	Signal Definition	Input/Output
01	TXD1 (+)	Transmit Data 1 (+)	Output
02	TXD1 (-)	Transmit Data 1 (-)	Output
03	Chassis Ground		
04	TFC1 (+)	Transmit Flow Control 1 (+)	Input
05	TFC1 (-)	Transmit Flow Control 1 (-)	Input
06	RXD1 (+)	Receive Data 1 (+)	Input
07	RXD1 (-)	Receive Data 1 (-)	Input
08	Chassis Ground		
09	RFC1 (+)	Receive Flow Control 1 (+)	Output
10	RFC1 (-)	Recevie Flow Control 1 (-)	Output
11	TXD2 (+)	Transmit Data 2 (+)	Output
12	TXD2 (-)	Transmit Data 2 (-)	Output
13	Chassis Ground		
14	TFC2 (+)	Transmit Flow Control 2 (+)	Input
15	TFC2 (-)	Transmit Flow Control 2 (-)	Input
16	RXD2 (+)	Receive Data 2 (+)	Input
17	RXD2 (-)	Receive Data 2 (-)	Input
18	Chassis Ground		
19	RFC2 (+)	Receive Flow Control 2 (+)	Output
20	RFC2 (-)	Recevie Flow Control 2 (-)	Output
21	Chassis Ground		
22	PPS1 (+)	Pulse Per Second 1 (+)	Output
23	PPS1 (-)	Pulse Per Second 1 (-)	Output
24	Chassis Ground		
25	PPS2 (+)	Pulse Per Second 2 (+)	Output
26	PPS2 (-)	Pulse Per Second 2 (-)	Output

3.2.2.2 RPU Power Connector

The RPU power port (J1) is connected to the GPS Power Conditioning Unit (PCU). Pins 13, 14, and 15 of this connector are internally connected inside the RPU, and therefore, all three of these pins may be used for triple redundancy. The pin and signal definitions of the power connector are given in Table 6. ON/OFF control of the RPU shall be controlled by the same housekeeping RSN as the telemetry connector is harnessed to, therefore three pins from the power connector (pins 8, 9 & 10) will be harnessed to the houskeeping RSN as shown in Figure 8.

Table 6: RPU Power Connector (J1) Signal Definition

Pin	Signal name	Signal Definition
01	Spare	
02	Spare	
03	Spare	
04	Pulse Return 2	Remote Unit #2 Control Signal Return
05	Off - Pulse 2	Power Off Control From Remote Unit #2
06	Return	Main Power Return to PCU
07	On - Pulse 2	Power On Control From Remote Unit #2
08	Pulse Return 1	Remote Unit #1 Control Signal Return
09	Off - Pulse 1	Power Off Control From Remote Unit #1
10	On - Pulse 1	Power On Control From Remote Unit #1
11	Return	Main Power Return to PCU
12	Return	Main Power Return to PCU
13	+29 VDC (+/-3 VDC)	Main Power Input from PCU
14	+29 VDC (+/-3 VDC)	Main Power Input from PCU
15	+29 VDC (+/-3 VDC)	Main Power Input from PCU

3.2.3 Preamplifier/Splitter Assembly

Power interface from the RPU to the Preamplifier/Splitter Assembly is through the RF cabling. Each preamplifier in the assembly is powered separately through its own RF cable. The connectors on the Preamplifier/Splitter Assembly are shown in Figure 3. Connectors J1 through J4 are the input ports which interface to the antennas. Connectors J5 through J12 are the outputs ports which interface to the RPU. Since this assembly is also a splitter the signals are split as follows: J1 into J5 & J9, J2 into J6 & J10, J3 into J7 & J11, and J4 into J8 & J12. Connectors J5 through J12 are female SMA connectors (MA-COM, P/N 2064-5038-94).

3.2.4 GPS Antenna

Each antenna has one female SMA connector (MA-COM, P/N 2064-5038-94).

3.2.5 RF Cabling

The RPU, Preamplifier/Splitter Assembly and antennas are interconnected with 50-Ohm, SMA-type, male, RF coaxial cables. GSFC will provide these RF cables connecting as indicated in the deliverables section of this ICD. The lengths and connectivity of the RF cables are given in Table 7. The tolerances of the cable lengths are ± 0.5 inch.

3.2.6 Wire Harness

The EO-1 project will supply all wire harnessing (and connections) between the EO-1 spacecraft and the GPS subassemblies.

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Table 7: GPS RF Cable Lengths and Connectivity

FROM	TO	Length	Serial #	Cable Type
Antenna #1 (Serial Number TBD)	Preamplifier/Splitter Assembly J4 (A1)	12' 0"	TBD	0.190 Gore
Antenna #2 (Serial Number TBD)	Preamplifier/Splitter Assembly J3 (A2)	12' 0"	TBD	0.190 Gore
Antenna #3 (Serial Number TBD)	Preamplifier/Splitter Assembly J2 (A3)	12' 0"	TBD	0.190 Gore
Antenna #4 (Serial Number TBD)	Preamplifier/Splitter Assembly J1 (A4)	12' 0"	TBD	0.190 Gore
Preamplifier/Splitter Assembly J5	RPU J11	3' 6"	TBD	RG-142
Preamplifier/Splitter Assembly J6	RPU J9	3' 6"	TBD	RG-142
Preamplifier/Splitter Assembly J7	RPU J7	3' 6"	TBD	RG-142
Preamplifier/Splitter Assembly J8	RPU J5	3' 6"	TBD	RG-142

3.3 Operating Duty Cycle

The GPS shall be turned on after orbital injection and remain on, operating continuously at a 100% duty cycle throughout the one year design life of the EO-1 spacecraft.

3.4 Electrical Isolation

The GPS shall maintain isolation greater than 1 MW between the spacecraft primary power circuits and the RS-422 data circuits.

GPS - Global Positioning System

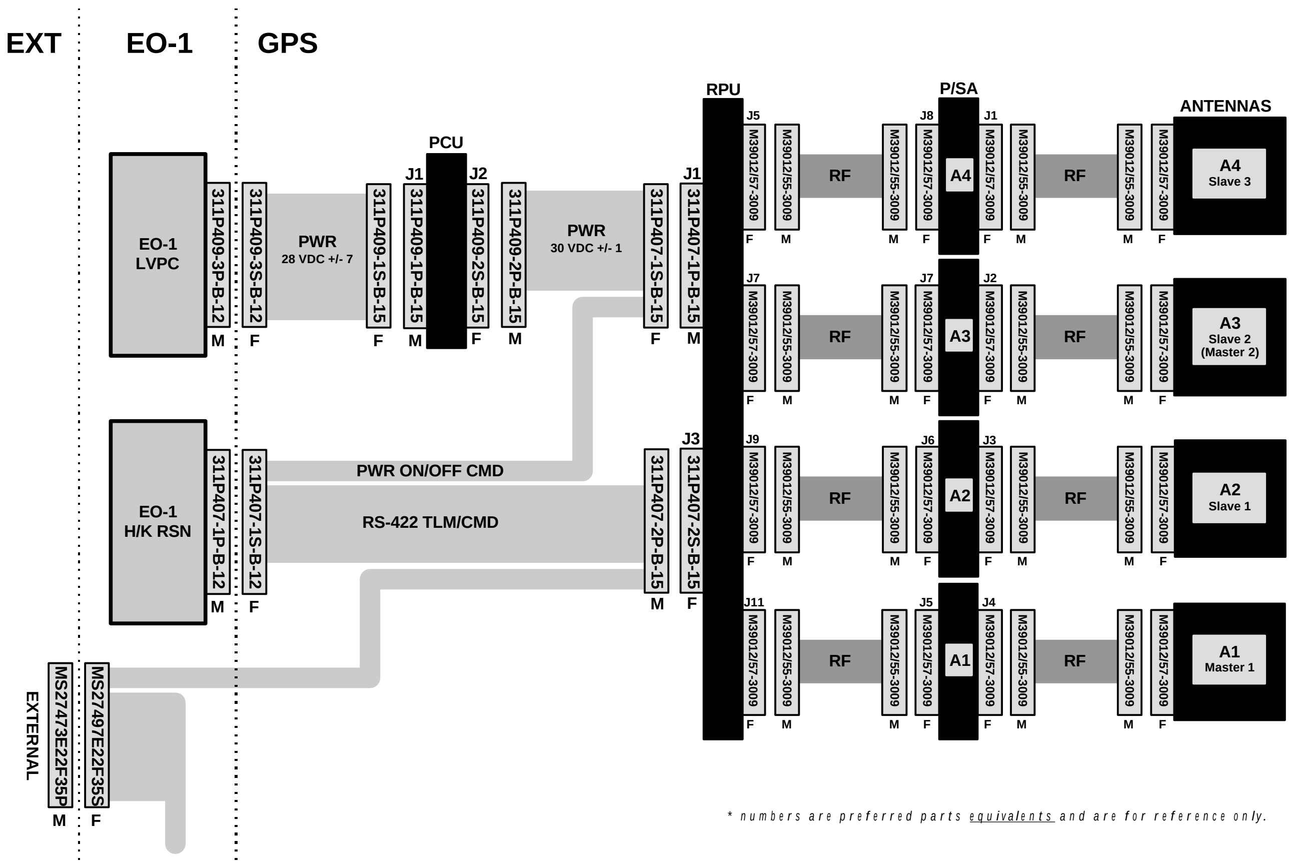

Figure 8: GPS Electrical Interface Diagram

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4. Mechanical Interface

4.1 Center of Gravity

The estimations of the locations of the centers of gravity for the PCU, RPU, Preamplifier/Splitter Assembly and antennas are shown in the figures below.

	PCU	RPU	P/SA	Ant
CM_x	81.28 mm	23.9 mm	25.40 mm	35.56 mm
CM_y	67.44 mm	133.0 mm	69.09 mm	35.56 mm
CM_z	18.92 mm	82.4 mm	31.75 mm	15.24 mm

4.2 Mounting Access and Alignment

4.2.1 Power Conditioning Unit

The PCU will be mounted in the EO-1 bay 6 as is shown in Figure 10.

4.2.2 Receiver Processor Unit

The RPU was originally designed to be flown as redundant pair, bolted together. For the EO-1 spacecraft, a single RPU will be flown, requireing a bracket support as shown in Figure 9. The RPU (in its bracket) will, in turn be mounted in the EO-1 bay 6 as is shown in Figure 10.

4.2.3 Preamplifier/Splitter Assembly

The Preamplifier/Splitter Assembly will be mounted in the EO-1 bay 6 as is shown in Figure 10.

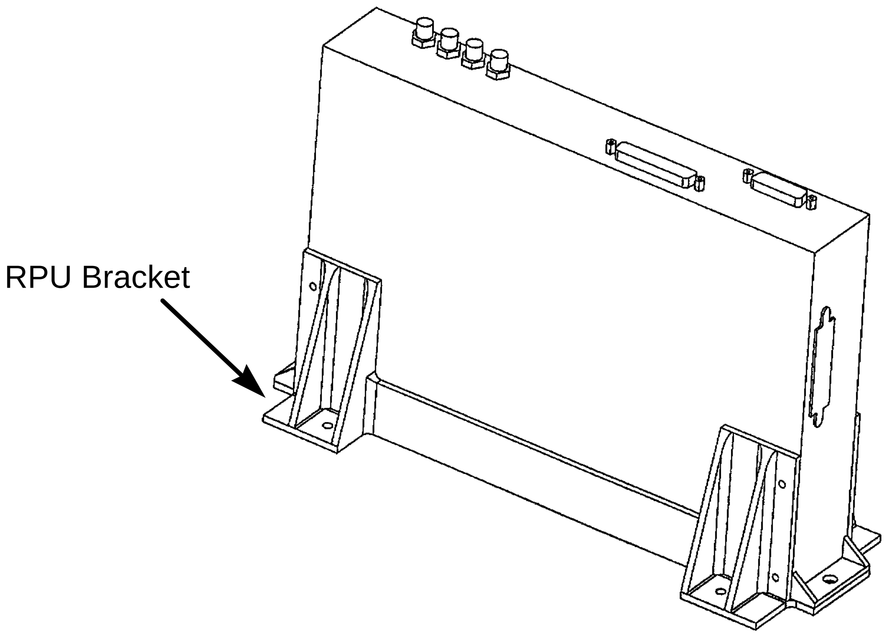

Figure 9: Single String RPU Bracket

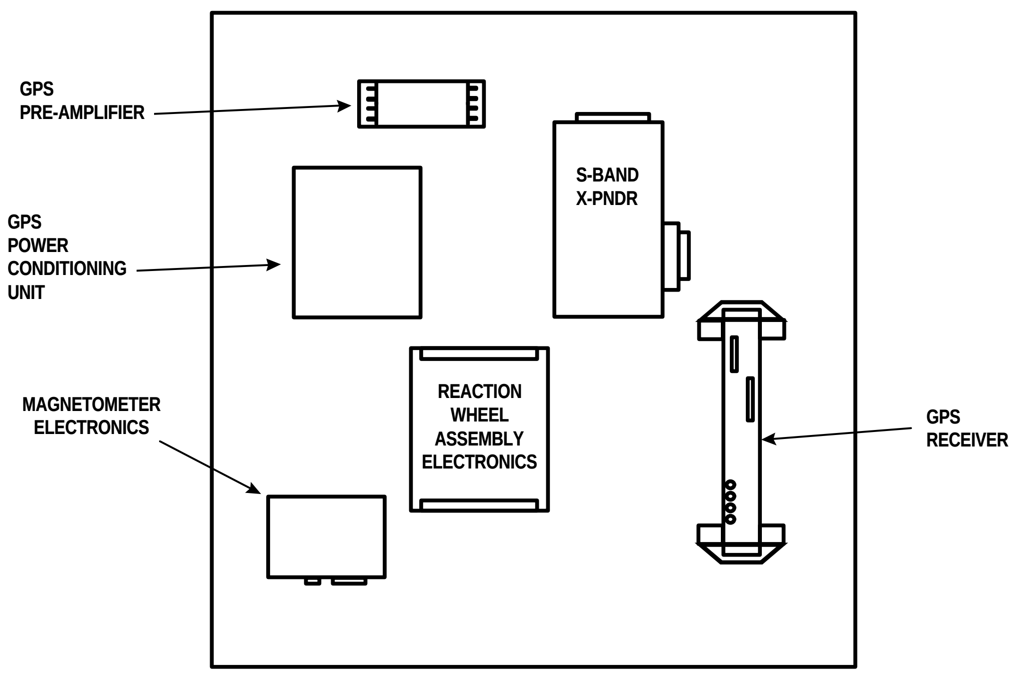

Figure 10: EO-1 Bay 6 Layout

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4.2.4 GPS Antennas

Four antennas shall be mounted on mounting brackets as shown in Figure 11. The mounting brackets for the antennas will accommodate the electrical and thermal needs of the antennas. Four such brackets shall be mounted on the zenith pointing deck of the EO-1 spacecraft according to the arrangement shown in Figure 12.

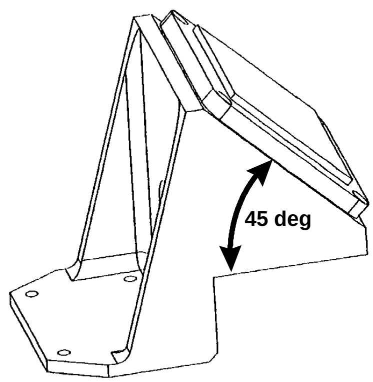

Figure 11 : GPS Antenna Mounting Bracket

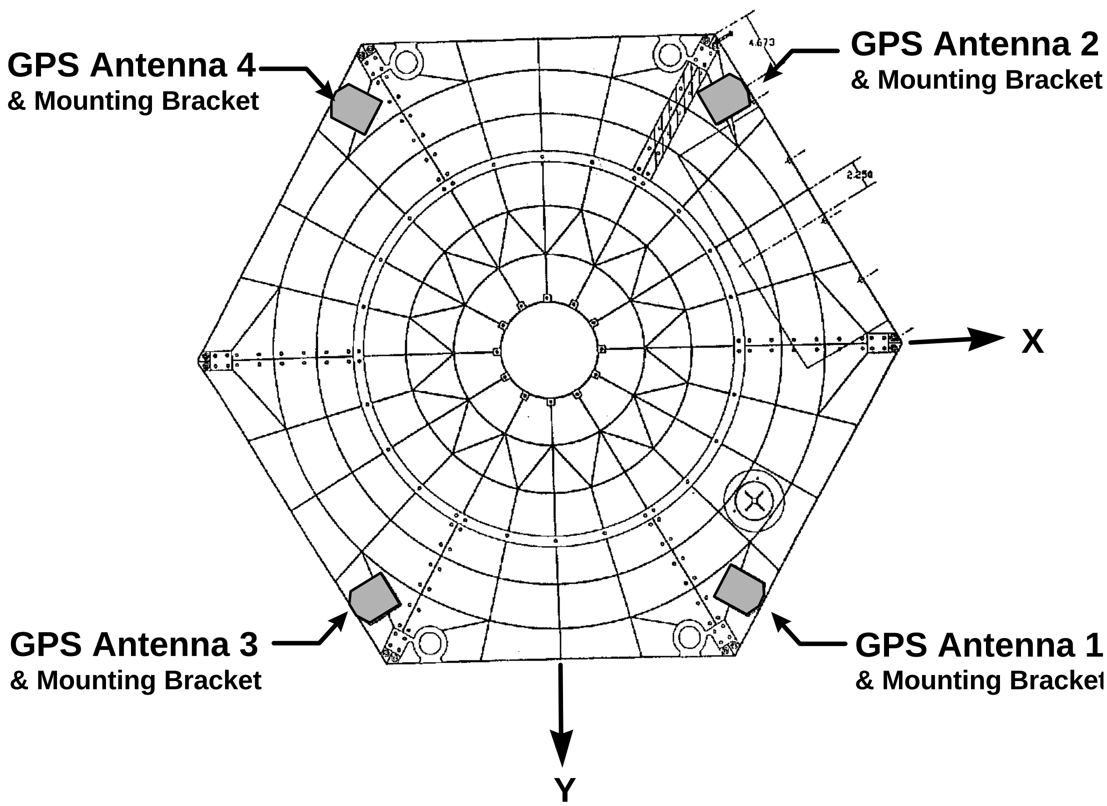

Figure 12 : GPS Antenna Mounting on EO-1 Zenith Pointing Deck

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5. Software Description

All data interface characteristics including all data packet definitions, formats and timing are outlined in explicit detail in Loral controlled document E101050, “GPS Attitude and Orbit Determination System and GPS Orbit Determination System (GPSAODS and GPSODS) Performance Specification”.

6. Operational Requirements

The following sections define the necessary steps for the successful operation of the GPS. Before proceeding, a clear definition of the terms command and telemetry are in order. Initialization commands are packets that are sent to the Tensor to configure it for flight operations. These commands are sent only once to the Tensor following a power-on sequence. If the power to the Tensor is cycled, then the initialization commands to the Tensor must be sent again.

6.1 Power-on Sequence

The following steps shall be followed to successfully power-on the GPS:

1. Apply 28 ± 7 VDC spacecraft bus voltage to the PCU.
2. Wait 10 seconds.
3. Apply 26 ± 4 VDC Power-On pulse to RPU relay.
4. Wait 20 seconds.
5. When power is applied to the RPU, it performs a self-test for approximately the first 20 seconds, in which the RPU enters into a “sleep” mode. In this mode the RPU will not transmit any telemetry nor will it store or process any commands. Once 20 seconds have elapsed, the RPU autonomously switches into “nominal” mode, enabling telemetry output and the processing of commands. The following steps can now be performed.
6. Set RPU configuration for EO-1 mission via packet 35 hex.
7. Warm Start: Transmit Valid Almanac to RPU via packet XX (skip if cold start).
8. Warm Start: Transmit Valid S/C Ephemeris to RPU via packet XX (skip if cold start).
9. Warm Start: Transmit Valid Current time to RPU via packet XX (skip if cold start).
10. Wait for a valid position fix (for warm start ~ 5 min… for cold start ~ 45 min).
11. Immediately after the Tensor enters into “nominal” mode, it begins to output the default position, velocity and time packets (The data values of these packets are zero). From a "cold start", the Tensor requires 30 minutes (maximum) to obtain a valid position fix. A health status flag indicates when valid fixes are achieved. A cold start is defined as having no knowledge of current position, time and GPS almanac information. The time to achieve valid fixes can be reduced to under 3 minutes by providing the Tensor with an initial solution for position and time and a valid GPS satellite almanac. The table below lists the initialization command parameters, sent from the ground through the spacecraft on-board computer to the Tensor, to achieve such a "warm start".

6.2 Power-off Sequence

1. Apply 26 ± 4 VDC Power-Off pulse to RPU relay. No further action is required.

6.3 Commands

Commands to the RPU will be sent from the spacecraft on-board computer.

6.4 Telemetry

The data throughput scheme for the GPS is shown in figure 13. For a detailed description of the data packet definitions, formats or see the Loral controlled document E101050, "GPS Attitude and Orbit Determination System and GPS Orbit Determination System (GPSAODS and GPSODS) Performance Specification". GPS telemetry consists of the following:

To ACS via Buffer 'A':

Pulse-Per-Second
Packet 5E Digital GPS Time
Packet A1 Position, Velocity & Health
Packet D1 Filtered Position, Velocity
Packet 41 UTC Offset

To Ground via Buffer 'B' and polling software:

Any and all Packets as requested via polling software.

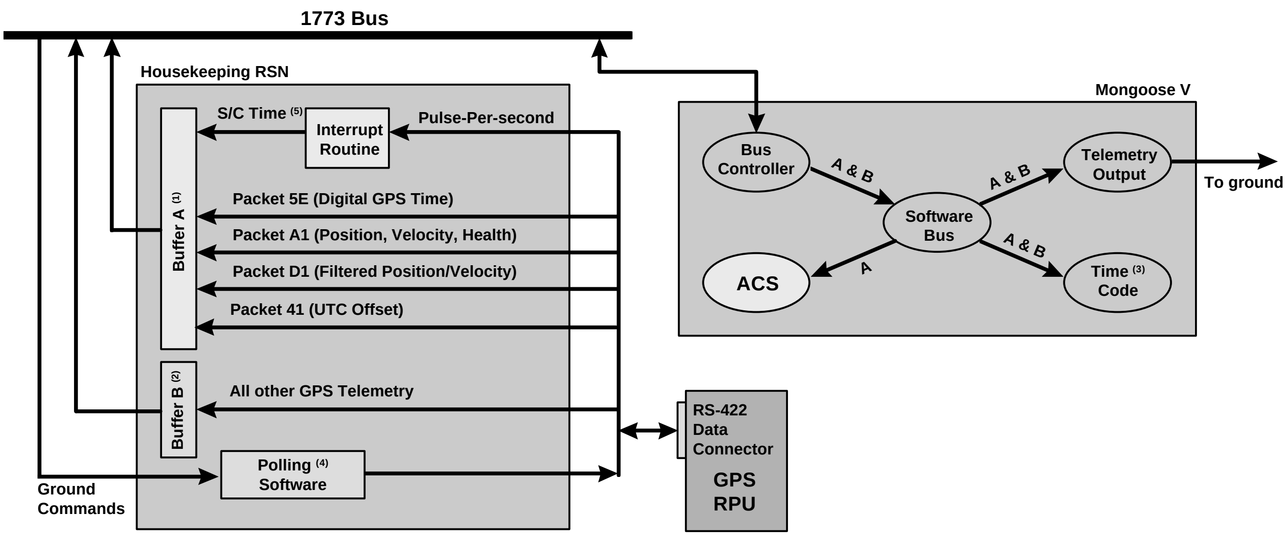

Figure 13: GPS to EO-1 S/C Data Throughput

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6.5 Performance

6.5.1 Position Accuracy

Standard Positioning Service (SPS) solutions (point solutions) position specification in "sigma terms" is: 450 m (3σ), RSS. This number is when Selective Availability is enabled.

6.5.2 Velocity Accuracy

Standard Positioning Service (SPS) solutions (point solutions) position specification in "sigma terms" is: 1 m/s (3σ), RSS. This number is when Selective Availability is enabled.

6.5.3 Timing Accuracy

There exists several "timing specs". The time stamps (or time tags) associated with the navigation and attitude fixes (and other packets which contain time-of-fix) are accurate to 1 millisecond (3σ) of true time (true time can be UTC or GPS). The rising edge of the pulse-per-second discrete pulse train (which is a differential output) is accurate to within 1 μsec (3σ) of every GPS second. However this 1 μsec accuracy is the "time at the next pulse" message (Loral calls this the digital time) coming from the receiver is only accurate to 1 msec (3σ). So should the “digital time” be employed in association with the pulse train, the accuracy will be 1 msec (3σ).

6.5.4 Coordinate Frame

Tensor packet A1 gives the single-precision position and velocity in rectangular coordinates at an autonomous ouput rate of 1 Hz. In packet 35 hex (I/O options), Byte #0, Bit 7, one can set the coordinate frame to ECI. In the same packet, Byte #0, Bit 3 can be used to set the ECI Coordinate Frame Time Reference to J2000 True-of Date, which is, in fact the default output state of the Tensor.

6.5.5 Output Update Interval

The Tensor design reflects a 1 Hz computation and output rate for all navigation data.

6.5.6 Number of Antennas

The Tensor has four antenna input ports, labeled Antenna Port 1, Antenna Port 2, Antenna Port 3, Antenna Port 4. By default (after Tensor power-up) Antenna Port 1 is considered ‘master’ for navigation. This is hard-coded into the receiver and cannot be changed. If for some reason the path of Antenna Port 1 (path is from the antenna, through the preamp and finally to the receiver) is "bad" and not working, the Tensor will automatically switch to Antenna Port 3 as ‘master’ for navigation. Again, this backup ‘master’ port for navigation is hard-coded coded into the receiver and cannot be changed. There is however, a packet 63 hex, which the user can send to the Tensor in order to force the receiver to use any of the four antenna ports as ‘master’ for navigation.

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7. Deliverables to the EO-1 Project

The following items will be delivered to the EO-1 project.

7.1 Hardware

The following items will be delivered to the EO-1 project by 15 July, 1998 for the integration onto the EO-1 spacecraft.

- One Power Conditioning Unit (PCU).
- One Receiver Processor Unit (RPU) with flight software installed.
- One four-channel Preamplifier/Splitter Assembly (P/SA).
- Four RF terminators for unused P/SA outputs.
- Four GPS antennas.
- Four 12’ 0” RF cables connecting the antennas to the P/SA.
- Four 3’ 6” RF cables connecting the P/SA to the RPU.

7.2 Documentation

With delivery of the GPS hardware to the EO-1 project, GSFC will submit an End Item Data Package including, but not limited to, the following:

7.2.1 Certificate of Compliance

A Certificate of Compliance will be submitted with the GPS hardware indicating compliance to each of the following topics:

- Safety
- Physical interface
    - Mechanical
    - Electrical
- Environmental Interfaces
    - Structural
    - Thermal
    - Mass properties
    - Temperature
- Functional Interface
    - Power
    - Command
    - Telemetry

7.2.2 Test Results/Reports

Test results and/or reports on the following tests must be submitted:

- Vibration Test
- Thermal Vacuum Test
- Performance Test

7.2.3 Test Procedures

7.3 Checkout and Operation Constraints for Spacecraft Integration

GSFC will perform a functional test of the GPS at the GSFC simulation facility prior to officially releasing the hardware to the EO-1 project. GSFC will support spacecraft level integration testing of the GPS.

7.4 Contamination and Handling Procedures

The GPS will comply with the contamination control and handling as given in the EO-1 Contamination Control Plan. The GPS has no special contamination requirements.

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8. EO-1 Spacecraft Specifics

8.1.1 Fuses and Protection

The spacecraft current to the RPU will be limited through a 2 Amp fuse.

8.2 Thermal Control

8.2.1 Power Conditioning Unit

The spacecraft will maintain the temperature of the PCU between 0° C and +40° C when operating. The non-operating survival temperature limits for the PCU will be -10° C to +50° C.

8.2.2 Receiver Processor Unit

The spacecraft will maintain the temperature of the RPU between 0° C and +40° C when operating. The non-operating survival temperature limits for the PCU will be -10° C to +50° C.

8.2.3 Preamplifier/Splitter Assembly

The spacecraft will maintain the temperature of the preamplifier between 0° C and +40° C when operating. The non-operating survival temperature limits for the PCU will be -10° C to +50° C.

8.2.4 GPS Antennas

The spacecraft will maintain the temperature of the GPS antennas between 0° C and +40° C when operating. The non-operating survival temperature limits for the PCU will be -10° C to +50° C.

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9. Appendix 1: Acronyms

^{o}C	Degrees Celsius
μsec	microsecond
A/D	Analog-to-Digital
dBi	decibel isotropic
dBm	decibel milli-Watt
DC	Direct Current
deg	degrees
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
GPS	Global Positioning System
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
H/W	Hardware
Hz	Hertz
ICD	Interface Control Document
kg	kilogram
kHz	kiloHertz
km	kilometer
LEO	Low Earth Orbit
LSW	Least Significant Word
m	meters
MHz	megaHertz
MΩ	megohms
MOA	Memorandum of Agreement
msec	milli-second
MSW	Most Significant Word
OBC	On-Board Computer
P/N	Part Number
PPS	Pulse Per Second
RF	Radio Frequency
RFC	Receive Flow Control
RPU	Receiver Processor Unit
RSN	Remote Services Node
RT	Remote Terminal
RXD	Receive Data
S/C	Spacecraft
SCD	Source Control Drawings
SPG	Single Point Ground
SOH	State of Health
SPS	Standard Positioning Service
SS/L	Space Systems/Loral
S/V	Space Vehicle

TBD	To Be Determined
TBR	To Be Resolved
TFC	Transmit Flow Control
TXD	Transmit Data
UTC	Universal Time Code
V	Volts
VDC	Volts Direct Current
W	Watt

```
Date: Mon, 04 May 1998 09:54:20 -0400 (Eastern Daylight Time)
From: Administrator@hst-nic.hst.nasa.gov
Reply-to: (Brian Smith)
Subject: CCR:0005R1 - DUE: 05/01/98   ROUTINE  Level-2 Brian Smit WWW-COMMENTS

USER :    (Brian Smith) sent the following comments on :

------------------------------------------------------------
Date: 04/15/98
CCR Number: 0005R1
Sponsor: N. Speciale/EO-1 Mission Tech
Due Date: 05/01/98
------------------------------------------------------------
CCR Title: BASELINE EO-1 S/C TO GPS NAVIGATION SENSOR ICD-025
------------------------------------------------------------
Remote host: 198.118.115.72  Email Address:
------------------------------------------------------------
APPROVAL STATUS:     APPROVED
Note:
------------------------------------------------------------
COMMENTS:
```

EO-1 CCR SPONSOR RECOMMENDATION FORM

CCR NUMBER: 0005R1
CCR TITLE: B/L EO-1 S/C TO GPS NAVIGATION SENSOR ICD -25

CCR SPONSOR: N. Speciale

SUMMARY OF COMMENTS RECEIVED: (list Level 4 CCB and internal reviewers who had comments and address those comments)

NONE

SPONSOR RECOMMENDATION: (Make changes to document where indicated, reference Sponsor Comments for changes to be implemented.)

COMMENTS: Approve as written.

Approve ___X___Approve with Change __________Disapprove__________

SPONSOR/ORGANIZATION: N. Speciale
DATE: 5/4/98