CCR Number: 0005 **CRITICALITY: ROUTINE** **DUE: 01/19/98**

DISTRIBUTION SHEET

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NEW MILLENNIUM PROJECT CONFIGURATION CHANGE REQUEST

PROGRAM EO-1

CCR NO. 0005

DATE INITIATED 12/29/97

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 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.

PROPOSED SOLUTION

Approve the attached 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

CHAIRPERSON ____________ DATE ____________

EO-1 ICD-25
Draft Issue
December 29, 1997

EO-1
GLOBAL POSITIONING SYSTEM (GPS)
NAVIGATION SENSOR
INTERFACE CONTROL DOCUMENT (ICD)

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EO-1 ICD-025
Draft Issue
December 29, 1997

Goddard Space Flight Center

NASA/Goddard Space Flight Center
Code 712
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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GPS - Global Positioning System

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 four subassemblies:

- One Power Conditioning Unit (PCU)
- One Receiver Processor Unit (RPU)
- One four-channel Preamplifier/Splitter Assembly
- Four GPS patch antennas (L1 frequency)

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.

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	
GEVS	General Environmental Verification Requirements	11/90
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	
Loral E101027	GLOBALSTAR GPS Tensor System Proto/FlightQualification/Acceptance Test Procedure	
Loral E034580	Receiver Processor Unit (RPU) Interface Control Drawing	
Loral E034811	Four-Channel Preamplifier/Splitter Assembly Interface Control Drawing	
Loral E123167	GPS Antenna Interface Control Drawing	

1.3 ICD Revision

Requests for revisions to this ICD shall be transmitted in written form between GSFC, Swales and Litton. All requests must include:

- Name of initiating engineer/manager
- Description of change
- Date on which change is needed
- Justification for change
- Relationship to previously submitted changes, if any.

The Swales Payload Manager shall review and negotiate the change with the appropriate engineers and managers, including GSFC personnel. Approved changes shall be signed by authorized representatives of GSFC, Swales and Litton. Upon completion of the signature cycle, the changes shall become effective immediately. The Swales Payload Manager is responsible for updating the ICD to reflect revisions as well as maintaining documentation of all requests for revision, whether approved or disapproved.

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).

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).

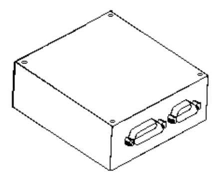


Figure 1: EO-1 GPS Power Conditioning Unit

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).

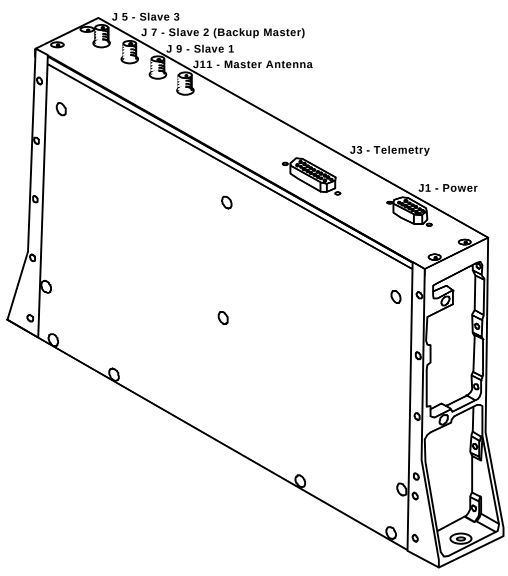


Figure 2: EO-1 GPS Receiver Processor Unit

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).

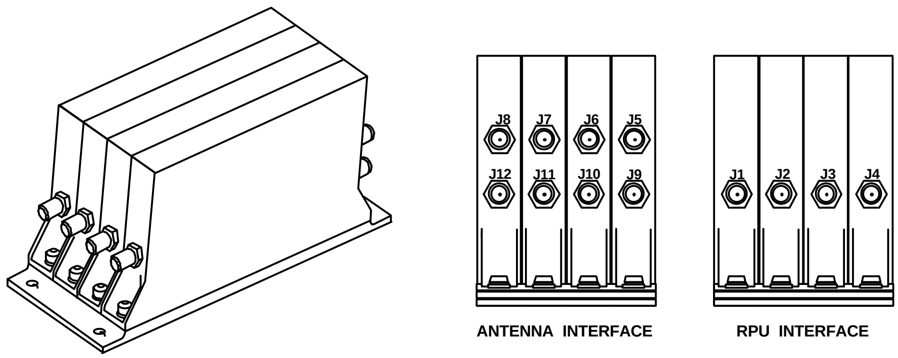


Figure 3: EO-1 GPS Preamplfier / Splitter Assembly

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). 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.

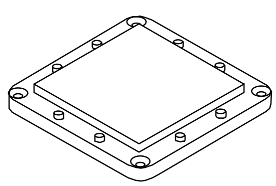


Figure 4: EO-1 GPS Antenna

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.

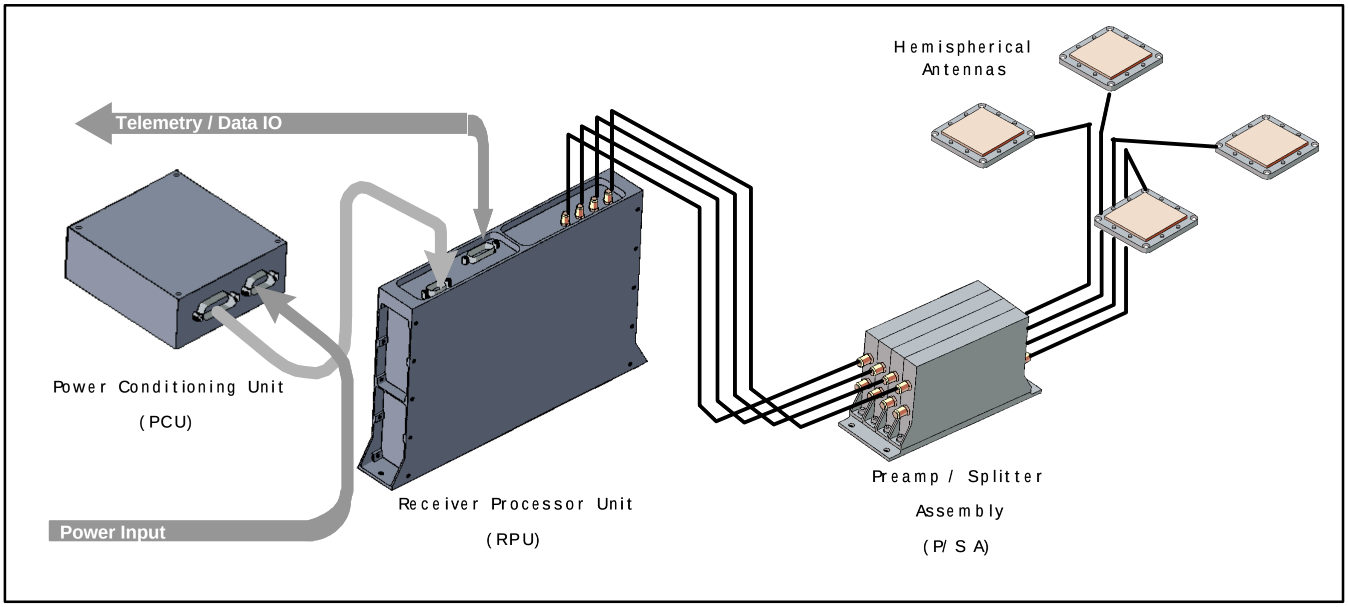


Figure 5: EO-1 GPS System

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, the PCU will dissipate 3.2 W.

3.1.1.1 PCU Line Load Regulation

The PCU operates effectively from an input voltage range of 16 VDC to 40 VDC. The resulting output voltage variation does not exceed 180 mV.

3.1.1.2 PCU Efficiency

In range of 10 W to 16 W output power level, the PCU converts power at 80% efficiency.

3.1.1.3 PCU In-Rush Current Limitation

The PCU is nominally tolerant of a 10 amp in-rush for a duration of TBD µsec.

3.1.1.4 PCU Output Ripple Voltage

During nominal operation, the PCU output ripple voltage does not exceed 120 mV.

3.1.2 Receiver Processor Unit

The power consumption of the RPU is 10 W, orbital average, and 16 W, maximum. It is important to remember that these numbers represent the power consumption of the RPU. Included in these numbers is the 1 W necessary to power the Preamplifier/Splitter Assembly. Therefore, if the measurement needed is power dissipation, then the numbers become 9 W dissipated, orbital average, and 15 W dissipated, maximim.

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. Therefore, the Preamplifier/Splitter Assembly has a power dissipation of 1 W.

3.1.4 GPS Antenna

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

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

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).

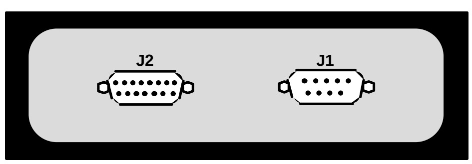


Figure 6: PCU Electrical Interface

TBD information here.
TBD information here.
TBD information here.
TBD information here.
TBD information here.

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	+28 VDC (+/-7 VDC)	Main Power Input from Spacecraft Bus
07	Spare	
08	Spare	
09	Return	Main Power Return to Spacecraft Bus

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).

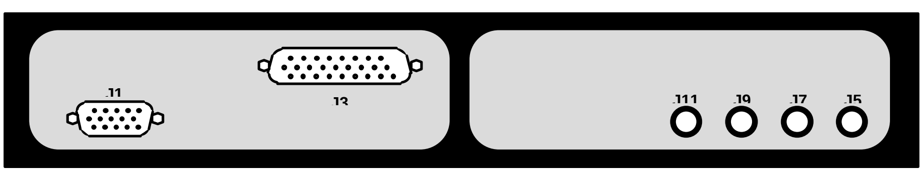


Figure 7: RPU Electrical Interface

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. Commanding to the RPU can be done on both RS-422 interfaces, however, not simultaneously. The data port is connected to the EO-1 Houskeeping RSN, which converts the signals to 1553 protocol for communication with the EO-1 on-board computer (Mongoose V). The I/O circuit of the data connector is shown in Figure 8. The RPU also has two (primary and secondary) discrete one-pulse-per-second outputs that are connected directly to the EO-1 on-board computer via the 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 through the RS-422/GEM 1553B converter followed by the Pulse-per-Second, UTC-synchronous discrete signal which is sent directly from the receiver to the S/C processor (i.e., not transmitted through GEM). This message pair is sent to the S/C once every second. 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 Pulse-Per-Second circuit is given in Figure 4-6. The pin and signal definitions of the RS-422 data connector are given in Table 5.

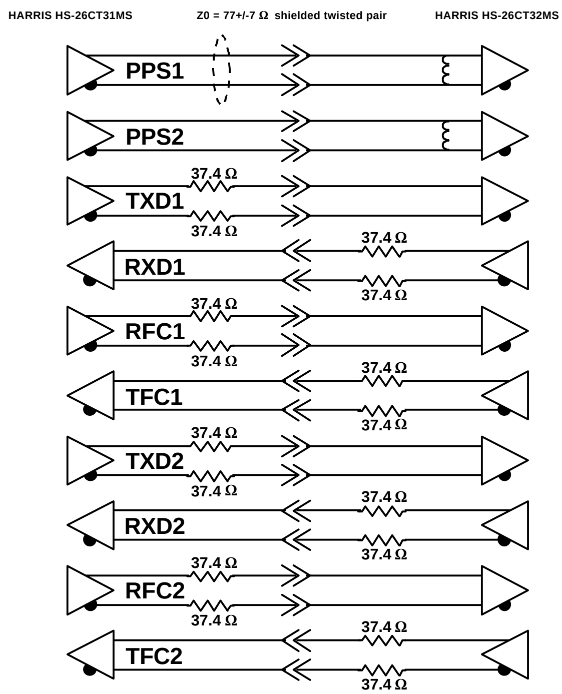


Figure 8: GPS Tensor Driving and Receiving

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 9.

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) which is shown below.

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 (as determined by the EO-1 project) are given in Table 7. The tolerances of the cable lengths are ± 0.5 inch.

Table 7: GPS RF Cable Lengths and Connectivity

FROM	TO	Length	Serial #	Cable Type
Antenna #1 (Serial Number TBD)	Preamplifier/Splitter Assembly J1	TBD	TBD	0.190 Gore (TBR)
Antenna #2 (Serial Number TBD)	Preamplifier/Splitter Assembly J2	TBD	TBD	0.190 Gore (TBR)
Antenna #3 (Serial Number TBD)	Preamplifier/Splitter Assembly J3	TBD	TBD	0.190 Gore (TBR)
Antenna #4 (Serial Number TBD)	Preamplifier/Splitter Assembly J4	TBD	TBD	0.190 Gore (TBR)
Preamplifier/Splitter Assembly J5	RPU J5 (TBR)	TBD	TBD	RG-142 (TBR)
Preamplifier/Splitter Assembly J6	RPU J7 (TBR)	TBD	TBD	RG-142 (TBR)
Preamplifier/Splitter Assembly J7	RPU J9 (TBR)	TBD	TBD	RG-142 (TBR)
Preamplifier/Splitter Assembly J8	RPU J11 (TBR)	TBD	TBD	RG-142 (TBR)

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 Transients

The GPS shall not be damaged by the application of 45 VDC for 5 seconds or a transient spike of 50 VDC for 50 ms.

3.5 Inrush Current

The inrush current shall not exceed 2 Amps.

3.6 Survival Power

The GPS shall not be damaged by the lack of power while in orbit and therefore, the GPS requires no on-orbit power for survival during spacecraft anomalous situations.

3.7 Reverse Voltage

The GPS shall not be damaged by a reverse voltage condition.

3.8 Under Voltage

The GPS shall not be damaged by any input voltage between 0 and 21 volts.

3.9 Over Voltage

The GPS shall not be expected to operate as specified herein during periods when the voltage is greater than 35 VDC, exclusive of short-duration transients. The GPS shall perform as specified herein after having been subjected to 35 VDC followed by a return to the range of 21 to 35 VDC.

3.10 Electrical Isolation

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

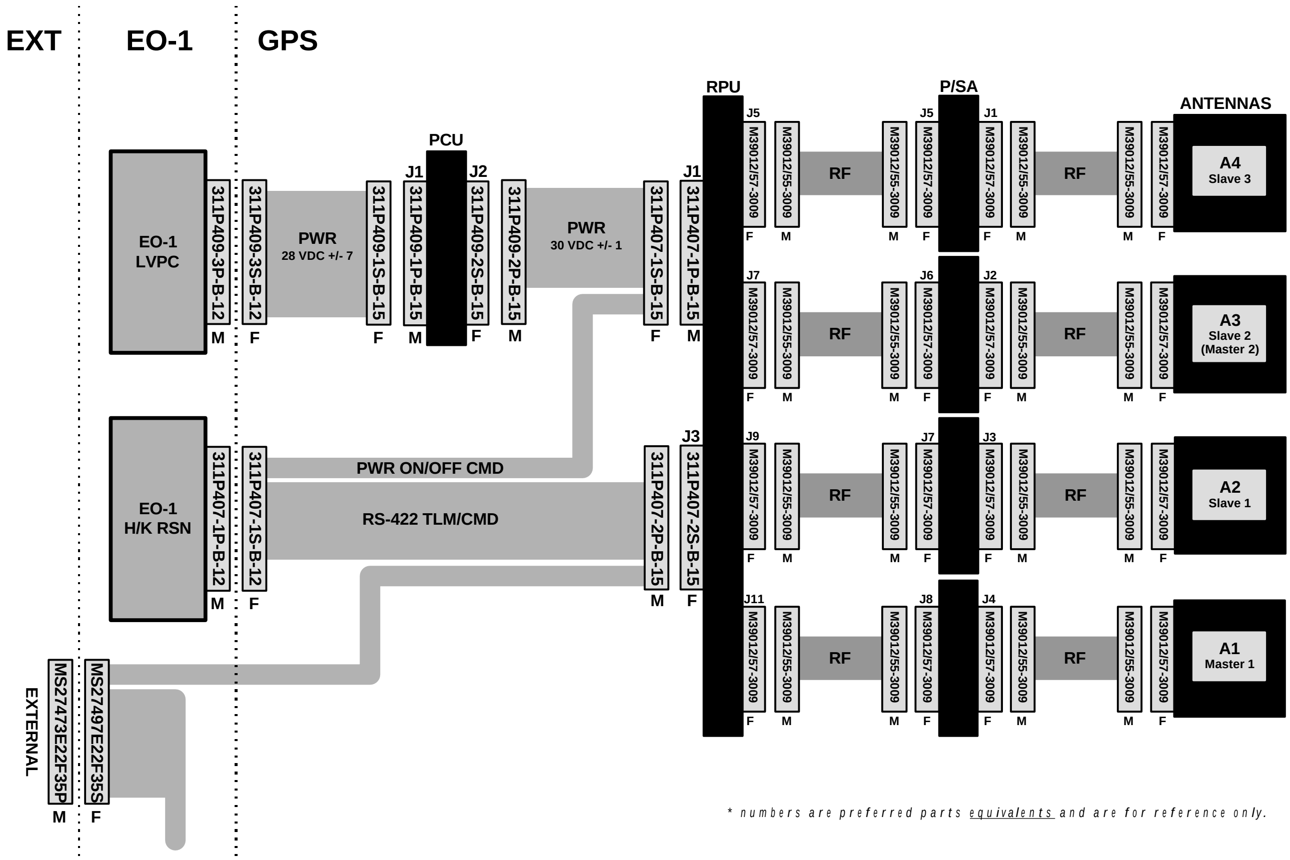


Figure 9: GPS Electrical Interface Diagram

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	TBD	25.40 mm	TBD
CM_y	67.44 mm	TBD	69.09 mm	TBD
CM_z	18.92 mm	TBD	31.75 mm	TBD

4.2 Mass Moments of Inertia

The mass moments of inertia for the PCU, RPU, Preamplifier/Splitter Assembly and antennas are given below.

	PCU	RPU	P/SA	Ant
I_{xx}	TBD	TBD	TBD	TBD
I_{yy}	TBD	TBD	TBD	TBD
I_{zz}	TBD	TBD	TBD	TBD
I_{xy}	TBD	TBD	TBD	TBD
I_{xz}	TBD	TBD	TBD	TBD
I_{yz}	TBD	TBD	TBD	TBD

Table 8: Mass Moments of Inertia for GPS subassemblies

4.3 Mounting Access and Alignment

4.3.1 Power Conditioning Unit

The PCU will be mounted as TBD.

4.3.2 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 10. The RPU (in its bracket) will, in turn be mounted in the EO-1 bay 6 as is shown in Figure 11.

4.3.3 Preamplifier/Splitter Assembly

The Preamplifier/Splitter Assembly will be mounted in the EO-1 bay 6 as is shown in Figure 11.

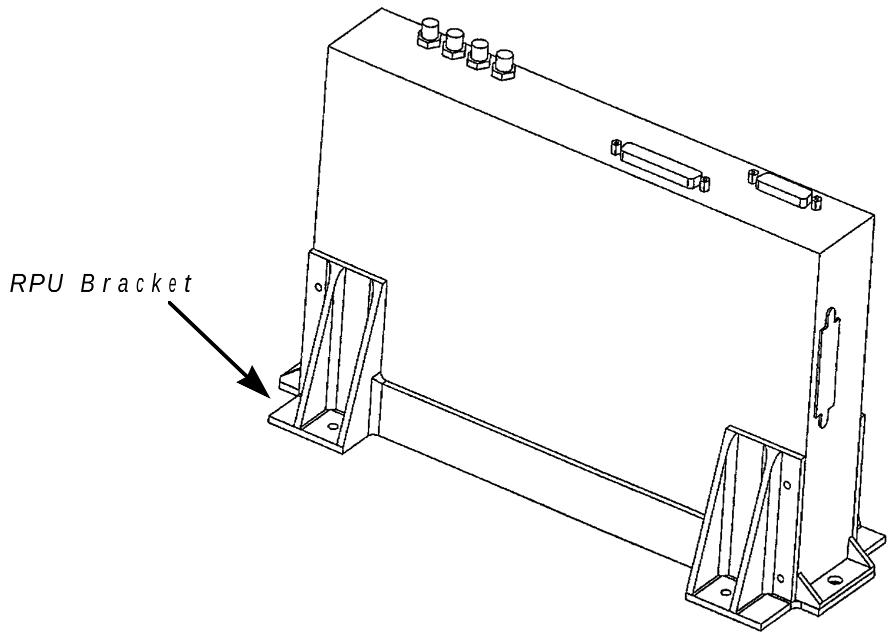


Figure 10: Single String RPU Bracket

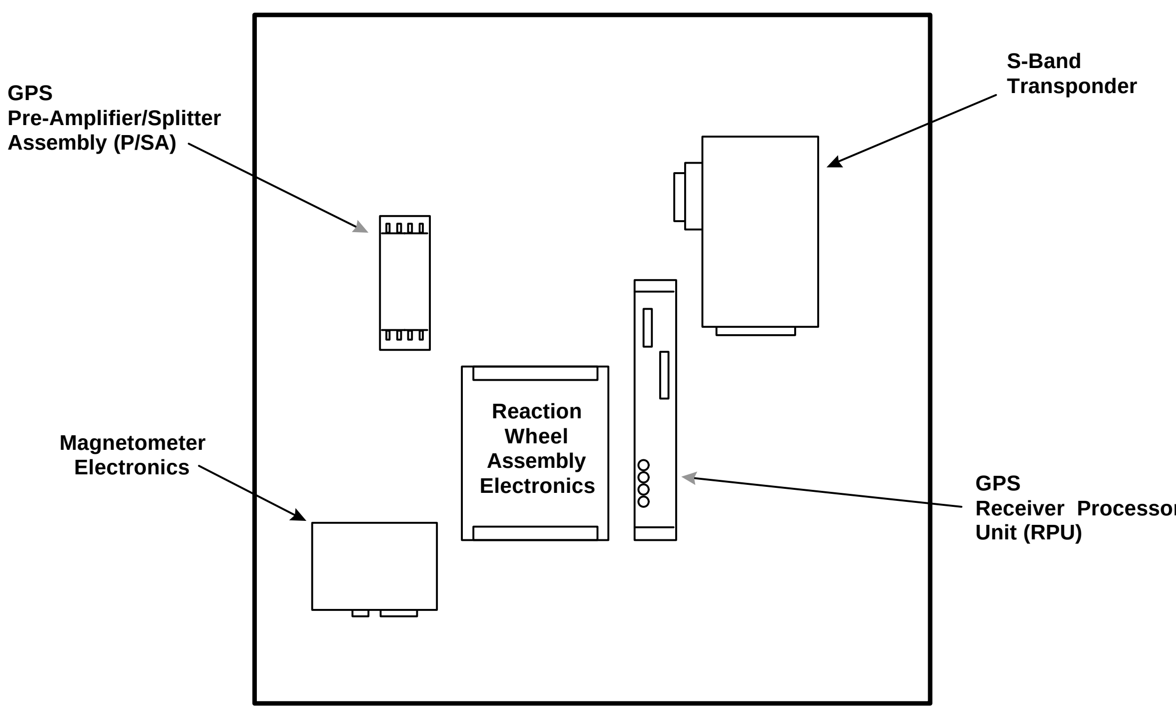


Figure 11: EO-1 Bay 6 Layout

4.3.4 GPS Antennas

Four antennas shall be mounted on mounting brackets as shown in Figure 12. 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 13.

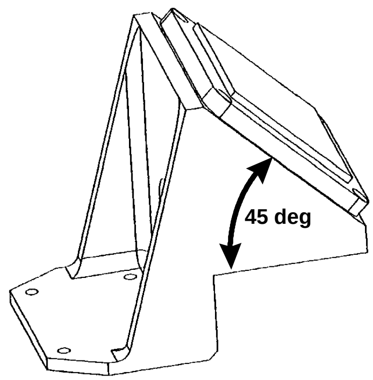


Figure 12 : GPS Antenna Mounting Bracket

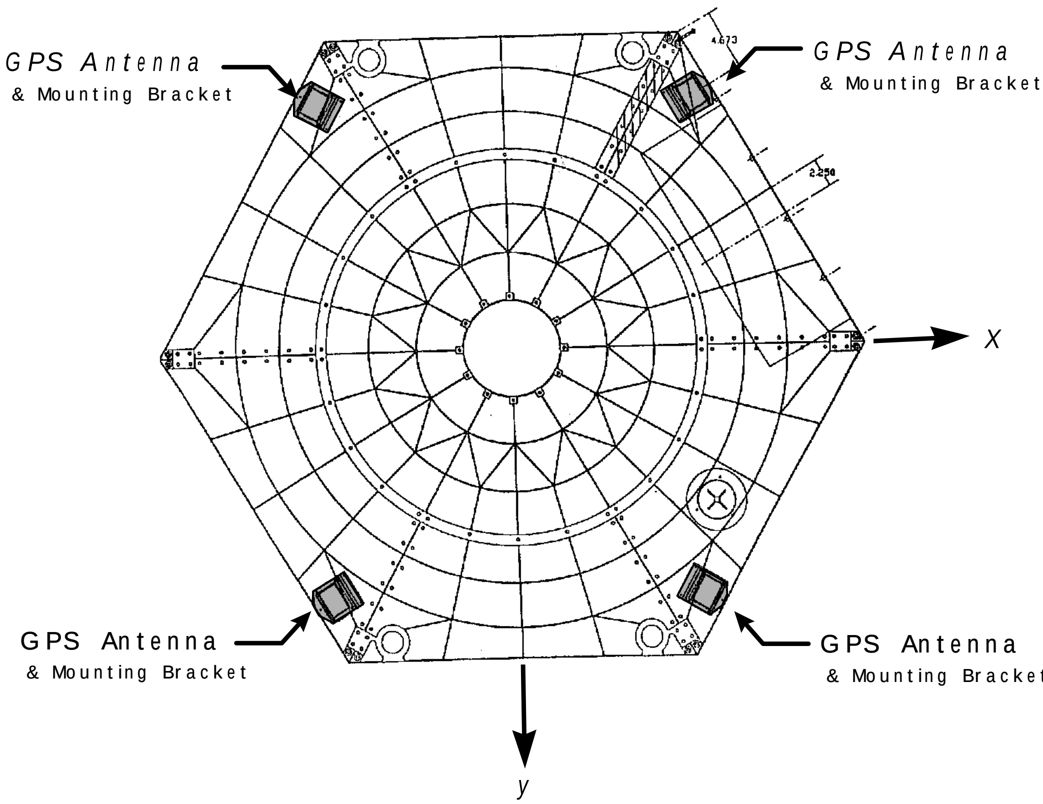


Figure 13 : GPS Antenna Mounting on EO-1 Zenith Pointing Deck

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 simply 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 spacecraft bus voltage to the RPU.

2. Wait 20 seconds

3. When power is applied to the Tensor, it performs a self-test for approximately the first 20 seconds, in which the Tensor enters into a “sleep” mode. In this mode the Tensor will not transmit any telemetry nor will it store or process any commands. Once 20 seconds have elapsed, the Tensor autonomously switches into “nominal” mode, enabling telemetry output and the processing of commands. The following steps can now be performed.

4. Send the following initialization commands to the RPU. These need to be sent only once upon Tensor power-on.

5. TBD

6. Wait for a valid position fix.

7. When does the Tensor output a valid position fix?

8. 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".

9. TBD

6.2 Power-off Sequence

1. Remove spacecraft bus voltage from the RPU. No further action is required.

6.3 Commands

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

6.4 Telemetry

GPS telemetry consists of the following:

7. Environmental Testing Requirements

7.1 EMI Compatibility

TBD

7.2 Susceptibility

TBD

7.3 EMC Testing

TBD

7.4 Thermal Vacuum Testing

TBD

7.5 Vibration Testing

TBD

7.6 Functional/Performance Testing

TBD

7.7 Optional Environmental Tests

TBD

7.8 Special Testing Requirements

TBD

7.9 Ephemerides

TBD

7.10 Factory and Launch Site Requirements

TBD

7.11 Operational Requirements

TBD

7.12 Other Special Requirements

TBD

8. Deliverables to the EO-1 Project

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

8.1 Hardware

The following hardware items will be delivered to the EO-1 project for the integration onto the spacecraft.

- One Power Conditioning Unit (PCU).
- One Receiver Processor Unit (RPU).
- One four-channel Preamplifier/Splitter Assembly (P/SA).
- Four GPS antennas.
- Four RF cables connecting the antennas to the P/SA.
- Four RF cables connecting the P/SA to the RPU.

8.2 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:

8.2.1 Certificate of Compliance

A Certificate of Compliance will be submitted with the Tensor 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

8.2.2 Test Results/Reports

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

- Vibration Test
- Thermal Vacuum Test
- Performance Test

8.3 Ground Support Equipment

TBD

8.4 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.

8.5 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 contamination requirements.

9. EO-1 Spacecraft Specifics

9.1 Electrical Power

The spacecraft provides switched, unregulated, fused power of 28 to 35 VDC to the PCU. As mentioned previously, the PCU in turn provides power to the RPU and to the Preamplifier/Splitter Assembly via the RF cabling.

9.1.1 Fuses and Protection

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

9.1.2 Ripple Voltage

The power supplied by the spacecraft will have a ripple ≤ 0.5 V, peak-to-peak, from 1 Hz to 100 MHz..

9.1.3 Grounding and Shielding

The spacecraft primary power bus employs a Single Point Ground (SPG).

9.2 Thermal Control

9.2.1 Power Conditioning Unit

The spacecraft will maintain the temperature of the PCU between -20° C and +60° C when operating. The non-operating survival temperature limits for the PCU will be -40° C to +65° C.

9.2.2 Receiver Processor Unit

The spacecraft will maintain the temperature of the RPU between -20° C and +60° C when operating. The non-operating survival temperature limits for the RPU will be -40° C to +65° C.

9.2.3 Preamplifier/Splitter Assembly

The spacecraft will maintain the temperature of the preamplifier between -20° C and +60° C when operating. The non-operating survival temperature limits for the preamp are -40° C to +65° C.

9.2.4 GPS Antennas

The spacecraft will maintain the temperature of the GPS antennas between -55° C and +85° C when operating. The non-operating survival temperature limits for the GPS antennas are -55° C to +85° C.

9.3 Orbit and Stabilization

The GPS has no special orbit or spacecraft stabilization requirements.

The EO-1 spacecraft is a three-axis stabilized, earth pointing platform with the following orbit parameters:

- Altitude: 705 km
- Inclination: 98.2 deg
- Local time of ascending node: 10:00 AM

10. Appendix 1: Acronyms

°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

Position Accuracy: SEP (Spherical Error Probability), The radius of a sphere such that 50% of the position estimates will fall within the surface of the sphere. Standard Positioning Service (SPS) solutions (point solutions) position specification in "sigma terms" is: 450 meter (3-sigma), RSS. This number is when Selective Availability is enabled. GEODE will improve accuracy to < 60 meters, 3-sigma and WAAS will further improve this to < 5 meters. Both GEODE and WAAS capabilities are to be baselined for this application.

Velocity Accuracy: There has been some disagreements about the velocity accuracy of the Tensor. I believe 0.6 meter/second, 3-sigma, is now what SS/L is quoting for the velocity spec. As with the position, this is when Selective Availability is enabled.

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. If GEODE/WAAS is used to provide navigation information then these algorithms will need to be written to output the desired coordinate frame and time reference.

Time 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 (3-sigma) 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 microsecond (3-sigma) of every GPS second. However, the catch to this 1 microsecond accuracy is the "time at the next pulse" message (Loral calls this the digital time) coming from the receiver is only accurate to 1 millisecond (3-sigma). So if you will be using the digital time in association with the pulse train, the accuracy will only be 1 millisecond (3-sigma).

Output Update Interval: Current Tensor design reflects a 1 Hz computation and output rate for the navigation data. We will need to talk to SS/L about increasing this to 2 Hz.

Number of Antennas: The way the Tensor works is as follows. The Tensor has four antenna input ports, labeled Antenna Port 1, Antenna Port 2, Antenna Port 3, Antenna Port 4. By default Antenna Port 1 is used for navigation (By default I mean after Tensor power-up). This is hard-coded 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 for navigation. Again, this backup antenna port for navigation is hard-coded and cannot be changed. There is however, a packet 63 hex, which the user can send to the Tensor to force the antenna used for navigation to any of the four antenna ports. The receiver does assume the antenna boresight is pointed zenith. This seems to be inherent in all present GPS receivers. If there is enough time and money, then the Tensor software could be potentially be changed (we need to ask Loral) to accept an external attitude to aid the Tensor in searching for GPS satellites.

Dimensions: One RPU:, One Quad Preamp/Splitter:, One Antenna: 3” x 3” x 0.3” = 76 mm x 76 mm x 8 mm. Again, if we baseline the Trimble antennas, then the antenna dimensions will increase to approximately.

Power: One RPU consumes 10 Watts, orbital average. I think 15 Watts, maximum is a safe number to use. If GEODE/WAAS is implemented in the receiver, this may increase the power consumption for both orbital average and maximum.

Temperature: RPU Operating: -20 to +60 degrees Celsius, RPU Non-operating: -40 to +65 degrees Celsius, Preamp Operating: -20 to +60 degrees Celsius, Preamp Non-operating: -40 to +65 degrees Celsius, Antenna Operating: -55 to +85 degrees Celsius, Antenna Non-operating: -55 to +85 degrees Celsius.

Flight Testing: First short-term flight of the Tensor will be onboard the Shuttle, Orfeus-SPAS, scheduled for launch in November 1996. First long-term flight will be SSTI/Lewis mission scheduled for launch in December, 1996.

Vendor Testing: The Tensor design has been qualified per SS/L's qualification test plan. If required the unit that we procure for EO-1 can be environmentally tested (thermal vacuum and vibration).

It is a sun-synchronous orbit, 705 Km altitude, 98.2 degree inclination with a 10:15 AM descending node crossing. The design life is 1 year with expendabled for 1.5 years. EO-1 prime contractor is Swales Aerospace. Litton Amecom Space System Operations has subcontract for the avionics and the ACS. Hammers Company is doing ACS flight software. The Phase B development is underway, with the spacecraft PDR scheduled for late November. Component deliveries for I&T will be required in the time period from June 1997 through June 1998, depending on component. Launch is expected in the first quarter of calendar year 1999. The interfaces between the GPS Receiver System are defined in this document.

From: Paul Sanneman <Paul_Sanneman@amecom.com>
To: "'Mark Perry'" <mperry@swales.com>
Cc: "'Quinn, David'" <David.Quinn@gsfc.nasa.gov>,
"'Schneider, Steve'"
<sschneider@hst.nasa.gov>
Subject: RE: Baseline EO-1 GPS Navigation Sensor ICD-025
Date: Thu, 8 Jan 1998 07:30:21 -0500

Mark et al.
Here are my comments on the GPS ICD-025 you provided:

pg 7 sec 3.1.1.3 unclear as to whether this is the in-rush into the PCU at turn-on or what it can withstand at the RPU side; the LVPC upstream of the PCU can only handle 10A for 1usec, 3A for 50msec

pg 10 Is the acronym "GEM" an EO-1 item

pg 19 the Power-On initialization command sequence will need to have the packet 35 settings for setting coord frame to ECI, J2000; also, it would be helpful to know if providing a time and EO1 ephemeris is useful for a 'lukewarm' start (i.e. we will not download the GPS almanac)

pg 25 EO-1 orbit 10 AM crossing is on descending node, not ascending

pg 29 GPS performance for velocity, position and position stability accuracies should be moved to a more prominent number section in the document

pg 29 remove references to GEODE/WAAS in two places, and output interval statement about 2 Hz

pg 30 not necessary in this document

From: Mark Perry[SMTP:mperry@swales.com]
Sent: Tuesday, January 06, 1998 9:18 AM
To: Paul Sanneman
Subject: Fw: Baseline EO-1 GPS Navigation Sensor ICD-025

```
Date: Fri, 23 Jan 1998 14:10:51 -0500 (Eastern Standard Time)
From: Administrator@hst-nic.hst.nasa.gov
Reply-to: (Mark Perry/Swales)
Subject: CCR:0005 - DUE: 01/19/98   ROUTINE  Level-2 Mark Perry/Swale WWW-COMMENTS

USER :    (Mark Perry/Swales) sent the following comments on :

------------------------------------------------------------
Date: 01/23/1998
CCR Number: 0005
Sponsor: N. Speciale/EO-1 Mission Tech
Due Date: 01/19/98
------------------------------------------------------------
CCR Title: BASELINE EO-1 S/C TO GPS NAVIGATION SENSOR ICD-025
------------------------------------------------------------
Remote host: 198.118.115.46  Email Address:
------------------------------------------------------------
APPROVAL STATUS:     APPROVED WITH COMMENTS
Note:  Hard Copy Marked Up Graphics Mailed Separately
------------------------------------------------------------
COMMENTS:
```

1. Introduction

The Goddard Space Flight Center (GSFC) Earth Orbiter-l (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 ~~four~~ subassemblies:

- FLIGHT SOFTWARE
- One Power Conditioning Unit (PCU)
- One Receiver Processor Unit (RPU)
- One four-channel Preamplifier/Splitter Assembly
- Four GPS patch antennas (L 1 frequency)
- WIRE HARNESS CONNECTING THE ABOVE 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^{TM}. 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 USING GPS DATA FOR Autonomous Orbit Control and an Enhanced Formation Flying experiment.

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 and Environmental Specification for the NMP EO-1	
~~GEVS~~	~~General Environmental Verification Requirements~~	~~11/90~~
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	
Loral E101027	GLOBALSTAR GPS Tensor System Proto/FlightQualification/Acceptance Test Procedure	
Loral E034580	Receiver Processor Unit (RPU) Interface Control Drawing	12/97
Loral E034811	Four-Channel Preamplifier/Splitter Assembly Interface Control Drawing	12/97
Loral E123167	GPS Antenna Interface Control Drawing	12/97
AM-147-0020(155)	SYSTEM LEVEL ELECTRICAL REQUIREMENTS, EO-1	6/97

1.3 ICD Revision

Requests for revisions to this ICD shall be transmitted in written form between GSFC, Swales and Litton. All requests must include:

- Name of initiating engineer/manager
- Description of change
- Date on which change is needed
- Justification for change
- Relationship to previously submitted changes, if any.

The Swales Payload Manager shall review and negotiate the change with the appropriate engineers and managers, including GSFC personnel. Approved changes shall be signed by authorized representatives of GSFC, Swales and Litton. Upon completion of the signature cycle, the changes shall become effective immediately. The Swales Payload Manager is responsible for updating the ICD to reflect revisions as well as maintaining documentation of all requests for revision, whether approved or disapproved.

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).

2. Physical Characterisitcs

GIVE DRAWING NUMBERS

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).

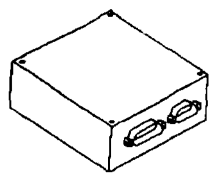


Figure 1: EO-1 GPS Power Conditioning Unit

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).

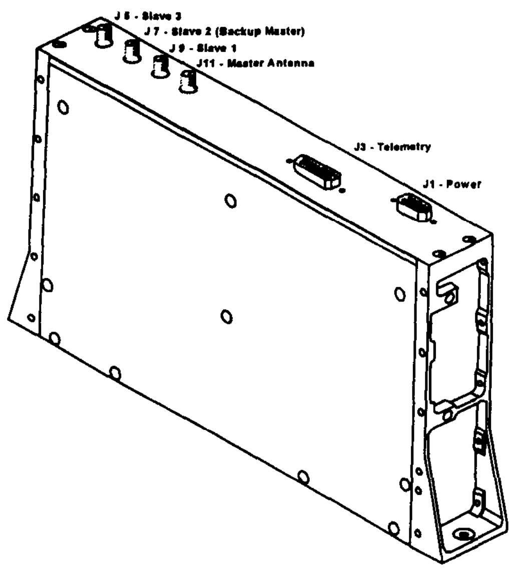


Figure 2: EO-1 GPS Receiver Processor Unit

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 5 1 x 76 mm (6 x 2 x 3 in.), and the weight is 0.5 kg (1 lb).
ONLY ONE OF THE PRE-AMP OUTPUTS WILL BE USED FOR EO-1.

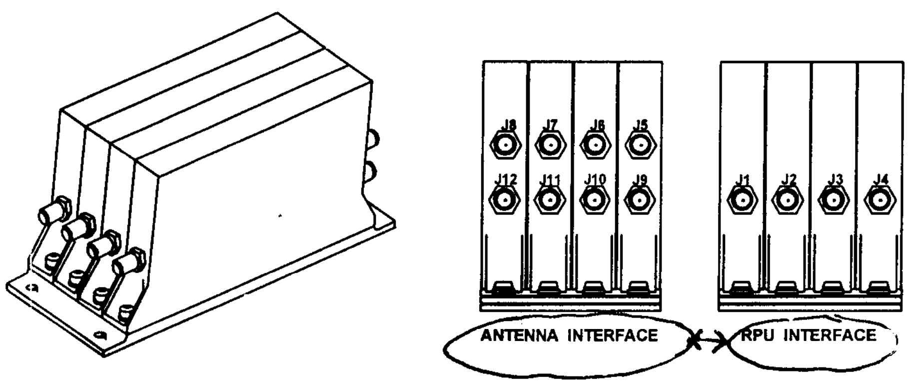
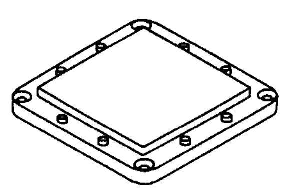


Figure 3: EO-1 GPS Preamplfier / Splitter Assembly

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). 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.



UPDATE
(ANTENNA HAS CHANGED)

Figure 4: EO-1 GPS Antenna

Table 2: Specifications for the EO-1 GPS Antenna

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

3. Electrical Characteristics

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

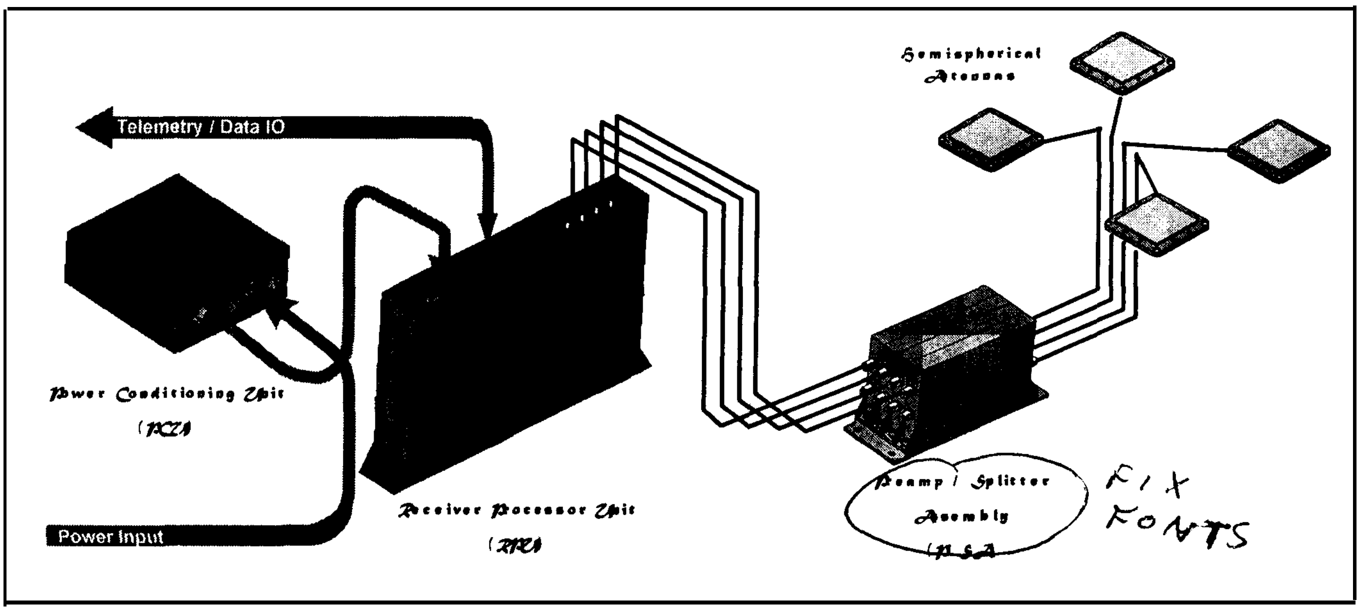


Figure 5: EO-1 GPS System

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, the PCU will dissipate 3.2 W.

3.1.1.1 PCU Line Load Regulation

The PCU operates effectively from an input voltage range of ~~16~~ VDC to ~~40~~ VDC. ~~The resulting output voltage variation does not exceed 180 mV.~~

3.1.1.2 PCU Efficiency

In range of 10 W to 16 W output power level, the PCU converts power at 80% efficiency.

3.1.1.3 PCU In-Rush Current Limitation

The PCU is nominally tolerant of a 10 amp in-rush for a duration of TRD µsec.

3.1.1.4 PCU Output Ripple Voltage

During nominal operation, the PCU output ripple voltage does not exceed 120 mV.

3.1.2 Receiver Processor Unit

The power consumption of the RPU is 10 W, orbital average, and 16 W, maximum. It is important to remember that these numbers represent the power consumption of the RPU. Included in these numbers is the 1 W necessary to power the Preamplifier/Splitter Assembly. Therefore, if the measurement needed is power dissipation, then the numbers become 9 W dissipated, orbital average, and 15 W dissipated, maximim.

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. Therefore, the Preamplifier/Splitter Assembly has a power dissipation of 1 W.

3.1.4 GPS Antenna

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

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

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 3 11 P407- 1 P-B- 15). J2 is the power output connector, a 15-pin, low-density, subminiature "D" female connector (P/N 3 11 P407-2S-B- 15).

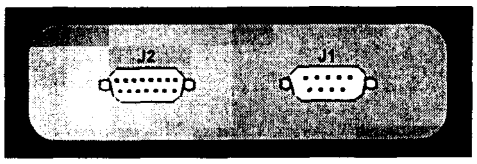


Figure 6: PCU Electrical Interface

TBD information here.
TBD information here.
TBD information here.
TBD information here.
TBD information here.

Table 3: PCU Input Connector (J1) Signal Definition

Pin	Signal name	Signal Deflnition
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	~~+28 VDC (+/-7 VDC)~~ SPARE	~~Main Power Input from Spacecraft Bus~~
07	Spare	
08	Spare	
09	~~Return~~ SPARE	~~Main Power Return to Spacecraft Bus~~

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, PM DD26F4B300S). Connectors J5, J7, J9 and J1 1 are the RF inputs into the RPU; they are female SMA connectors (MA-COM, P/N 2064-5038-94).

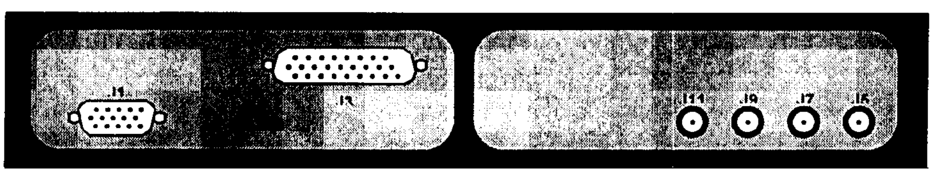


Figure 7: RPU Electical Interface

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. Commanding to the RPU can be done on both RS-422 interfaces, however, not simultaneously. The data port is connected to the EO-1 Houskeeping RSN, which converts the signals to 1553 protocol for communication with the EO-1 on-board computer (Mongoose V). The I/O circuit of the data connector is shown in Figure 8. The RPU also has two (primary and secondary) discrete one-pulse-per-second outputs that are connected directly to the EO- I on-board computer via the Houskeeping RSN. The RPU provides precise time to the spacecraft in is this correct what GEM

a "The time at the tone will be" format. Digital time in packetized format is sent to the S/C through the RS-422/GEM 1553B converter followed by the Pulse-per-Second, UTC-synchronous discrete signal which is sent directly from the receiver to the S/C processor (i.e., not transmitted through GEM). This message pair is sent to the SIC once every second. 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 Pulse-Per-Second circuit is given in Figure 4-6. The pin and signal definitions of the RS-422 data connector are given in Table 5.

No figure 4-6

No, this will be standard, 24-gauge twisted shielded pair (~120Ω, uncontrolled

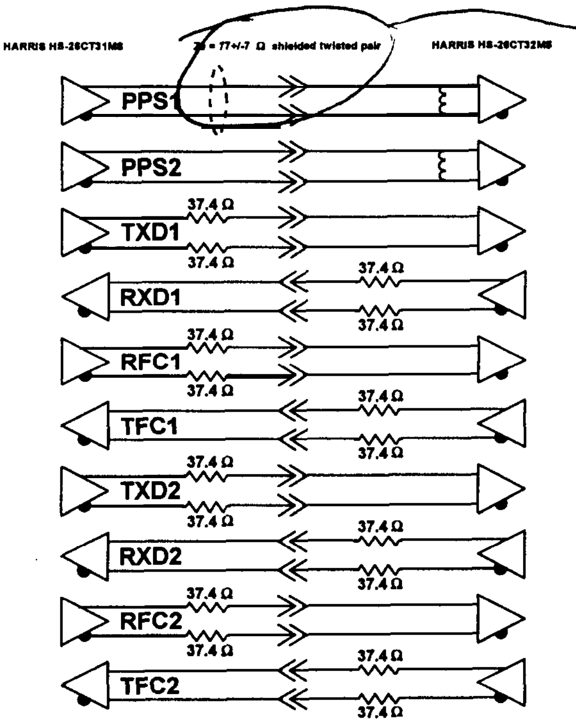


Figure 8: GPS Tensor Driving and Receiving

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

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 9.

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) which is shown below.

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 (as determined by the EO- 1 project) are given in Table 7. The tolerances of the cable lengths are ± 0.5 inch.

3 , 2. 6 WIRE HARNESS
GSFC WILL SUPPLY THE FLIGHT HARNESS BETWEEN THE PCU AND THE RPU

Table 7: GPS RF Cable Lengths and Connectivity

FROM	TO	Length	Serial #	Cable Type
Antenna #1 (Serial Number TBD)	Preamplifier/Splitter Assembly J1	TBD	TBD	0.190 Gore (TBR)
Antenna #2 (Serial Number TBD)	Preamplifier/Splitter Assembly J2	TBD	TBD	0.190 Gore (TBR)
Antenna #3 (Serial Number TBD)	Preamplifier/Splitter Assembly J3	TBD	TBD	0.190 Gore (TBR)
Antenna #4 (Serial Number TBD)	Preamplifier/Splitter Assembly J4	TBD	TBD	0.190 Gore (TBR)
Preamplifier/Splitter Assembly J5	RPU J5 (TBR)	TBD	TBD	RG-142 (TBR)
Preamplifier/Splitter Assembly J6	RPU J7 (TBR)	TBD	TBD	RG-142 (TBR)
Preamplifier/Splitter Assembly J7	RPU J9 (TBR)	TBD	TBD	RG-142 (TBR)
Preamplifier/Splitter Assembly J8	RPU J11 (TBR)	TBD	TBD	RG-142 (TBR)

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 Transients

The GPS shall not be damaged by the application of 45 VDC for 5 seconds or a transient spike of 50 VDC for 50 ms.

3.5 Inrush Current

The inrush current shall not exceed 2 Amps.

These are all specified in the Electrical Systems Spec

3.6 Survival Power

The GPS shall not be damaged by the lack of power while in orbit and therefore, the GPS requires no on-orbit power for survival during spacecraft anomalous situations.

3.7 Reverse Voltage

The GPS shall not be damaged by a reverse voltage condition.

3.8 Under Voltage

The GPS shall not be damaged by any input voltage between 0 and 21 volts.

3.9 Over Voltage

The GPS shall not be expected to operate as specified herein during periods when the voltage is greater than 35 VDC, exclusive of short-duration transients. The GPS shall perform as specified herein after having been subjected to 35 VDC followed by a return to the range of 21 to 35 VDC.

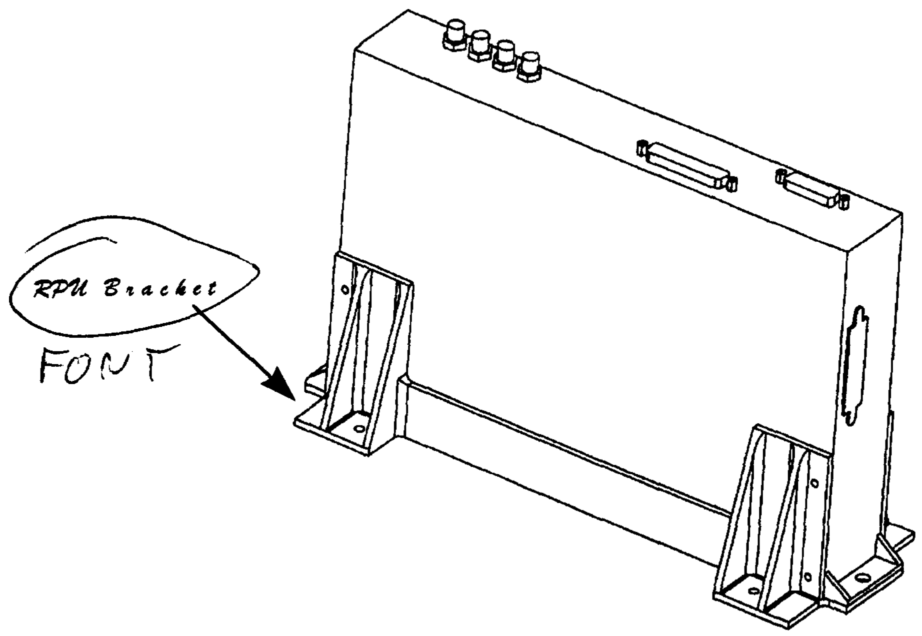
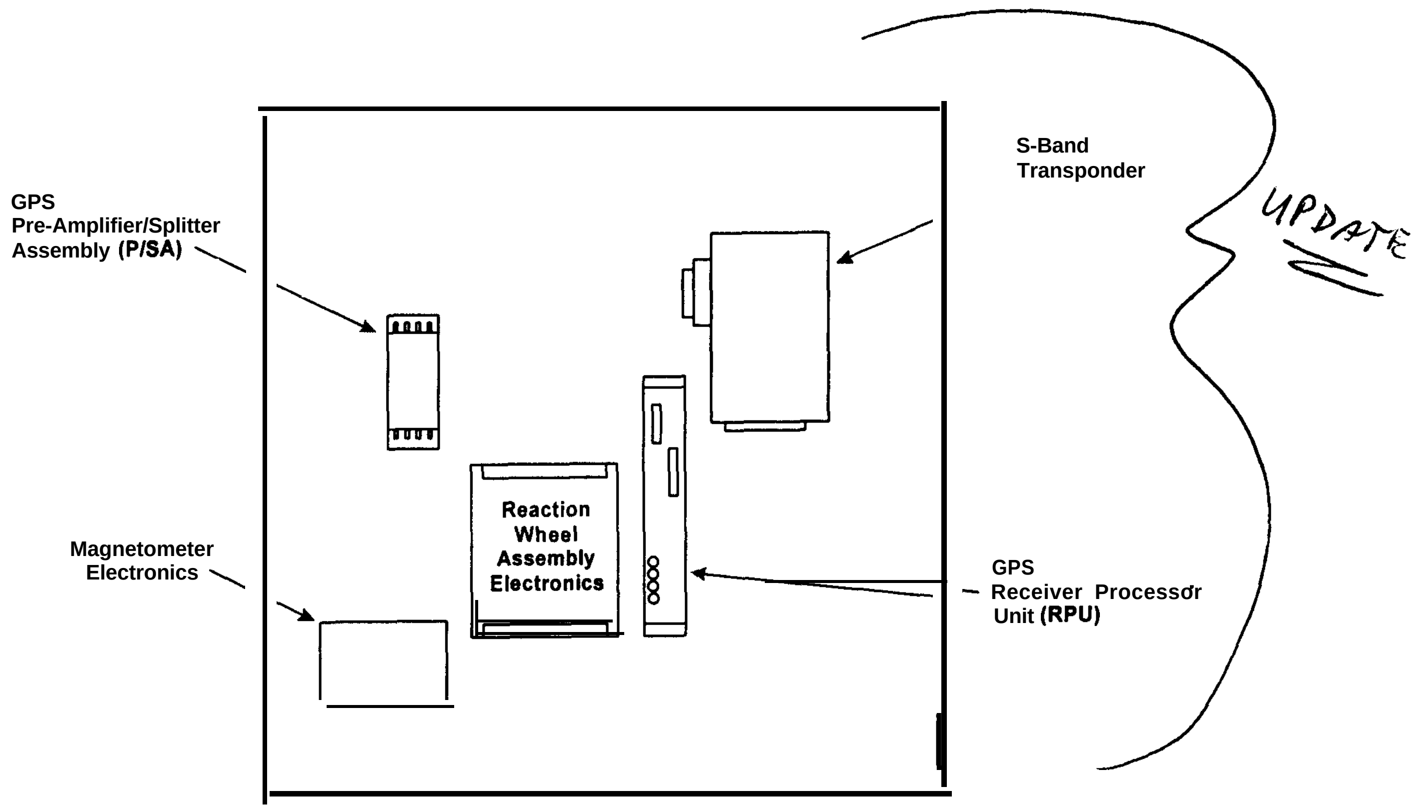


Figure 10: Single String RPU Bracket



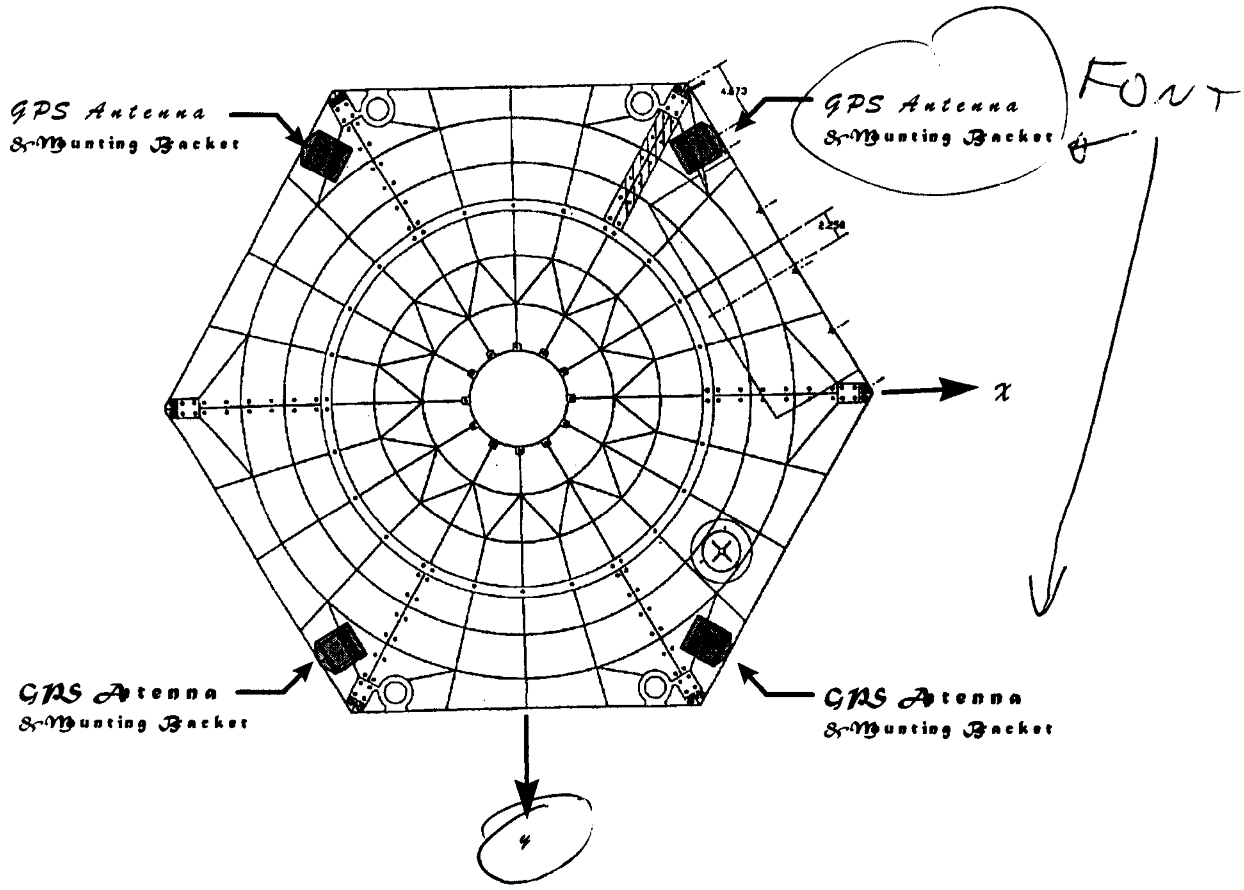


Figure 13 : GPS Antenna Mounting on EO-1 Zenith Pointing Deck

5. Software Description

All data interface characteristics including all data packet definitions, formats and timing are outlined in explicit detail in Loral controlled document E 101050, "GPS Attitude and Orbit Determination System and GPS Orbit Determination System (GPSAODS and GPSODS) Performance Specification". *For*

IS EO-1 using all the S/W?
DOES EO-1 need all data packets?
What packets are required for technology validation

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 ~~simply~~ 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 spacecraft bus voltage to the RPU.

2. Wait 20 seconds

3. When power is applied to the Tensor, it performs a self-test for approximately the first 20 seconds, in which the Tensor enters into a "sleep" mode. In this mode the Tensor will not transmit any telemetry nor will it store or process any commands. Once 20 seconds have elapsed, the Tensor autonomously switches into "nominal" mode, enabling telemetry output and the processing of commands. The following steps can now be performed.

4. Send the following initialization commands to the RPU. These need to be sent only once upon Tensor power-on.

5. TBD

6. ~~Wait for a valid position fix,~~ *APPROXIMATELY 30 minutes, without an estimate of satellite location.*

7. ~~When does the Tensor output a valid position fix?~~

8. 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". *NEED THIS COMPLETED*

9. ~~TBD~~

— DOES IT HELP IF THE S/C SUPPLIES TIME AND EPHEMERIS? (NO GPS ALMANAC, THOUGH)
— NEED PACKET #35 SET FOR ECI J2000 COORDINATE FRAME.

6.2 Power-off Sequence

I. Remove spacecraft bus voltage from the RPU. No further action is required.

6.3 Commands

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

6.4 Telemetry

include list

GPS telemetry consists of the following:

COMPLETE THIS

6.5 PERFORMANCE

(A) FROM PAGE 29

7. Environmental Testing Requirements

The GPS will meet the requirements of the EO-1 verification PLAN, SAI-SPEC-158

7.1 EMI Compatibility
TBD

7.2 Susceptibility
TBD

7.3 EMC Testing
TBD

7.4 Thermal Vacuum Testing
TBD

7.5 Vibration Testing
TBD

7.6 Functional/Performance Testing
TBD

7.7 Optional Environmental Tests
TBD

7.8 Special Testing Requirements
TBD

7.9 Ephemerides
TBD

COMPLETE THESE TBDs

7.10 Factory and Launch Site Requirements
TBD

7.11 Operational Requirements
TBD

7.12 Other Special Requirements
TBD

8. Deliverables to the EO-1 Project

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

8.1 Hardware

by 15 JULY 1998

The following ~~hardware~~ items will be delivered to the EO- 1 project for the integration onto the spacecraft.

- One Power Conditioning Unit (PCU).
- One Receiver Processor Unit (RPU).
- One four-channel Preamplifier/Splitter Assembly (P/SA).
- Four GPS antennas.
- Four RF cables connecting the antennas to the P/SA.
- Four RF cables connecting the P/SA to the RPU.
- SOFT WARE
- PCU-TO-RPU HARNESS

8.2 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:

8.2.1 Certificate of Compliance

A Certificate of Compliance will be submitted with the ~~Tensor~~ 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

8.2.2 Test Results/Reports

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

- Vibration Test
- Thermal Vacuum Test
- Performance Test

8.2.3 Test procedures

8.3 Ground Support Equipment

TBD NEED description of H/W supplied for testing GPS.

8.4 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.

HOW? WHAT TES ARE REQUIRED?

8.5 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 contamination requirements.

9. EO-1 Spacecraft Specifics

9.1 Electrical Power

The spacecraft provides switched, unregulated, fused power of 28 to 35 VDC to the PCU. As mentioned previously, the PCU in turn provides power to the RPU and to the Preamplifier/Splitter Assembly via the RF cabling.

9.1.1 Fuses and Protection

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

9.1.2 Ripple Voltage

The power supplied by the spacecraft will have a ripple ≤ 0.5 V, peak-to-peak, from 1 Hz to 100 MHz..

9.1.3 Grounding and Shielding

The spacecraft primary power bus employs a Single Point Ground (SPG).

9.2 Thermal Control

9.2.1 Power Conditioning Unit

The spacecraft will maintain the temperature of the PCU between -20” C and +60° C when operating. The non-operating survival temperature limits for the PCU will be -40” C to +65° C.

9.2.2 Receiver Processor Unit

The spacecraft will maintain the temperature of the RPU between -20” C and +60° C when operating. The non-operating survival temperature limits for the RPU will be -40” C to +65° C.

9.2.3 Preamplifier/Splitter Assembly

The spacecraft will maintain the temperature of the preamplifier between -20° C and +60° C when operating. The non-operating survival temperature limits for the preamp are -40” C to +65° C.

9.2.4 GPS Antennas

The spacecraft will maintain the temperature of the GPS antennas between -55” C and +85° C when operating. The non-operating survival temperature limits for the GPS antennas are -55° C to +85° C.

9.3 Orbit and Stabilization

The GPS has no special orbit or spacecraft stabilization requirements.

The EO- 1 spacecraft is a three-axis stabilized, earth pointing platform with the following orbit parameters:

- Altitude: 705 km
- Inclination: 98.2 deg
- Local time of ascending node: 10:00 AM

6.5.1
Position Accuracy: SEP (Spherical Error Probability), The radius of a sphere such that 50% of the position estimates will fall within the surface of the sphere. Standard Positioning Service (SPS) solutions (point solutions) position specification in "sigma terms" is: 450 meter (3-sigma), RSS. This number is when Selective Availability is enabled. ~~GEODE will improve accuracy to < 60 meters, 3-sigma and WAAS will further improve this to < 5 meters. Both GEODE and WAAS capabilities are to be baselined for this application.~~ SHALL BE PART OF THE EO-1 GPS.

6.5.2
Velocity Accuracy: ~~There has been some disagreements about~~ the velocity accuracy of the Tensor. ~~I believe~~ SHALL BE 0.6 meter/second, 3-sigma ~~is now what SS/L is quoting for the velocity spec.~~ As with the position, this is when Selective Availability is enabled.

6.5.3
Coordinate Frame: Tensor packet Al 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 52000. If GEODE/WAAS is used to provide navigation information then these algorithms will need to be written to output the desired coordinate frame and time reference.

6.5.4
Time 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 (3-sigma) 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 microsecond (3-sigma) of every GPS second. However, the catch to this 1 microsecond accuracy is the "time at the next pulse" message (Loral calls this the digital time) coming from the receiver is only accurate to 1 millisecond (3-sigma). So if you will be using the digital time in association with the pulse train, the accuracy will only be 1 millisecond (3-sigma).

6.5.5
Output Update Interval: Current Tensor design reflects a 1 Hz computation and output rate for the navigation data. ~~We will need to talk to SS/L about increasing this to 2 Hz.~~

6.5.6
Number of Antennas: ~~The way the Tensor works is as follows:~~ The Tensor has four antenna input ports, labeled Antenna Port 1, Antenna Port 2, Antenna Port 3, Antenna Port 4. By default Antenna Port 1 is used for navigation (By default I mean after Tensor power-up). This is hard-coded 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 for navigation. Again, this backup antenna port for navigation is hard-coded and cannot be changed. There is however, a packet 63 hex, which the user can send to the Tensor to force the antenna used for navigation to any of the four antenna ports. The receiver does assume the antenna boresight is pointed zenith. This seems to be inherent in all present GPS receivers. If there is enough time and money, then the Tensor software could be potentially be changed (we need to ask Loral) to accept an external attitude to aid the Tensor in searching for GPS satellites.

Dimensions: One RPU:, One Quad Preamp/Splitter:, One Antenna: 3" x 3" x 0.3" = 76 mm x 76 mm x 8 mm. Again, if we baseline the Trimble antennas, then the antenna dimensions will increase to approximately.

Power: One RPU consumes 10 Watts, orbital average. I think 15 Watts, maximum is a safe number to use. If GEODE/WAAS is implemented in the receiver, this may increase the power consumption for both orbital average and maximum.

Temperature: RPU Operating: -20 to +60 degrees Celsius, RPU Non-operating: -40 to +65 degrees Celsius, Preamp Operating: -20 to +60 degrees Celsius, Preamp Non-operating: -40 to +65 degrees Celsius, Antenna Operating: -55 to +85 degrees Celsius, Antenna Non-operating: -55 to +85 degrees Celsius.

Flight Testing: First short-term flight of the Tensor will be onboard the Shuttle, Orfeus-SPAS, scheduled for launch in November 1996. First long-term flight will be SSTI/Lewis mission scheduled for launch in December, 1996.

Vendor Testing: The Tensor design has been qualified per SS/L's qualification test plan. If required the unit that we procure for EO- 1 can be environmentally tested (thermal vacuum and vibration).

It is a sun-synchronous orbit, 705 Km altitude, 98.2 degree inclination with a 10: 15 AM descending node crossing. The design life is 1 year with expendabled for 1.5 years. EO-1 prime contractor is Swales Aerospace. Litton Amecom Space System Operations has subcontract for the avionics and the ACS. Hammers Company is doing ACS flight software. The Phase B development is underway, with the spacecraft PDR scheduled for late November. Component deliveries for I&T will be required in the time period from June 1997 through June 1998, depending on component. Launch is expected in the first quarter of calendar year 1999. The interfaces between the GPS Receiver System are defined in this document.

Date: Wed, 28 Jan 1998 10:08:08 -0500 (Eastern Standard Time)
From: Administrator@hst-nic.hst.nasa.gov
Reply-to: (Brian Smith / 426)
Subject: CCR:0005 - DUE: 01/19/98 ROUTIN Level-2 Brian Smith / 42 WWW-COMMENTS

USER : (Brian Smith / 426) sent the following comments on :

Date: 01/28/1998
CCR Number: 0005
Sponsor: N. Speciale/EO-1 Mission Tech
Due Date: 01/19/98

CCR Title: BASELINE EO-1 S/C TO GPS NAVIGATION SENSOR ICD-025

Remote host: 128.183.212.183 Email Address: brian.s.smith@gsfc.nasa.gov

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APPROVAL STATUS: DISAPPROVED
Note:

COMMENTS: Here are my comments for the GPS ICD.
I agree with most of the comments already made, and have a few to add.

Page 2 The text of section three should be replaced with:
"revisions to this ICD shall be proposed using the EO-1 project level CM system.

Page 4 I think we use two of the pre-amps, not one or four.

Page 10 The text must be updated to apply to EO-1, not GEM. Also, figure 8 does not specify which end is the tensor, and which is the HK RSN. It specifies a Harris Part for the HK RSN, is that the part being used? The termination resistors are not specified. for the twisted pair cable we are using, this may need redesign?

Page 12 No figure 9 shown.

Page 19 I've heard there is a relay, although I cannot find the interface description in this ICD. Does it need to be closed or opened in this sequence, or does it not exist?

Page 29 One of the more important aspects of this unit is not specified! We need numbers which will be met, for Position and velocity accuracy, not a story. If we don't yet know what the unit can provide, we should specify the absolute minimum acceptable by the current design of the ACS.
Since we don't control SA, do we need specs when we don't have SA? Otherwise, how do we determine performance in those conditions?

Page 30 is inappropriate for an ICD.