EO-1 ICD-026
Baseline
March 30, 1998

Earth Orbiter-1 (EO-1) Spacecraft to Wideband Advanced Recorder/Processor (WARP) Interface Control Document

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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Availability of WARP I&T Procedures	4		

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Section 1. Scope

This interface control document (ICD) defines all interface requirements between the Wideband Advanced Recorder/Processor (WARP) and the Earth Orbiter-1 (EO-1) spacecraft. The ICD documents all interface-related agreements concluded between the technology provider and Swales Aerospace, the spacecraft contractor.

The purpose of this document is to specify the interface requirements in order to assure compatibility between the equipment furnished by the respective contractors. Changes to this document may be proposed by either party for formal approval by the EO-1 Project Office.

This ICD will serve as the controlling technical document between the WARP and the EO-1 spacecraft. This ICD shall apply to all phases of the WARP/EO-1 design, assembly, integration, test, launch, and operations. This document is controlled by the Goddard Space Flight Center (GSFC) EO-1 Project Office.

Section 2. Documents

2.1 Applicable Documents

The following documents of the exact issue shown form a part of the ICD to the extent specified herein. In the event of conflict between this ICD and the document referenced herein, the contents of this ICD shall be considered a superseding requirement.

SAI-PLAN-130	EO-1 Integration and Test Plan
SAI-PLAN-138	EO-1 Contamination Control Plan
SAI-SPEC-158	EO-1 Verification Plan and Environmental Specification
	Command Handbook, Litton Amecom
AM149-0031(155)	EO-1 Telemetry Specification, Litton Amecom
AM149-0020(155)	System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom
AM149-0050(155)	Data Systems 1773 ICD EO-1, Litton Amecom
AM149-XXXX(155)	EO-1 X-Band Downlink ICD, Litton Amecom
	WARP Integration and Test Plan
ICD-026	S/C to WARP ICD
ICD-056	ALI to WARP RS-422 ICD
ICD-023	S/C to Ground ICD
ICD-057	A/C to WARP RS-422 ICD
ICD-065	Hyperion ICD
ICD-067	WARP to ACDS S-Band ICD

2.2 Reference Documents

GSFC-PPL	GSFC Preferred Parts List (latest issue)
MIL-M-38510	General Specification for Microcircuits
MIL-S-19500	General Specification for Semiconductors
MIL-STD-1547	Electronic Parts, Materials, and Processes for Space and Launch Vehicles

MIL-STD-975	Standard (EEE) Parts List
MIL-STD-202	Test Methods for Electronic and Electrical Components
MIL-STD-883	Test Methods and Procedures for Microelectronics

Section 3. Interface Requirements

3.1 Interface Definition

The WARP is a spacecraft component that receives, stores, and processes high-rate science data and associated ancillary data. For the EO-1 mission, these science interfaces originate at the Advanced Land Imager (ALI), ~~and~~ the Linear Etalon Imaging Spectral Array (LEISA) Atmospheric Corrector (LAC), and Hyperion. The WARP then transmits the data to the ground via an X-band or S-band transmitter.

Figure 3-1 shows a block diagram of the WARP and its data interfaces to the spacecraft and instruments.

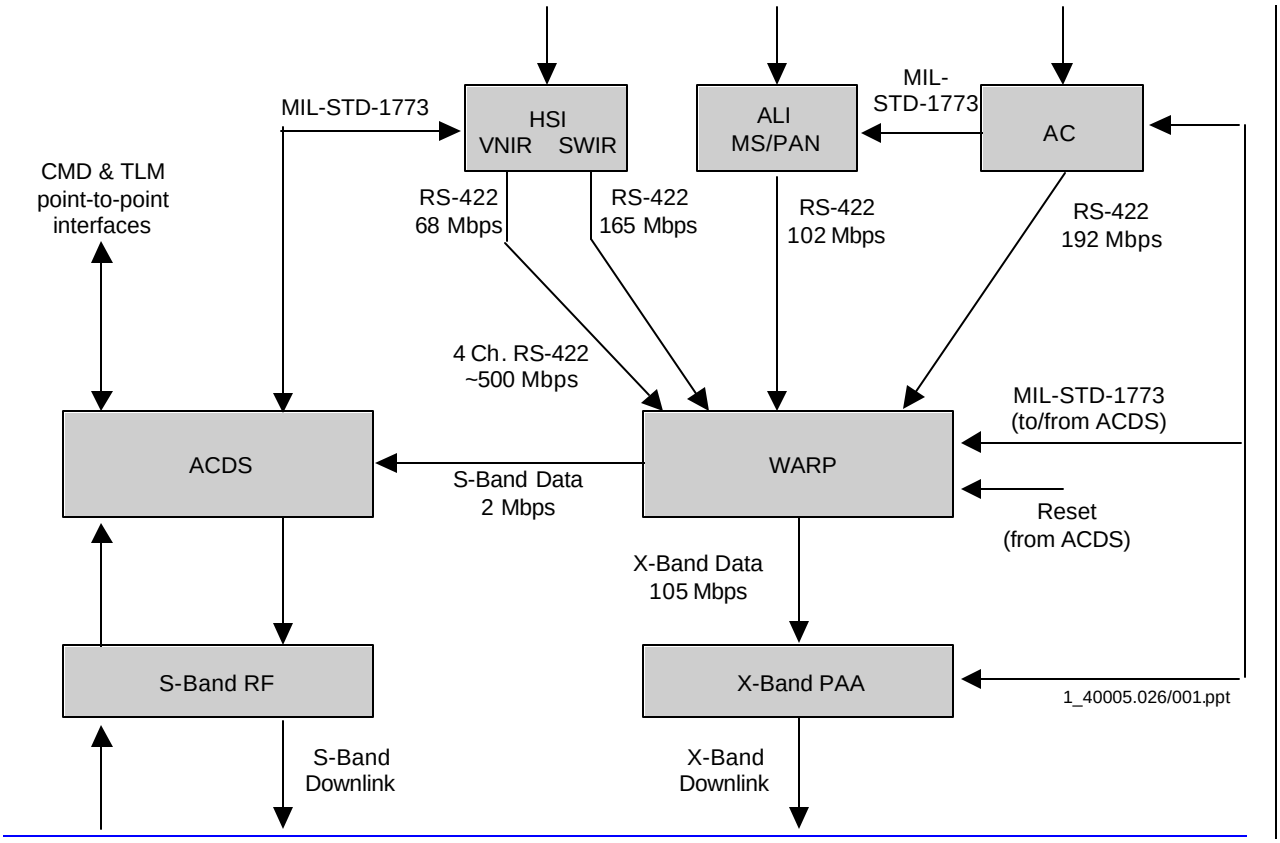

Figure 3-1. WARP Block Diagram

3.1.1 Interface Functions

The functions provided to the WARP by the spacecraft, and conversely, are delineated as follows.

a. 1773 interface for command and telemetry.

b. WARP transfers data to the S-band transponder via the ACDS.

c. WARP sends high-rate science data to the X-band phased array.

d. Spacecraft provides power at 28 ±7 VDC.

e. Spacecraft provides mounting interface for the WARP.

f. Spacecraft provides thermal control during normal and survival operations.

g. Spacecraft provides discrete command for WARP boot mode.

3.2 Mechanical Interface Requirements

The WARP is mounted on the Bay 1 equipment panel of the spacecraft. Threaded inserts shall be supplied by the spacecraft contractor, on the interior of the panel, for mounting the WARP.

3.2.1 Configuration

The dimensional drawing of the WARP on the Bay 1 equipment panel is shown in Figure 3-2. Interface Control Drawing A0758 has complete details of the mechanical interface.

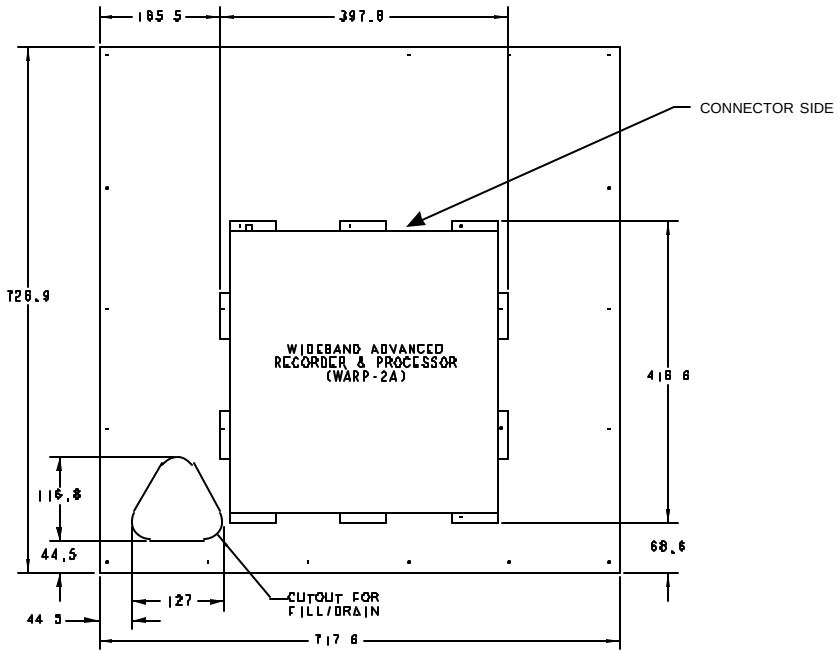

Figure 3-2. WARP Configuration

3.2.1.1 Coordinate System

Orthogonal reference axes are established for the WARP, as shown in Figure 3-3.

Figure 3-3. WARP Reference Axes

3.2.1.2 Mounting Interface

The WARP is mounted to the spacecraft at 10 attachment points, as shown in Figure 3-2.

3.2.1.2.1 Flatness Specification

The mounting points on the spacecraft shall not be out of plane more than 0.25 mm.

3.2.1.2.2 In-Plane Accuracy

The mounting point centerlines shall not change more than 0.25 mm from nominal.

3.2.2 Mass Properties

A finite element model of the EO-1 satellite will be generated to be used in the launch vehicle coupled loads analysis. To aid in this effort, the mass properties of the deliverable hardware will be required.

3.2.2.1 Mass

The total mass of the WARP shall not exceed 27 kg. All changes in mass estimates, including expected growth, shall be reported promptly. The final WARP mass shall be measured to an accuracy of 0.1 kg.

3.2.2.2 Center of Gravity

The center of gravity (CG) of the WARP shall be located, ±12 mm, at X_w= 195 mm, Y_w= 180 mm, Z_w= 122 mm relative to the coordinate system, as shown in Figure 3-3. The final WARP CG shall be measured to 5 percent accuracy.

3.2.2.3 Moment of Inertia

The moment of inertia (MOI) of the instrument shall be calculated with 5 percent accuracy.

3.2.3 Mechanical Design and Analysis Requirements

3.2.3.1 Structural Design Safety Factors

All hardware shall be designed and analyzed to the applicable safety factors defined in Table 3-1. The analyses shall indicate a positive margin of safety. Limit loads are defined as the maximum expected flight loads.

Table 3-1. Design Safety Factors

All Flight Hardware Except Pressure Vessels	Test Qual	Analysis Only
Material yield factors	1.25	2.0
Material ultimate factors	1.4	2.6

3.2.3.2 Loads Environment

3.2.3.2.1 Limit Load Factor

All hardware shall be designed to withstand the quasi-static limit load (with applicable safety factors) defined in Table 3-2. This load should be applied in any direction at the component CG.

Table 3-2. Limit Load Factor

± 13 g

3.2.3.2.2 Random Vibration

All hardware shall be designed to withstand the random vibration environment (with applicable safety factors) defined in Table 3-3.

3.2.3.3 Structural Stiffness Requirement

In the launch configuration, the WARP shall have a first mode frequency greater than 80 Hz when hard-mounted at the flight interface.

Table 3-3. WARP Random Vibration Test Levels

Frequency (Hz)	Level	
	Acceptance	**Protoflight**
20	0.013 g^2/Hz	0.026 g^2/Hz
20-50	+6 dB/octave	+6 dB/octave
50-800	0.08 g^2/Hz	0.16 g^2/Hz
800-2000	-6 dB/octave	-6 dB/octave
2000	0.013 g^2/Hz	0.026 g^2/Hz
Overall	10.0 grms	14.1 grms

NOTES:
1. Levels are for each of three orthogonal axes, one of which is normal to the mounting surface and one of which is parallel to the spacecraft z-axis.
2. Levels are to be applied at the interface with the EO-1 spacecraft equipment panel.
3. Test duration is 1 minute per axis.
4. The table shows flight acceptance and protoflight test levels. These levels may be reduced in specific frequency bands, with Project concurrence, if required to preclude damage resulting from unrealistic high amplification resonant response due to the shaker mechanical impedance and/or shaker/fixture resonance.
5. Flight-type attach hardware (including any thermal washers, etc.) shall be used to attach the component to the test fixture, and preloads and fastener locking features shall be similar to the flight installation.
6. Cross-axis responses of the fixture shall be monitored during the test to preclude unrealistic levels.

3.2.3.4 Stress Analysis Requirement

A stress analysis shall be performed to verify the integrity of the component structure and attachments when subjected to the specified loads with the applicable safety factors. Margins of safety shall be determined, dominant failure modes identified, and this information transmitted to the satellite integrator. Existing mechanical stress analysis reports and data may be used if applicable.

3.2.3.5 Fastener Capacity

The deliverable hardware will be attached to the spacecraft panel using threaded fasteners. A positive margin factor of safety shall be maintained for all the fasteners used on the spacecraft. The maximum load on any fastener shall not exceed 667 N (150 lb) axial and 1223 N (275 lb) shear.

3.2.4 WARP Handling Operations and Lift Points

3.2.4.1 Handling Operations

Normal care shall be exercised during handling and installation of the equipment. Protective covers shall be supplied by the WARP contractor for protection of the hardware.

3.2.5 Access Requirements

Access requirements to the WARP shall be as defined in WARP Integration and Test (I&T) Plan. Access requirements include connector mate/demate clearances, removal and replacement clearances for electronic components and protective covers, and access to purge fittings.

3.2.6 Aperture Covers

There will be no red-flag cover or other items on the WARP.

3.2.7 Thermal

The WARP electronic box shall be thermally coupled to the Bay 1 spacecraft equipment panel.

3.2.7.1 Heat Flow Across the Interface

The maximum allowable heat flow from all sources and interface temperatures during normal operations and survival operations is 0.4 W/in^2. The WARP base plate at the spacecraft interface shall have an irridite coating with ChoTherm as an interface material between the WARP base plate and the spacecraft.

3.2.7.2 Heat Input to Bay 1 Radiator

The environmental heat flux on the Bay 1 radiator shall be between 0 and 70 W. The radiator optical properties are for Silver Teflon and 3 mil Kapton. The radiators are sized assuming hot environment and end-of-life degraded thermal coating properties.

3.2.7.3 Design Responsibility

The spacecraft contractor is responsible for the thermal analysis of the combined WARP and spacecraft. The technology provider will supply a thermal design, analysis, and model to the spacecraft contractor.

3.2.7.4 Thermal Coatings and Multilayer Insulating Blankets

GSFC is responsible for all external optical coatings for the WARP. The spacecraft contractor is responsible for all externally located multilayer insulating (MLI) blankets.

3.3 Electrical Interface Requirements

3.3.1 Electrical Interfaces

There are ~~four~~ five electrical interfaces to the WARP:

- RS-422 from ALI, AC, and Hyperion
- Power from PSE
- RS-422 to ACDS

- Terminal control for the Fiber Optic Data Bus (FODB) terminal box
- Modulated X-band to X-band Phased Array Antenna (PAA)

In addition, there is one~~are two~~ optical data bus~~es:~~ 1773~~. and the high rate FODB~~

3.3.2 Power Requirements

The spacecraft operating bus voltage and power characteristics are as specified in System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM-149-0020(155) and Avionics Requirements Specification. GSFC shall ensure that the WARP shall successfully operate within this power regime.

3.3.2.1 Power Distribution

Power from the spacecraft shall be provided to the WARP via a normal mode EMI filter and a common mode EMI filter, connected in series. The WARP (and filters) will draw ___~~4.6~~ A at peak and ___~~1.5~~ A for orbital average. The +28 V power input ~~from the spacecraft~~ to the normal mode EMI filter s~~s~~hall use a DB~~-15~~37P~~p~~~~9~~ connector. The connector shall also include the filtered output power to the common mode EMI filter~~. on the WARP. The wires into the WARP LVPC power input connector shall be 20 AWG.~~ The connector pinout is shown in Table 3-4.

Table 3-4. Normal Mode EMI Filter Connector Pinout

Pin Number	Connection
14	Filtered +28 V (to common mode EMI filter)
15	Filtered +28 V (to common mode EMI filter)
18	Unfiltered +28 V (from spacecraft)
19	Unfiltered +28 V (from spacecraft)
32	Filtered +28 V Return (to common mode EMI filter)
33	Filtered +28 V Return (to common mode EMI filter)
36	Unfiltered +28 V Return (from spacecraft)
37	Unfiltered +28 V Return (from spacecraft)

The common mode EMI filter then provides the filtered power to the WARP DB15P power input connector. This connector pinout is shown in Table 3-5.

The WARP LVPC shall be designed in accordance with the specification for the spacecraft main power bus as shown in Table 3-6~~5~~ and described in the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM-149-0020(155).

Table 3-54. Connector Pinout

Pin Number	Connection
1	+28 V
2	+28 V
3	+28 V
4	+28 V
5	+28 V
6	+28 V
7	+28 V
8	NC
9	+28 V Return
10	+28 V Return
11	+28 V Return
12	+28 V Return
13	+28 V Return
14	+28 V Return
15	+28 V Return

Table 3-65. Main Power Bus Specification

Electrical Specification	Value
Voltage regulation	28 ± 7 V
Transients	≤ 5 V
Ripple and spikes	≤ 1.5 V p-p (DC to 10 MHz)
Inrush current	< 56 A for 1 ms
Harness output impedance	per Litton Specification

3.3.2.2 Noise Suppression

All inductive loads associated with the WARP, such as relay coil circuits, shall be provided with suppression circuits to prevent excessive transients and associated EMC noise due to power interrupts. For further details, refer to the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM-149-0020(155).

3.3.3 WARP-to-1773 Interfaces

The WARP receives and transmits control and status to the spacecraft via a MIL-STD-1773 serial fiber optic bus. For further details, refer to the Data Systems 1773 ICD EO-1, Litton Amecom document AM-149-0050(155).

3.3.4 WARP-to-S-Band Transponder Interface

The WARP transmits S-band telemetry downlink data to the spacecraft Command and Data Handling (C&DH) system via a serial RS-422 interface. The S-band interface will support the ~~2~~ Mbps rate requirement. For further details, refer to the ~~WARP~~ WARP S-Band ICD (WARP-735-0013).

3.3.5 WARP-to-Instrument RS-422 Interface (Wideband Data)

Science data are transmitted from the instruments to the WARP across a parallel RS-422 interface. This interface will have a throughput capability of 840 Mbps under all operational conditions. For further details, refer to the EO-1 Instrument RS-422 ICD (WARP-735-0026).

3.3.6 WARP-to-X-Band Transmitter Interface

The WARP will provide an X-band modulated output at a rate of 105 Mbps. The WARP will provide fill data for sync acquisition and for unequal length I and Q data streams. For further details, refer to the EO-1 X-Band Downlink ICD, Litton Amecon document AM-149-XXXX(155).

3.3.7 Electromagnetic Compatibility

For further details, refer to the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM-149-0020(155).

3.4 Ordnance Requirements

There are no electro-explosive devices used on the WARP.

Section 4. Deliverables

Item	Delivered By	Delivered To	Need Date	Comment
WARP box	GSFC	Swales	6/24/98	
WARP software	GSFC	Swales	6/24/98	
WARP EGSE	GSFC	Swales	6/24/98	
WARP I&T Procedures	GSFC	Swales	TBD	
WARP normal mode filter box	GSFC	Swales		
WARP common mode filter assy	GFSC	Swales		

Abbreviations and Acronyms

A	ampere
AC	Atmospheric Corrector
ACDS	
ALI	Advanced Land Imager
AWG	
bps	bits per second
CG	center of gravity
C&DH	Command and Data Handling
DC	direct current
dB/octave	decibel per octave
EGSE	?electrical ground support equipment?
EO-1	Earth Orbiter-1
FODB	Fiber Optic Data Bus
g	gram
g^2/Hz	
grms	
GSFC	Goddard Space Flight Center
HSI	
Hz	hertz
I&T	Integration and Test
ICD	interface control document
IFT	
kg	kilogram
LAC	LEISA Atmospheric Corrector
lb	pound
LEISA	Linear Etalon Imaging Spectral Array
LVPC	

Mbps	megabits per second
MHz	megahertz
MLI	multilayer insulating
mm	millimeter
MOI	moment of inertia
ms	millisecond
MS	multispectral
NMP	New Millennium Program
PAA	Phased- Array Antenna
PAN	panchromatic
PSE	
SWIR	shortwave infrared
TBR	to be resolved
V	volt
VDC	volt direct current
VNIR	visible and near infrared
W	watt
W/in^2	watts per square inch
WARP	Wideband Advanced Recorder/Processor