CCR Number: 00015	CRITICALITY: ROUTINE	DUE:07/17/98

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NEW MILLENNIUM PROJECT **CONFIGURATION** CHANGE REQUEST

'ROGRAM EO-1 CCR NO. 0015 DATE INITIATED 07/02/98	TITLE BASELINE EO-1 S/C TO GROUND ICD-023 ORIGINATOR D. Mandl/GSFC ORIGINATOR'S CHG. NO. SPONSOR/CODE D. Mandl PHONE -
EFFECTIVITY ITEM: SIC - GRND 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-023

'ROBLEM

The attached draft version of **EO1-ICD-023,** Earth Orbiter -1 (EO-1) Spacecraft to Ground Interface Control Document (ICD) requires baselining. The document defines the data encoding and data formats which provide communications and control of the EO-1 spacecraft from the ground.

'ROPOSED **SOLUTION**

Approve the attached draft version of EO-1 ICD-023, EO-1 **Spacecraft** to Ground 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	APPROVAL LEVEL REQUIRED	CRITICALITY LEVEL	PROCUREMENT CHANGE ORDER CLASSIFICATION		
APPROVE ☑	LEVEL I HQS ☐	EMERGENCY ☐	ROUTINE	URGENT	EMERGENCY ☐
APPROVE WITH CHANGE ☐	LEVEL II GSFC ☑	URGENT ☐	OPTION 1 ☐	OPTION 1 ☐	
DISAPPROVE ☐	LEVEL III ☐	ROUTINE ☒	OPTION 2 ☐	OPTION 2 ☐	
WITHDRAW ☐					

COMMENTS Delete Reference to Appendix E in Table of Contents, Page 5.

CHAIRPERSON [signature] DATE 9/24/98

3/28/96

EO-1 ICD-23
Draft Issue
July 2, 1998

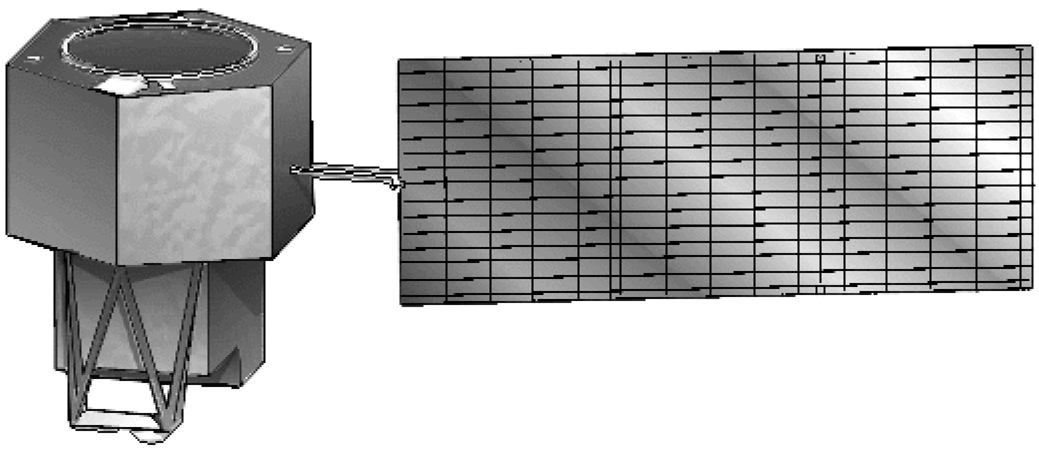
EO-1 Spacecraft to Ground (ICD)

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EO-1 ICD-023
Draft Issue
July 2, 1998

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER



EO-1

Spacecraft to Ground
Interface Control Document

Version 3

June 26, 1998

TABLE OF CONTENTS

1 OVERVIEW

1.1 Scope

This document defines the data encoding and data formats which provide communications and control of the EO-1 spacecraft from the ground. This document also defines the communication and data interfaces between the Mission Operations Center and the EO-1 ground stations.

This Interface Control Document (ICD) defines interfaces among the EO-1 spacecraft, the EO-1 (MOC) at the Goddard Spaceflight Center (GSFC), and the facilities comprising the EO-1 ground network. Both data interfaces between the EO-1 spacecraft and ground stations and the inter-facility interfaces between ground elements are covered. The EO-1 ground network consists of Wallops Flight Facility resources supporting EO-1, which are collectively referred to as the Wallops Ground Stations (WGS) in this document

1.2 Interface Identification

The EO-1 mission is the first earth observing mission of the NASA New Millenium program. This document defines the interface between the EO-1 spacecraft and the ground. Also included herein is the definition of the interface between the EO-1 ground station and the EO1 MOC. Details of the radio frequency communications are documented in the Radio Frequency Interface Control Document Between the Earth Orbiter (EO-1) Spacecraft and the Ground Network (GN) and the Space Network (SN) which is an appendix to this document.

1.3 Interface Responsibilities

Spacecraft
The EO-1 spacecraft is being supplied by a contractor team including Swales and Litton Amecom. The individual responsible for insuring the EO-1 spacecraft complies with the interfaces specified herein is Brian Smith (NASA GSFC code 730).

Ground System
The EO-1 Gournd System is being provided by NASA GSFC code 580. The individual responsible for insuring the EO-1 Ground System complies with the interfaces specified herein is Dan Mandl (NASA GSFC code 584).

Ground Stations
The EO-1 ground stations are being provided by NASA Wallops Flight Facility (WFF). The individual responsible for insuring the EO-1 ground stations comply with the interfaces specified herein is Paul Garza (NASA GSFC code 452).

Ground Communication Links
The EO-1 ground communications links are being provided by NASCOM. The individual responsible for insuring the EO-1 ground communications comply with the interfaces specified herein is Paul Garza (NASA GSFC code 452).

2 APPLICABLE DOCUMENTS

2.1 Applicable Documents

EO-1 Command and Telemetry Handbook (spec tbd)

EO-1 Requirements (spec tbd)

Radio Frequency Interface Control Document Between the Earth Orbiter (EO-1) Spacecraft and the Ground Network (GN) and the Space Network (SN). January 1988

2.2 Reference Documents

CCSDS 101.0-B-3: Telemetry Channel Coding. Blue Book. Issue 3. May 1992.

CCSDS 102.0-B-4: Packet Telemetry. Blue Book. Issue 4. November 1995.

CCSDS 201.0-B-2: Telecommand Part 1 -- Channel Service. Blue Book. Issue 2. November 1995

CCSDS 202.0-B-2: Telecommand Part 2 -- Data Routing Service. Blue Book. Issue 2. November 1992.

CCSDS 202.1-B-1: Telecommand Part 2.1 -- Command Operation Procedures. Blue Book. Issue 1. October 1991.

CCSDS 701.0-B-2: Advanced Orbiting Systems, Networks and Data Links: Architectural Specification. Blue Book. Issue 2. November 1992.

3 COMMUNICATIONS REQUIREMENTS

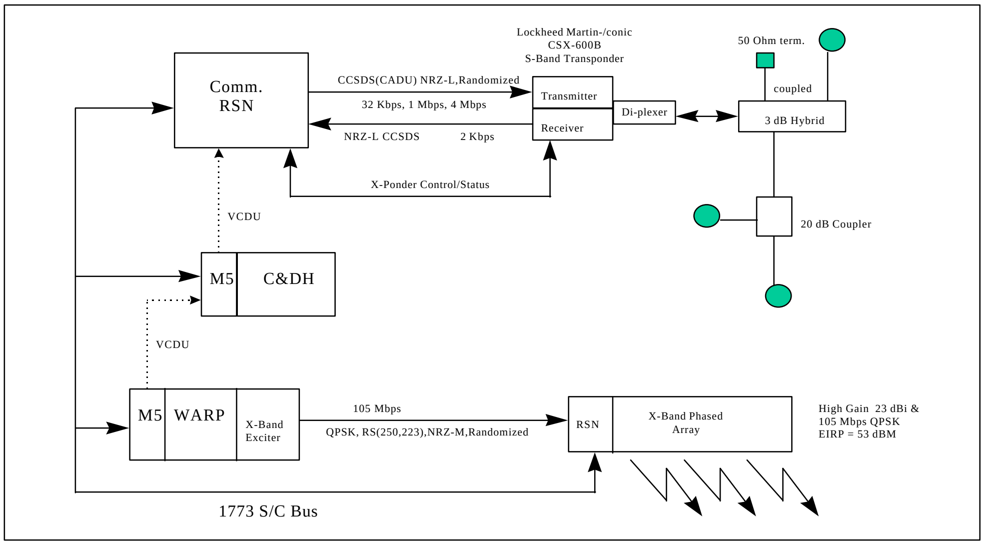
3.1 General

This document defines the space-to-ground and ground-to-space interface between the EO-1 spacecraft and the EO-1 ground stations. The primary ground station will be the Spitzbergen Ground Station (SGN) located at Svalbard (Norway). Backup ground stations for launch and early orbit (L&EO) will be located at Wallops Island, Virginia and Poker Flats Alaska. The McMurdo ground station located on Ross Island in the Antarctic will be used for backup LEO and maneuver support. The Svalbard ground station will provide S-band uplink, S-band downlink, X-band downlink, and Doppler tracking. The backup ground stations will be capable of supporting all interfaces defined in this ICD.

EO-1 normally requires two ground station passes per day. These passes will require simultaneous S-band uplink, S-band downlink, X-band downlink, and Doppler tracking. Additional ground station passes may be required for L&EO or contingency operations.

3.2 EO-1 Spacecraft Communications System

The EO-1 S-band communications system consists of a Lockheed Martin CSX-600B transponder, Omni nader and zenith antennas. The X-band communications system consists of an X-band exciter designed by Litton Amecom and a phased-array antenna supplied by Boeing.



EO-1 Communications Block Diagram

3.3 EO-1 Ground Station Communication System

The EO-1 ground station at Svalbard consists of an 11.3 meter, Solid Parabolic dual optics antenna with the following specifications:

- G/T @ S-Band (2250 MHz): 23.0 dB/K @ 60 deg El angle & 23 C amb.
- G/T @ X-Band (8500 MHz): 35.0 dB/K @ 60 deg El angle & 23 C amb.
- EIRP @ S-Band 94 dBm
- Gain Transmit: 44.6 dB @ 2070 MHz
- Gain Receive: 46.0 dB @ S-Band, 58 dB @ X-Band
- Polarization-Transmit: Selectable LHCP/RHCP
- RF Beamwidth: 0.93 deg@2070 MHz, 0.23 deg @ 8275 MHz
- Antenna Noise Temp: 40 deg K @ S-Band, 45 deg k @ X-band @ 5 deg El angle
- System Noise Temp: 165 deg K @ S-band, 170 deg K @ X-Band
- Low Noise Amplifier (LNA)

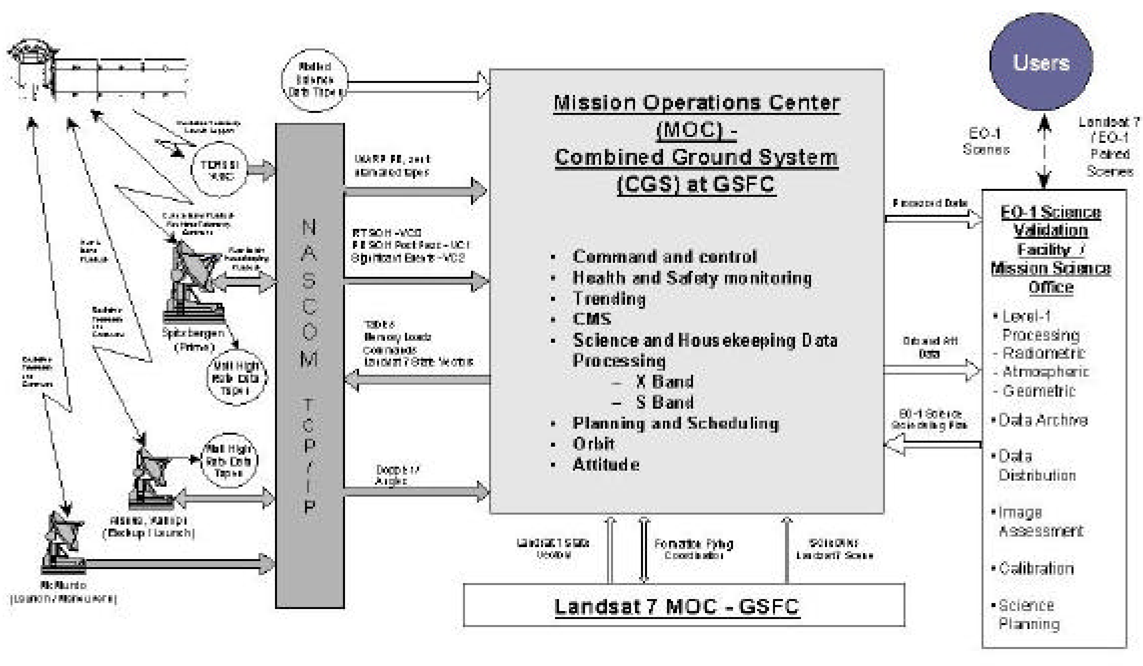
- S-Band 48 degress K, 38 dB gain
- X-Band 80 degrees K, 45 dB gain

- High Power Amplifier: S-Band 200 Watts SSPA

The Svalbard ground station will be capable of simultaneous S-band uplink, S-Band downlink, X-Band downlink, and Doppler Tracking.

3.4 EO-1 Ground System Overview

The EO-1 ground system consists of the ground stations, the Mission operations Center (MOC) located at Goddard Space Flight Center (GSFC), the Science Validation Facility (SVF) located at GSFC, and the ground stations. Physical data links interconnecting the ground stations and the MOC will be provided by NASCOM. Physical data links interconnecting the MOC and the SVF will be provided by NASCOM.



3.5 Interface Functional Requirements

3.5.1 WGS to EO-1 S-Band Uplink

The EO-1 ground stations will send uplink commands to EO-1 using the S-Band frequency of 2039.65 MHz.

3.5.2 EO-1 to WGS S-Band downlink

EO-1 will generate and transmit engineering and science telemetry to the ground stations at the S-Band frequency of 2215.00 MHz.

3.5.3 EO-1 to WGS X-Band Downlink

EO-1 will generate and transmit science telemetry to the ground stations at the X-Band frequency of 8225.00 MHz.

3.5.4 EO-1 to TDRSS S-Band Downlink

EO-1 will generate and transmit engineering telemetry to TDRSS at the S-Band frequency of 2215.00 Mhz..

3.5.5 Command Data Rates

The command uplink data rate is 2 KBPS.

3.5.6 Telemetry Data Rates

The downlink data rates are as follows:

- TDRSS S-Band
  1. 2 KBPS

- WGS S-Band
  1. 2 KBPS
  2. 32 KBPS
  3. 1 MBPS
  4. 4 MBPS

- WGS X-Band

  105 mbps (52.5 mbps I + 52.5 mbps Q)

3.5.7 Ranging

No tone ranging support is planned for EO-1.

3.5.8 Doppler Tracking

The Ground Network(GN) shall generate two-way Doppler(i.e., range rate) tracking data that is derived from the Spacecraft to GN S-band RF carrier which is a coherent turnaround of the GN RF carrier. In the coherent mode, the Spacecraft's transmit carrier frequency will be related to the received carrier frequency by the ratio 240/221.

3.6 EO-1 Modes of Operation

This section describes the spacecraft communications configuration in the various mission modes. For all modes, the command link will be configured for 2 KBPS uplink from the ground stations.

3.6.1 Launch Communication Configuration

The EO-1 spacecraft communications system will be configured for TDRSS S-band downlink for launch. Fairing separation is 11 minutes after launch. EO-1 will being transmitting 2 KBPS S-Band telemetry data to TDRSS 30 seconds after fairing separation.

3.6.2 Normal Operations Mode Communications

For normal operations, the EO-1 spacecraft will not transmit telemetry routinely. Telemetry downlinks will be planned, coordinated with ground stations, and initiated by real time or stored commands. The nominal S-band housekeeping data rate will be 32 kbps. The data rate for S-band playback of housekeeping data will be 1 Mbps. The 1 MBPS data will contain up to 32 KBPS of real time (VC0) virtual channel data units (VCDUs). The ground station will perform virtual channel separation of the real time and playback data streams. The VC0 data stream will be forwarded to the MOC in real time. The playback data streams will be buffered by the ground station and forwarded as ground link bandwidth permits.

The X-band data will be downlinked at 105 MBPS to the ground station simultaneous with the S-band downlink and the uplink S-band commands. The ground station will demodulate the X-band data I and Q channels. The I and Q data streams will be stored to AMPEX tape by the ground station.

3.6.3 Backup Science Mode

In case of communication problems with the X-band science downlink, a backup S-band science communications mode is implemented. The data rate for S-Band playback of science data will be 4 MBPS. The 4 MBPS data will contain up to 32 KBPS of real time (VC0) virtual channel data units (VCDUs). The ground station will perform virtual channel separation of the real time and playback data streams. The VC0 data stream will be forwarded to the MOC in real time. The entire 4 KBPS downlink stream will be stored to AMPEX tape.

3.6.4 Safe Mode Communications.

TBD

3.7 Communications and Tracking Performance Requirements

3.7.1 Command Channel

The maximum forward link bit error rate (BER) for the detected digital data in the EO-1 spacecraft command channel shall be 1x10-7.

3.7.2 Telemetry Channel

The maximum return link bit error rate (BER) for the detected digital data in the EO-1 S-band telemetry channel shall be 1x10-7 after forward error correction.

The maximum return link bit error rate (BER) for the detected digital data in the EO-1 X-band telemetry channel shall be 1x10-6 after forward error correction.

3.7.3 Doppler Tracking

The allowable random error for measurement noise is,

Doppler: 8 millimeters / sec.

Angles: 0.0030 deg

4 EO-1 SPACECRAFT AND GROUND NETWORK RADIO FREQUENCY LINK INTERFACE CHARACTERISTICS

4.1 Link Functional Designs

4.1.1 WGS to EO-1 Forward Link

Digital commands originate in the MOC. The ground station receives blocked command data and formats it in order generate a 2 KBPS NRZ-L data stream. The ground station will generate a 16 kHz subcarrier. The 16 kHz subcarrier shall be Phase Shift Keyed (PSK) at 2 KBPS. The modulated subcarrier shall phase modulate(PM) the uplink carrier at the ground station. The uplink frequency is 2039.65 MHz. The uplink deviation shall be 0.7 radians peak.

The uplink signal shall be received at the spacecraft, via the omni antennas by the EO-1 transponder. The 16 kHz baseband subcarrier signal will be demodulated and NRZ-L data and clock will be passed to the on-board command detector in the C&DH subsystem.

4.1.2 EO-1 to WGS S-Band Downlink

Data will be provided by the EO-1 C&DH at 2 KBPS, 32 KBPS, 1 MBPS, and 4 MBPS. Prior to transmission, the C&DH will generate Reed-Solomon check symbols to form CCSDS formatted Channel Access Data Units (CADUs). The CADU data will then be CCSDS pseudo-randomized. Randomized data and clock are provided to the transponder in NRZ-L format at 2 KBPS, 32 KBPS, 1 MBPS, and 4 MBPS.

The transponder Binary Phase Shift Key (BPSK) modulates the data directly onto the 2215.00 MHz downlink carrier.

4.1.3 EO-1 to WGS X-Band Downlink

The EO-1 Wideband Advanced Recorder Packetizer(WARP) component of the spacecraft C&DH will provide two 52.5 mbps streams of CCSDS formatted, Reed Solomon encoded, randomized CADU data. The CADU data will be differentially encoded using a Grey code:
The dual differential data shall be Quadriphase Shift Keyed at a rate of 105 mbps.

4.1.4 EO-1 to TDRSS SSA Return Link

Data will be provided by the EO-1 C&DH at 2 KBPS. Prior to transmission, the C&DH will generate Reed-Solomon check symbols to form CCSDS formatted Channel Access Data Units (CADUs). The CADU data will then be CCSDS pseudo-randomized and convolutionally encoded at a rate of ½. The encoded data and clock are provided to the transponder in NRZ-L format at 2 KBPS.

The transponder Binary Phase Shift Key (BPSK) modulates the data directly onto the 2215.00 MHz downlink carrier.

5 TELEMETRY DATA FORMATS

5.1 Telemetry Data Formats

This section defines the EO-1 telemetry data formats. Details of the X-band data formatting performed by the spacecraft WARP are provided in Appendix A.

The telemetry is formatted according to the CCSDS AOS recommendations. The CCSDS Channel Access Data Unit (CADU) is the basic unit of downlink transfer. The CADU length is 1260 total bytes consisting of 1100 bytes of data plus 160 byes of check symbols.

10 CCSDS virtual channels (VCs) will be used for data. One VC is defined for fill data . CCSDS VC numbers 0-3 contain multiplexed packet data units (M_PDUs). VCs 4-9 contain bitstream payload data units (B_PDUs). VC63 contains fill VCDUs.

5.1.1 CADU Field Values

5.1.1.1 Sync Mark

The 4 byte sync pattern “1ACFFC1D” (hex) is appended to the beginning of each CADU.

5.1.1.2 VCDU Primary Header Field Definition

The VCDU Header has the following fields:

a. Version Number (2) - It’s value is binary “01” which is the value for an CCSDS AOS virtual channel data unit.
b. Spacecraft ID (8) - Value set to hexadecimal “89”
c. Virtual Channel (6) – Virtual channels are assigned as follows:
   0 S/C Real Time Telemetry
   1 Recorded S/C Telemetry
   2 Recorded S/C Events
   3 Spacecraft Housekeeping Telemetry
   4 TBD

5 TBD
6 TBD
7 TBD
8 Science Bit-Stream Raw Data - MS/PAN
9 Science Bit-Stream Raw Data - ACU
63 Fill VCDU's

d. VCDU Counter (24) - Its value represents the number of the CADU frame and is continuous for each virtual channel. This value may be reset to 0.
e. Replay Flag (1) - It is usually 0, but will be set to 1 when a known discontinuity occurs in VCDU Counter.
f. Time Correlation Flag (1) - This bit is set to indicate that the time this CADU is output will be latched and the value telemetered for the ground to use in determining spacecraft time.
g. Spare (6) – Spare bits set to zero.

5.1.1.3 2.5.3 VCDU Trailer

This field is for Error Control CRC, which will be Zero for X-Band and valid for S-Band.

5.1.1.4 RS Check Symbols

The 160-byte long RS check symbols provide error detection and forward error correction capability.

5.1.2 B_PDU Telemetry Format

The Bitstream Protocol Data Unit (B_PDUs) will be the internal CADU format for ALI data. The B_PDU header is defined as follows:

a. Spare(2) - The Spare field is currently undefined by CCSDS: by convention, it shall therefore be set to the reserved value of "00".
b. Bitstream Data Pointer - (14) - Because it may be necessary to insert fill data if an insufficient number of Bitstream Data bits have been received before a B_PDU is released for transmission, the Bitstream Data Pointer indicates the location of the last valid user data bit within B_PDU Bitstream Data Zone (i.e., the boundary between user data and any inserted fill). This 14-bit field contains a binary count "B" (modulo 16384)which, when incremented by "1", points directly to the number of the last valid user data bit within the B_PDU Bitstream Data Zone (starting at bit number one, which is the first bit within the Bitstream Data Zone). The count "B" is expressed as:

B = { (Number of the bit) - 1 }

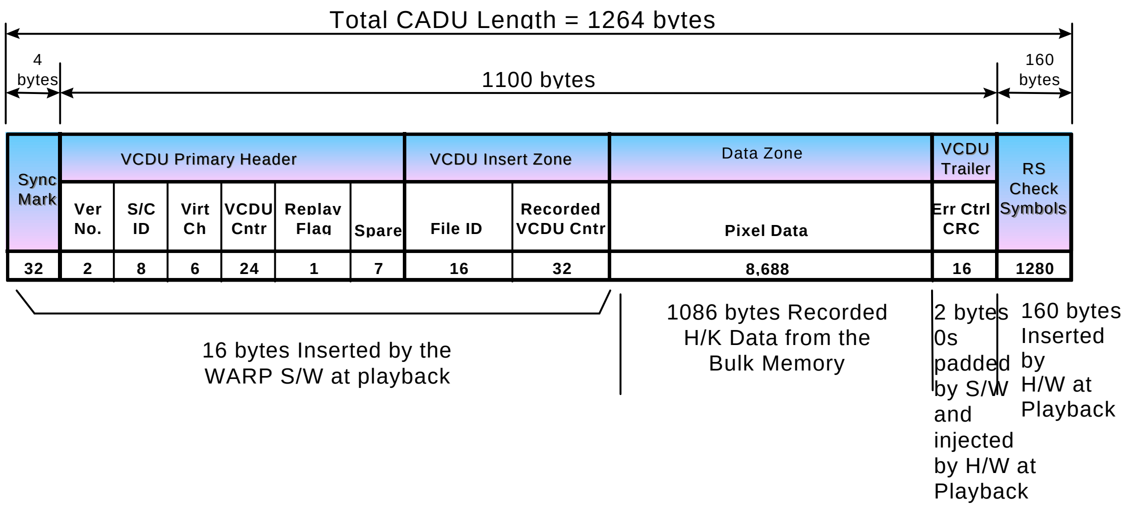
If there are no fill data in the Bitstream Data Zone (i.e., the B_PDU contains only valid user data), the Bitstream Data Pointer shall be set to the value "all ones". If there are no valid user data in the Bitstream Data Zone (i.e., the B_PDU contains only fill), the Bitstream Data Pointer shall be set to the value "all ones minus one".

c. B_PDU Bitstream Data Zone - The Bitstream Data Zone contains either a fixed-length block of the user Bitstream Data (possibly terminated with fill data at a location delimited by the Bitstream Data Pointer), r a fixed-length Project-specified fill pattern.

The B_PDUs have an insert zone for WARP recorder management. Included are the following fields:

a. File ID (16) - This is the 16-bit ID of the file that is being played back.
b. Recorded VCDU Counter - This field is set to 0 at the recorded beginning of the file. It can be used to determine which piece of data of a particular file this CADU contains.

The Bitstream CADU format is shown below.

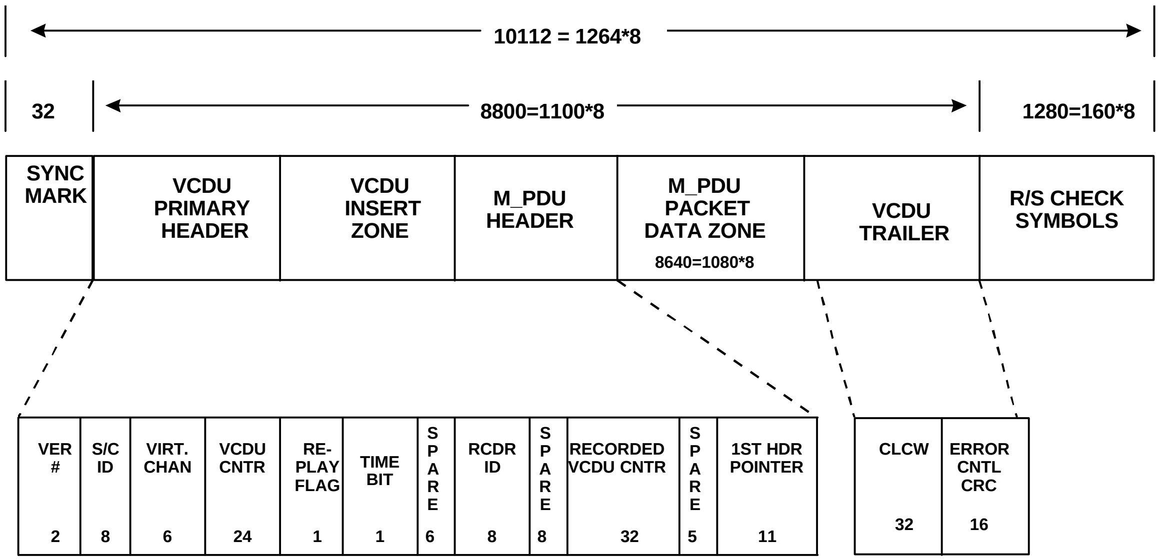


CADU data including the check symbols but excluding the sync mark are pseudo-randomized following the CCSDS Telemetry Channel Coding recommendations. The pseudo-randomized data is sent to the RF-exciter in NRZ-L format.

The details of the X-band data formats are included in Chapter 6 - "WARP to Ground System Interface Control Document for Playback Data Formats"

5.1.3 M_PDU Telemetry Format

EO-1 spacecraft housekeeping and instrument housekeeping data will be formatted according to the CCSDS Packet Telemetry recommendations. The packet format is as follows:



EO-1 Telemetry CADU -- VC0

For individual packet data formats see the EO-1 spacecraft Command and Telemetry handbook and individual subsystem documentation (e.g. mini-specs).

The M_PDU CADUs have an insert zone for WARP C&DH recorder management. Included are the following fields:

a. Recorder ID (8) - This is the 8-bit ID of the virtual recorder that is being played back.
b. Spare (8) - Spare bits set to zero.
c. Recorded VCDU Counter (32) This field is set to 0 at the recorded beginning of the file. It can be used to determine which piece of data of a particular file this CADU contains.

The M_PDU Header contains two fields:
a. Spare (5) - This field will contain the value zero,
b. First Header Pointer (11) - Points to the first packet in the VCDU as per CCSDS recommendations.

The Packet Data Zone contains the packet data. For VCDUs with the command link control words (CLCWs), 1080 octets of packet data are included in the Packet Data Zone. For VCDUs without the CLCW, 1084 octets of data are included in the packet data zone.

5.1.4 Telemetry Packet Format

The telemetry source packet of the return link holds the spacecraft & instrument housekeeping data that are to be transported from the EO-1 spacecraft to the ground.

The EO-1 C&DH takes the application data and encapsulates then in the telemetry source packet format. The source packet consists of a primary header, a secondary header, and the application data, shown the figure below.

Packet Identification				Packet Sequence Control		Packet Length	Secondary Header	User Data Field
Version	Type	Secondary Header Flag	Application Process ID	Sequence Flags	Source Sequence Count	Packet Length	Time Code	Application Data
'000'	'1'	'1'=present	(0-2046 decimal) (2047 dec. = fill					
(3)	(1)	(1)	(11)	(2)	(14)	(16)	(64)	(N*8)

CCSDS Telemetry Packet

The CCSDS packet fields are used as follows:

a. Version Number (3) - Set to zero per CCSDS standards.
b. Type (1) - For telemetry packets, this bit is set to zero. Note that his bit is not used in the AOS standard, but may be set to either a "0" or a "1".
c. Secondary Header Flag (1) - This bit is set to indicate the presence of a secondary header.
d. Application Process ID (11) - This is the primary method for identifying packets. The C&DH implementation is limited to tbd unique telemetry application IDs.
e. Segment Flags (2) - EO-1 telemetry packets will not be segmented so this field will be set to 11 (base 2).
f. Source Sequence Count (14) - As per CCSDS, this 14 bit counter maintained for each application ID that increments for each packet generated with the specified application ID. Note - this field is used by the C&DH to filter telemetry packets to a desired transmission rate. Each application ID has an associated filter factor. Packets will be transmitted when the source sequence count modulo filter factor = offset. Where offset < filter factor.

g. Packet Length (16) - The overall packet length will be restricted to no more than TBD bytes. This actual packet length is restricted to an even number of bytes. This field will contain the actual packet length -7 and will always contain an odd number.
h. Secondary Header (64) - All telemetry packets include a secondary header containing the spacecraft time. The first 32 bits of the secondary header will contain the "seconds" portion of the spacecraft time code and the second 32 bits will contain the "subseconds".
i. Application Data - The Application Data field contains application data.

5.2 Telemetry Data Encoding

5.2.1 Reed Solomon Code

The Reed Solomon code is defined in CCSDS 101.0-B-3: Telemetry Channel Coding. Blue Book. Issue 3. May 1992. To insure 32-bit compatibility, the technique of "Virtual Fill" is used. The virtual fill, which is not transmitted to the ground, is used to shorten each Reed-Solomon Code block by "n" octets. For EO-1, I=5 (Interleave Depth) and n=15 (Virtual Fill). The shortened RS code is (250,232). The Coded Virtual Channel Data Unit (CVCDU) length with the Virtual Fill is 1275 Octets (10200 bits). As stated above, the virtual fill is not downlinked, thus a CVCDU is 1260 bytes (10080 bits) in length.

5.2.2 Pseudo-Random Code

The synchronization marker is not pseudo-randomized. The pseudo-random code is applied after the Reed-Solomon check symbols are generated. The CADUs are randomized as defined in CCSDS 101.0-B-3: Telemetry Channel Coding. Blue Book. Issue 3. May 1992.

5.2.3 Checksum Computation

For S-band data a checksum is included in the VCDU trailer field.
The cyclic redundancy code contained within this field shall be characterized as follows:

a. The generator polynomial shall be: g(x) = x**16 + x**12 + x**5 + 1
b. Both encoder and decoder shall be initialized to the "all ones" state for each VCDU.
c. Parity "P" generation shall be performed over the entire VCDU excluding the final 16-bit VCDU Error Control field.
d. The generated parity symbols shall then be inserted into the VCDU Error Control field which occupies the final 16-bits of the VCDU.

5.2.4 Convolutional Code

Note – Convolutional code will be used for the 2 KBPS S-band link to TDRSS. Convolutional encoding will NOT be used for downlinks to ground stations.

Convolutional coding is implemented as defined in CCSDS 101.0-B-3: Telemetry Channel Coding. Blue Book. Issue 3. May 1992. The convolutional code has the following characteristics:

- Convolutional code with maximum- likelihood (Viterbi) decoding
- Code Rate: ½ bit per symbol
- Constraint length: 7 bits
- Connection vectors: G1 = 111001; G2 = 1011011
- Phase relationship: G1 is associated with first Symbol
- Symbol inversion: On output of G2

5.2.5 Modulo-4 Grey Code Differential Encoder

Waiting for Scientific-Atlanta specification for differential decoding

5.2.6 Quadrature Phase Shift Key Encoder

The I and Q channel data will be QPSK encoded as:

I=0,Q=0	0 degrees
I=0,Q=1	90 degrees
I=1,Q=1	180 degrees
I=1,Q=0	-90 degrees

6 WARP TO GROUND SYSTEM INTERFACE CONTROL DOCUMENT FOR PLAYBACK CONTROL AND DATA FORMATS – REVISION D

6.1 Overview

6.1.1 Scope

This appendix provides the definitions of the playback data formats between the Wide-band Advanced Recorder Processor (WARP) and the Ground Segment. The document contains both the S-Band and X-Band data playback formats as well as an overview of the WARP commands necessary to control data acquisition, storage, and playback.

6.1.2 References

Spec ID	Title	Source	Date
WARP582-00xx	*Recorder Management (RM) Software Specification*	GSFC 735/DSC	8/12/97
???????	*EO-1 Command & Telemetry Handbook*	GSFC 735/Litton	
	CCSDS Blue Books		
WARP735-0023	*RS-422 Terminal Board Mini Specification*		

6.2 Data Storage & Playback Control

Both science and spacecraft housekeeping data are stored in the bulk memory in logical file structures. The *Recorder Management(RM) Software Specification* contains details on the file system. Each file contains data from a single spacecraft housekeeping data record session or from a single science data input channel (ie., MS/PAN) associated with a science data scene acquisition. Hence data record and playback commands communicate to the WARP software in terms of file transactions.

The following commands can initiate the WARP to perform record and S-Band/X-Band playback operations. All commands to the WARP are first received by the C&DH from the ground for real-time distribution or for subsequent stored command processor execution. At the proper time, commands are transmitted across the spacecraft's 1773 bus for prompt execution by WARP software.

The WARP does not have the exact start and stop spacecraft times associated with a scene acquisition. This information must be derived from the science instruments' housekeeping telemetry recorded during science data acquisition
==
TBD Start and Stop time for Science Data from WARP
===

6.2.1 Science Data Acquisition & Storage Commands

6.2.2 S-Band Playback Control Commands

The following command starts **an S-Band Playback session**. It is assumed that the S-Band Communications RSN has already been commanded to the proper configuration.

- **S-Band Queue File Command:**

  Upon receiving of this command, the WARP queues the specified file(s) for S-Band playback. The WARP then automatically fetches data from the first file in the queue, formats this data into CADU's, and sends it out to the C&DH via the Medium Speed Serial Port (MSSP) to the S-Band transponder. The maximum file queue depth is 64. Once all specified files in the queued are played back, the WARP terminates output operations to the MSSP, resulting in the output of fill frames by the S-Band Comm RSN hardware on Virtual Channel 63. When the WARP detects a non-empty queue again (ie., another S-Band Queue File command is received), it will once again start output data to the Communications RSN.

To de-queue a file or abort the entire S-Band playback session can be achieved by sending the following command to WARP:

- **S-Band De-queue File Command:**

  This command is used to prevent queued files from being played back or to terminate the playback of a file currently being played back over the S-Band transponder. If the specified file(s) are queued, they are de-queued. If a specified file is currently being played back, the playback data stream will switch to the next queued file, if any, at the nearest possible CADU boundary. If the specified File ID is 0xFFFF, the entire queue is emptied. If no more files are in the queue, data output on MSSP will cease, resulting in the output of fill frames by the S-Band Comm RSN.

6.2.3 X-Band Playback Control Commands

The following commands, in the sequence given here, are required to initiate an X-Band playback operation:

[1] Start X-Band Output Command:

When this command is received, the WARP initiates output of fill frames (Virtual Channel 63, Fill Pattern 0xEB90) to both the I and Q channels of the X-Band transponder via the Memory Interface Card

(MIC). Fill frames are output continuously until either one of two conditions are met:

- receipt of a valid X-Band Queue File Command
- receipt of a Stop X-Band Output Command

The exact format of the fill frames is described in Section 4.

[2] X-Band Queue File Command:

There is a single playback queue for both X-Band channels. This command outputs a file to either queue. Once a file is in one queue, the WARP will begin to output data of the first file of that queue on that particular channel. Whenever the queue is empty, fill frames will go out on that particular channel. WARP will reject this command if the <**START X-Band Output**> command discussed previously command has not been received.

The following command dequeues a file or empties a queue from either I or Q channel:

[1] X-Band Dequeue File Command:

If the specified file is indeed in the queue, it will be deleted from the queue. If the file is currently being played back, the playback data stream of that channel will switch to the next queued file, if any, at the nearest CADU boundary. If the specified File ID is 0xFFFF, then the entire queue will be emptied. Whenever the queue is empty, fill frames are output to both channels.

The following command terminates an X-Band playback session:

[2] Stop X-Band Fill Output Command:

This command terminates both I and Q channel output to the X-Band transponder.

6.2.4 Commands verses Modes of Operation

Due to certain limitations, certain commands can only be sent when the WARP is in certain modes of operation. The following table shows the valid commands each mode of operation. “Reject” denotes that the command will be rejected and "Accept" denotes that the command is acceptable under the corresponding mode.

Ground Command	STDBY	INIT	CONFIG	SCI_REC	SB_PB	XB_PB
No Op	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
Reset Counters	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
Format Memory	ACCEPT	REJECT	REJECT	REJECT	REJECT	REJECT
Config Mask	ACCEPT	REJECT	REJECT	REJECT	REJECT	REJECT

	s					
	ACCEPT Config Refresh Int	REJECT	REJECT	REJECT	REJECT	REJECT
	ACCEPT Start H/K Record	REJECT	REJECT	ACCEPT	REJECT	REJECT
	NO-OP Stop H/K Record	NO-OP	NO-OP	NO-OP	NO-OP	NO-OP
	ACCEPT Start Science R	REJECT	REJECT	REJECT	REJECT	REJECT

	ecord					
	Stop Science Record NO-OP	NO-OP	NO-OP	ACCEPT	NO-OP	NO-OP
	S-Band Q File REJECT	REJECT	REJECT	REJECT	ACCEPT	REJECT
	S-Band DQ File REJECT	REJECT	REJECT	REJECT	ACCEPT	REJECT
	Start XB Output ACCEPT	REJECT	REJECT	REJECT	ACCEPT	ACCEPT
	S NO-OP	NO-OP	NO-OP	NO-OP	NO-OP	ACCEPT

	top XB Output					
	XB Q File REJECT	REJECT	REJECT	REJECT	REJECT	ACCEPT
	XB DQ File REJECT	REJECT	REJECT	REJECT	REJECT	ACCEPT
	Reset EDAC ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
	Delete File ACCEPT	ACCEPT	REJECT	REJECT	REJECT	REJECT
	Deallocate ACCEPT	ACCEPT	REJECT	REJECT	REJECT	REJECT

	Blocks					

6.3 Playback CCSDS Frame Formats

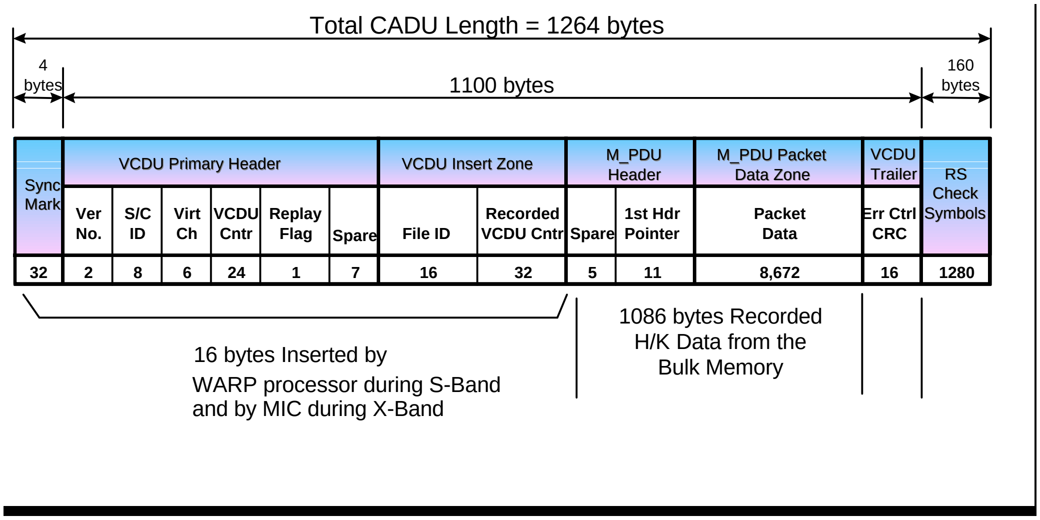
Playback data is in the CADU format that is based on XTE CADU layout (interleaving depth = 5). Only 1086 bytes of a CADU come straight from the bulk memory. The 4-byte sync mark, the 6-byte VCDU Primary Header, and the 6-byte VCDU Insert Zone will be inserted at playback by the MIC (for X-Band) or by the M-5 processor (for S-Band). The 2-byte Error Control CRC will be padded with zero by the MIC hardware during X-Band transmission or by the WARP software during S-Band transmission. During S-Band playbacks, the Communications RSN inserts valid data into this field. The last 160-byte long RS check symbols are inserted during playback by the S-Band Comm RSN (S-Band) or the MIC (X-Band).

6.3.1 Spacecraft Housekeeping Data Frames

The processor receives the spacecraft housekeeping data from C&DH. Only the 2-byte M_PDU header and the 1084-byte M_PDU packet data zone are retained and sent to the bulk memory. This data will be retrieved at playback.

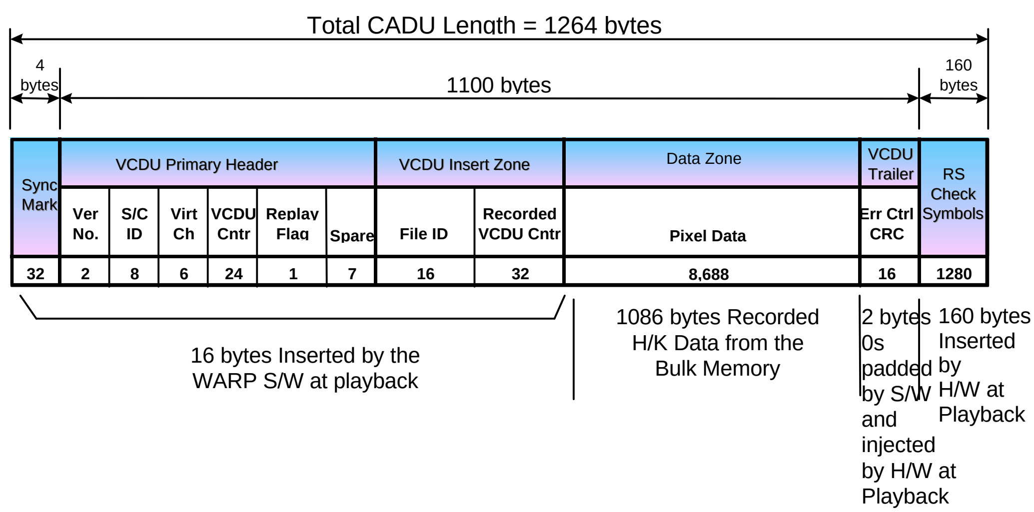
During S-Band playback, the WARP processor inserts the 4-byte sync mark, the 6-byte VCDU primary header, and 6-byte VCDU Insert Zone prior to S-Band output. The WARP processor also pads the 2-byte error control CRC field with zeros. The S-Band Comm RSN hardware inserts the error control CRC into the VCDU trailer and appends the 160-byte RS check symbols. The Recorded VCDU Counter in the VCDU Insert Zone indicates the record number within a particular file. The first record of each file has a VCDU counter value of one (1).

During X-Band playbacks, the MIC inserts the 4-byte sync mark, 6-byte VCDU primary header, and 6-byte VCDU Insert Zone and sends to the X-Band transponder. The Error Control CRC will contain 0's. The CADU is appended with 160-byte long RS check symbols at the end.



6.3.2 Raw Science Data Frames

The raw science data frame formats for S-Band and X-Band are identical. The common format is depicted below:



6.3.3 CADU Field Descriptions

The M_PDU Header and M_PDU Packet Data Zone fields are associated with CCSDS AOS packetized telemetry, and are not discussed in this section. Details of these fields can be found in the relevant C&DH software documentation or the CCSDS "Blue" Books.

6.3.3.1 Sync Mark

Item	Definition
1. Synchronization Marker	CADU sync for Transmission over space to ground communication link; it's value is "1ACFFC1D".

6.3.3.2 VCDU Primary Header

Item	Definition
1. Version #	It's value is binary "01" which is the value for an CCSDS AOS TLM Frame.
1. Spacecraft ID	It's value is decimal "393", Octal "611", or 189hex.
1. Virtual Channel ID	Value — Description 0-2 — Reserved for S/C C&DH transmitted Telemetry 3 — Scene S/C Housekeeping Data 4 — Raw Science Data - WIS SWIR 5 — Raw Science Data - WIS VNIR 6 — Raw Science Data - GIS SWIR 7 — Raw Science Data - GIS VNIR 8 — Raw Science Data - MS/PAN 9 — Raw Science Data - ACU
1. VC Data Unit Counter	Its value represents the # of the CADU frame and is continuous for each virtual channel. These counters are reset to (1) if the WARP processor experiences a "cold" restart
1. Replay Flag	It is usually 0, but will be set to 1 when a known discontinuity occurs in VCDU Counter.
1. Spare	This field is always zero.

6.3.3.3 Insert Zone

1. File ID	This is the 16-bit file ID of the file to which a recorded VCDU is apart.
2. Recorded VCDU Counter	This field is equivalent to a recorded record #.

6.3.3.4 Data Zone

6.3.3.5 Trailer

This field is for Error Control CRC, which will be Zero for X-Band and used by the S-Band Communications RSN.

6.3.3.6 RS Check Symbols

The 160-byte long RS check symbols are encoded by the MIC during X-Band playback and by the S-Band Transponder Comm RSN during S-Band playback.

6.4 Playback Data Format

6.4.1 Multi-Spectral/Pan Band (MS/PAN) Data File

The scan line sync patterns are inserted at every MS scan line start. Therefore some PAN pixel data could appear before the first science data sync pattern if PAN pixels come to the WARP before the MS. Please refer the *EO-1 WARP RS-422 Terminal Board Mini Specification* for detail and latest revision. The data format of a played back MS/PAN file is summarized as follows:

Bit 0 … bit 95

Pixel Data								
pixel data	pixel data	band ID	pixel data	pixel data	band ID	pixel data	pixel data	band ID
12 bit MSB...LSB	12 bit MSB...LSB	8bit	12 bit	12bit	8bit	12 bit	12 bit	8 bit

.
.
.

Bit K

Science Data Sync Pattern

72-bit fixed pattern + 24-bit counter
= 0xFF00FF00F0F0F0CCAA000000
96-bit

Bit K+96

Pixel Data

.
.
.

Science Data Sync Pattern
72-bit fixed pattern + 24-bit counter
= 0xFF00FF00F0F0F0CCAA000001
96-bit

Pixel Data

.
.
.

Bit N — N+95

End of Science Data Sync Pattern
72-bit fixed pattern + 0xFFFFFF
= 0xFF00FF00F0F0F0CCAAFFFFFF
96-bit

Bit N+96 — M-1

End of Science Data Fill Pattern
Till the end of the 1712-byte interleaved RS block
= repeated 0xA55A
(possible range of length: 0 - 1709 bytes)

Bit M — EOF

End of File Fill Pattern
Till end of the 934,752-byte logical block
= repeated 0x13C7
(possible range of length: 0 - 933,040 bytes)

6.4.2 Atmospheric Correction (AC) Data File

The detail of MS/PAN data format is yet unknown at this time. However, the playback file will have the End of Science Data Fill Pattern, and the End of File Fill Pattern, inserted at the beginning and at the end. The AC instrument will insert its own scanline sync among its 13-bit pixel data.

Bit 0

Science Data
TBD

.
.
.

Bit N — M-1

End of Science Data Fill Pattern
Till the end of the 1712-byte interleaved RS block
= repeated 0xA55A
(possible range of length: 0 - 1709 bytes)

Bit M — EOF

End of File Fill Pattern

Till end of the 934,752-byte logical block = repeated 0x13C7

(possible range of length: 0 - 933,040 bytes)

6.4.3 Spacecraft Housekeeping Data File

The following diagram summarizes the data file format of a Spacecraft Housekeeping Data File, without the 4-byte Sync Mark, 6-byte VCDU Primary Header, 2-byte Error Control CRC, and the 160-byte RS Check Symbol from the 1264-byte CADU frame. The Spacecraft Housekeeping Data file does NOT contain a file header block. In addition, when a Spacecraft Housekeeping Data File is played back at the X-Band, the repeated End of File Fill Pattern (0x13C7) will appear until the end of that logical block. *Please note that this pattern could be significantly shorter when played back at the S-Band for reducing the playback duration. Also note that if the End of the last Spacecraft Housekeeping Transfer Frame ends right at the end of a logical block, this fill pattern will* <u>*NOT*</u> *show up.* For detail and latest revision on the content of the Spacecraft Housekeeping data file, please refer to the *EO-1 Command & Telemetry Handbook.*

Bit 0 … 48 … 64 … 8735

VCDU Insert Zone		**M_PDU Header**		**M_PDU Packet Data Zone**
File ID	Recorded VCDU Cntr	Spare	1st Hdr Pointer	Packet Data

(first frame)

Bit 8736 … 8784 … 8800 … 17472

VCDU Insert Zone		**M_PDU Header**		**M_PDU Packet Data Zone**
File ID	Recorded VCDU Cntr	Spare	1st Hdr Pointer	Packet Data

(second frame)

.
.
.

Bit N-8736 … N-8688 … N-8672 … N-1

VCDU Insert Zone		**M_PDU Header**		**M_PDU Packet Data Zone**
File ID	Recorded VCDU Cntr	Spare	1st Hdr Pointer	Packet Data

(last frame)

Bit N … EOF

End of File Fill Pattern
Till end of the 934,752-byte logical block = repeated 0x13C7

(possible range of length: 0 - 934,752 bytes)

7 COMMAND DATA FORMATS

The EO-1 C&DH telecommanding subsystem us a subset of the CCSDS standard for telecommanding.

The options implemented in the C&DH subsystem are:

a. Channel Service - the C&DH subsystem will use 56 bit word length with 8 bits of parity.
b. Transfer Frame Layer:
- C&DH will use 2 virtual channels in the transfer frame layer;
- C&DH will only support command operation procedure no. 1 (COP-1);
- C&DH will not support transfer frame error control; C&DH in support of COP-1 will support control commands only for the "UNLOCK" and "SET NEXT EXPECTED FRAME SEQUENCE NUMBER TO ZERO" functions;
- C&DH will support a fixed size frame acceptance and reporting mechanism (FARM) "FARM SLIDING WINDOW" (size=127) and a fixed size "FARM NEGATIVE EDGE" (size=63) of the "FARM SLIDING WINDOW";
- C&DH will not support any other control commands;
- C&DH will not support "FARM FIXED WINDOW" operations;
- C&DH will make no use of CLCW "Status Field"
- C&DH will not use the "Wait field in the CLCW;
- C&DH will telemeter the CLCW for Command virtual channel 1 in both housekeeping packets and in the Operations Control Field of the Virtual Channel Data Unit (VCDU) for real time data (VC0). The C&DH will telemeter the CLCW for Command virtual channel 2 only in a housekeeping packet.

c. Segmentation Layer - segmentation of packets across transfer frames will not be supported. However, the commands will be formatted with the Segmentation data included to allow for future expansion.
d. Packetization Layer - Application Process ID will serve as the principal method for addressing elements in the C&DH. All command octets will contain a Secondary Header that contains additional routing information and a 8 bit exclusive-or checksum over all applications data and packetization layer header.

7.1 Command Channel Coding

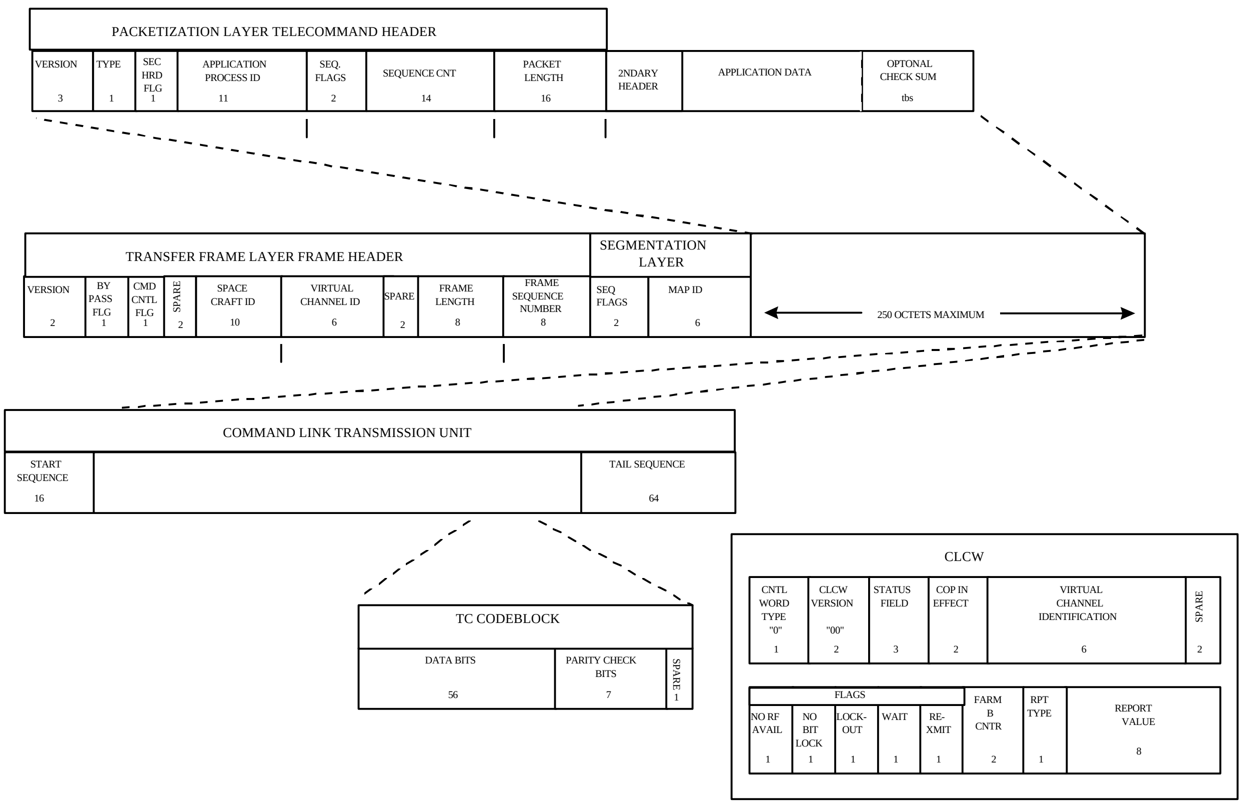
The encoding scheme presented in the CCSDS standard for telecommanding provides a reliable, error controlled data path from ground to spacecraft. All commands and data sent to the spacecraft will be divided into CCSDS codeblocks which consist of 56 information bits followed by 7 bits of parity and 1 spare bit, making a total of 64 bits of error controlled data.

All command data sent to the spacecraft will be sent with NRZ-L encoding

In order to eliminate the impact of the transmission of long strings of zeroes, the data portion of the command packets (on virtual channel 1) will be randomized by exclusive-or'ing the data with a fixed pattern of "A5A5" (hex).

7.2 Command Transfer Frame Format

The major unit of data in the telecommanding is the transfer frame. Telecommand transfer frames exist in the transfer layer. The transfer layer takes the source packets and encapsulates them in the transfer frame format. This section describes one of the standard data structures that reside within the transfer layer, the telecommand transfer frame, which is uplinked to the EO-1 spacecraft. A transfer frame consists of four major fields: Frame Header, Segmentation Layer, Frame Data Field, and an optional Frame Error Control. These fields are shown in the figure below.



EO-1 TELECOMMAND DATA STRUCTURES

The Frame Header consists of 5 octets of information that fully describe the transfer frame. The first two octets contain the following fields:

a. Version Number (2): At present only version 1 of the transfer frame standard is in use, therefore these 2 bits are both set to "0".
b. Bypass Flag (1) and Command Control Flag (1): These bits are used to determine if a control command or a bypass command is being sent. Normal commands (on virtual channel # 1)

may be sent in "bypass" mode during emergency conditions that call for commanding with no telemetry feedback. On virtual channel # 1, the C&DH uses COP-1 control commands to "unlock" the channel, or to set the next frame number to zero. Special commands (send on virtual channel # 2) may only be sent in Bypass mode. (i.e. the Bypass flag=1). No control commands are processed for virtual channel # 2 special commands.

c. Spares (2) Two spare bits both set to zero.
d. Spacecraft ID (10): This field specifies a unique code for the spacecraft. The value is '189' hexadecimal.

The third octet of the Frame Header contains the following fields:

a. Virtual Channel ID (6) For normal spacecraft commands, the C&DH uses virtual channel # 1. For special commands, C&DH uses virtual channel # 2.
b. Spares (2): Two spare bits both set to zero.

The fourth octet of the Frame Header consists of only one field:

a. Frame Length (8): This field contains one less than the total number of octets in the transfer frame.

The fifth octet of the Frame Header contains the following field:

a. Frame Sequence Number (8): This field is used to support COP-1 telecommand operations. It insures that commands are received and processed in the proper sequential order. Note that since only bypass commands are processed on virtual channel #2, this field will be zero on virtual channel # 2.

The segmentation layer is not supported by the EO-1 C&DH. However, for compatibility with future systems, the two fields associated with segmentation are included in command formats:

a. Sequence Flags (2): These 2 bits have a value of "11" (base 2).
b. MAP ID (6): C&DH will not use this option. The MAP ID will have a constant value of 1.

The next major field of the transfer frame id the Frame Data Field. This will contain packetized command or data. The CCSDS standard gives an upper bound for this field of 250 octets. C&DH supports this upper limit.

For virtual channel # 1, the only control commands implemented in C&DH are "UNLOCK", and "SET NEXT EXPECTED FRAME SEQUENCE NUMBER TO ZERO." Other control commands are not supported.

For virtual channel # 2, no control commands are supported.

The transfer frame layer produces the CLCW.

The CLCW is telemetered in the Operational Control Field of the VCDU and as part of a C&DH housekeeping data packet. The CLCW contains the following fields:

a. Control Word Type (1) - As per CCSDS, this field will have a value of “0”.
b. CLCW Version Number (2) - As per CCSDS, this field will have a value of “0”.
c. Status Field (3) - Not Used.
d. COP In Effect (2) - Only COP-1 is supported. This field will have a value of “00”.
e. Virtual Channel ID (6) - This field will indicate which virtual channel is being reported in this CLCW.
f. Spares (2) - Two spare bits to complete second octet; both set to “0”.
g. No RF Available(1) - This field will contain information obtained from the transponder indicating if the command detector is in lock.
h. No Bit Lock (1) - This field will contain information obtained from the command detector indicating if the command detector is in lock.
i. Lockout (1) - This field is used in COP-1 as per CCSDS standards.
j. Wait (1) - This field will not be used by C&DH.
k. Retransmit (1) - This field is used in COP-1 as per CCSDS standards.
l. FARM-B Counter (2) - This field is used as per CCSDS standards to provide verification of bypass commands.
m. Report Type (1) - As per CCSDS standards for COP-1, this field will have a fixed value of “0”.
n. Report Value (8) - As per CCSDS standards for COP-1.

7.3 Command Data Format

Data received on virtual channel 1 is packetized command data. Data received on virtual channel 2 is special command data.

7.3.1 Packetized Command Data

The telecommand packetization layer encapsulates the user commands within the transfer frame. The CCSDS standard defines the maximum packet size of 65,542 octets; however, the C&DH implementation limits the packet length to 250 octets to prevent a single transmission from monopolizing the command link. The command packet consists of three major fields: Packet Header, Application Data, and Secondary Packet Header (optional).

Of the 250 octets allowed in one packet, 6 are used to form the packet header. The packet header consists of three major fields:

a. Packet Identification
b. Packet Sequence Control
c. Packet Length

The Packet Identification Field consists of information describing the packet format and contents. The two octets of the Packet Identification Field consist of the following fields:

a. Version (3) - At present only version 1 of the packet standard is defined, therefore there 3 bits will be zero.
b. Type (1) - For telecommanding this bit is set to "1". Note that this bit is not used in the AOS standard but may be set to either a "0" or "1".
c. Secondary Header Flag (1) - This bit is set to one signaling the presence of a Secondary Packet Header.
d. Application Process Identifier (11) - These bits will serve as the principal method of addressing packets to users on-board the spacecraft.

The next major field of the Packet Header is the Packet Sequence Control. C&DH does not use this filed to support application layer segmentation.

The final major field of the Packet Header is the Packet Sequence Control. C&DH does not use this field to support application layer segmentation.

The final major filed of the Packet Header is the Packet Length. These two octets contain a sixteen bit binary number that is one more than the application data filed in octets.

The second major filed of the Command Packet is the optional Secondary Packet Header. Commands that are sent to C&DH software applications will use a two(2) byte secondary header. The secondary header consists of the following fields:

a. Zero(1) - This bit is set to zero to indicate the secondary header is non-CCSDS defined.
b. Function Code (7) - This field is used to identify an individual command associated with an application ID.
c. Checksum (8) - These bits are used for and exclusive-or checksum of the full command. When all bytes in the command are exclusive-or'ed together, the resulting value will be "1111 1111" (base 2).

The final major field of the Command Packet is the Application Data. This field contains the data bits that represent the actual data to be transmitted to the user.

Note that the data portion of the command field is "randomized" as described in section tbd. This randomization occurs after the generation of the checksum in the secondary header.

7.3.2 Special Command Data

On virtual channel # 2, special command may be transmitted that are used for special data system reconfiguration options.

The format of the special command is shown below:

	TRANSFER FRAME HEADER									SEGMENTATION		SPECIAL CMD FIELD			
[redacted]	VERSION NUMBER	BY-PASS FLAG	CNTL CMD FLAG	SPARE	S/C ID	VIRTUAL CHAN ID	SPARE	FRAME LENGTH	FRAME SEQ #	SEQ FLGS	MAP ID	SPARE	UPLINK SIDE	SPECIAL CMD ID	[redacted]
16	2	1	1	2	10	6	2	8	8	2	6	1	1	6	
eb90 hex	00	1	0	00	189 hex	000010	00	00000110	00000000	11	000001	0	0 - A	XXXXXX 0 - 7 hex	xxxxxxx0

Value for Special Command (underlined values checked by h/w decoder)
# of bits in field
#Field Name

The commands conform to the CCSDS protocol with the following restrictions:

a. Special commands may only be sent as the first command of a CLTU.
b. No other command may be included in a CLTU containing a special command.

8 TIME CODE AND TIME CORRELATION

8.1.1 Time format

The spacecraft time format consists of 32 bits of seconds and 32 bits of subceconds. The subseconds field is defined such that 80000000 hexadecimal = ½ second, 40000000 hexidecimal = ¼ second, 20000000 hex = 1/8 second, etc. The spacecraft clock will be a free running clock. The spacecraft will maintain a Universal Time Code (UTC) correlation factor which correlates the spacecraft clock to UTC. The UTC correlation factor will be telemetered in a spacecraft housekeeping packet. Adding the correlation factor to the spacecraft time will yield a delta time from the GPS epoch which is 80/006/00:00:00 or January 6, 1980.

8.1.2 Onboard GPS Receiver

The spacecraft will maintain the spacecraft UTC correlation factor to an accuracy of +/- 2 ms using an onboard GPS receiver.

8.1.3 Telemetry Method Correlation

Range Data Delay (RDD) method will be used with necessary ranging scheduled as needed. As a backup to GPS time correlation, the ground station will append the time each VC0 CADU was received at the ground station to the Internet Protocol Data Unit header (see Ground Station Interface Appendix). This time will be accurate to one millisecond. In addition, the spacecraft will include the time of (TBD- which frame does this time mark?) VC0 CADUs in the time code housekeeping data packet.

9 APPENDIX A INTER-FACILITY DATA FLOWS

9.1 Purpose

This portion of the ICD contains the mission-specific aspects of the data flows among the WGS (which consists of the AGS, SGS, and WPS), and the EO-1 MOC at GSFC. The sections that follow contain content and flow control requirements necessary for effective mission support for five types of communications interfaces: telemetry, commands, tracking data, schedules and supporting data, and reports.

9.1.1 General

Figure 9-1 shows the interfaces among the EO-1 MOC and WGS for the delivery of required EO-1 products. Transmission Control Protocol/Internet Protocol (TCP/IP) serves as the basis for data exchanges among EO-1 ground system elements. Real-time data are typically transferred via TCP/IP sockets while files are transmitted with the File Transfer Protocol (FTP). All command and S-Band telemetry transfers between the MOC and GN use the TRACE delivery formats. The TRACE Delivery Format (TDF) is basically a TRACE header concatenated with a CCSDS-compliant data unit (i.e. command transfer frame or telemetry CADU). The tables in Appendix B show the complete TRACE header structure and associated field definitions. Specific values applicable to EO-1 telemetry and commands are found in Sections 9.2 and 9.3 respectively. Tracking data, schedule files, and reports are all file-based transfers with the originator "pushing" the files to the recipient. Details about these types of data are in Sections 9.4 through 9.6.

Information necessary for IP transfers includes network addresses, port numbers, and passwords. Since these can change during the mission, they will not be documented in this ICD. Operations agreements, memoranda of understanding, and similar arrangements or documentation will provide these parameters.

9.2 Telemetry Interface

9.2.1 General

EO-1 downlinks science and spacecraft telemetry in the X and S frequency bands, respectively.

Figure 9-1. EO-1 MOC / GN Interface Diagram

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Determine what happens for Prepass Readiness Test (PRT)

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From any of the WGS sites, S-Band telemetry, which includes both real-time and playback data, is transferred in real-time to the MOC. All commands and S-Band telemetry are transmitted over a closed network. X-Band data received at the AGS/SGS are recorded then sent to the MOC. Upon receipt at the ground stations, X- and S-Band data are processed differently due to their differing rates, purposes, and destinations. Details about data formats and transfer mechanisms for the telemetry interfaces follow the next paragraph, which describes S- and X-Band processing at the ground stations.

9.2.1.1 S-Band Telemetry Processing

S-Band telemetry received at WPS, SGS, or AGS are processed by a Programmable Telemetry Processor (PTP) following successful bit synchronization. The PTP provides frame synchronization, Reed-Solomon (R-S) decoding, data receipt time stamping, and TDF header formulation/application. The telemetry data are also recorded at the receiving ground station so that retransmission is possible. This is described in paragraph 9.2.4. The incoming data stream consists of CCSDS-compliant CADUs. After successful processing at the ground station, the CADUs are prepended with IPDU headers and are sent to the MOC.

Real-time and SSR playback telemetry are maintained in separate data streams between the ground station and the MOC. Prior to each support, with the ground station acting as the server, the MOC initiates two independent TCP/IP sockets, one for each data stream. In the MOC, the real-time telemetry stream is used for clock correlation, spacecraft and instrument status assessment, and command verification. The playback telemetry is used primarily for on-going trend analysis and for troubleshooting, should problems arise. Most of these functions involve the extraction of information from successive protocol layers to recover spacecraft packets..

Backup mode clock correlation makes use of the spacecraft time code in the telemetry data and the PTP-supplied time stamp in the TDF header. The MOC calculates the spacecraft clock's deviation from the station's reference time by subtracting the spacecraft clock value, transmission delay, and station equipment delay from the IPDU time stamp. Prior to launch, equipment delays are characterized at each station and provided to the MOC for the development of clock correlation functionality.

While S-Band data are being captured and processed, the PTP maintains processing status information. These statistics can be used locally to verify system status and can be reported to the MOC post-pass for use in trending and in problem isolation, should the need arise.

9.2.1.2 X-Band Telemetry Processing

All X-band data recovered at the WGS are forwarded to the EO-1 Data Processing System (DPS) for Level-Zero processing. X-band data received at the SGS and AGS are recorded on tapes so they can be sent to the MOC, where they are mounted on Ampex recorders and replayed to the DPS.

The tapes created at the WGS sites contain digital recordings of the bit stream received from a specified X-Band link during EO-1 contacts. Tapes, along with supporting documentation, are shipped within 48 hours of data receipt.

9.2.2 Telemetry Formats

9.2.2.1 S-Band Telemetry Format

EO-1 S-Band telemetry is transmitted via TCP/IP from the WGS sites to the MOC as TDFs, each containing a header and a CADU. Formats for the telemetry IPDU and its components are shown in Figure 9-2. The TDF header, with EO-1 telemetry values is defined in Appendix B

9.2.2.2 X-Band Telemetry Format

EO-1 X-band data received at the AGS/SGS are recorded as a raw bit stream of CCSDS CADUs onto Ampex DD-2 tapes. The WGS equipment was selected specifically to ensure compatibility among the facilities supporting EO-1. The bits recovered from the bit synchronizers are recorded in time-tagged, numbered blocks, allowing playbacks to start and stop at operator-specified tape locations. During periods in which the bit synchronizers do not detect data, their output is inhibited so that recording does not take place. This may occur, for example, prior to signal acquisition and during link outages. Each tape will contain both I and Q-channel data recorded during one or more X-band supports .

Automated recording/tape handling units allow unattended operation of the AGS/SGS for up to 48 hours. The amount of data recorded per tape depends on the amount of data received at the site over a given interval. This, in turn, depends on the season, data requests, scene cloud cover, and other factors. Operations agreements and support plans contain details regarding tape capacity to be available to EO-1 over specified time intervals and shipping criteria (e.g. ship data 48 hours after recording, even if tape not full) for recorded tapes.

The Ampex recorders WGS is using are model 260I. They support the D-1 format. The ground stations will use the AMPEX D-1 LARGE 165 GBYTE tapes.

For identification purposes, each tape is assigned an ID number which is both recorded onto the tape and attached to the cartridge as a bar-coded sticker. To identify the tape's data contents, a tape log accompanies each tape sent from the AGS/SGS to the MOC. This file is described in paragraph 9.6.4, and the MOC response, the tape acknowledgment report, is described in paragraph 9.6.5.

9.2.3 Data Retention

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The WGS sites retain copies EO-1 S-Band telemetry to serve as a back-up in case real-time transmission outages occur. These back-ups are kept for 72 hours unless the MOC or project personnel request longer retention on specific occasions. Upon request from the FOT to GN operations personnel, a replay will be scheduled for the requested data at a mutually acceptable time. For GN sites, the FOT initiates retransmission scheduling with a phone call to GN operations. An electronic-mail message with specifics to identify the data needing replay, such as AOS/LOS times, formalizes the request. For unmanned stations, retransmissions may have to occur during the next shift when personnel are available. Emergency situations will receive a higher priority and can be scheduled accordingly.

AGS/SGS will make duplicate copies of X-Band tapes and will retain the copies until notified that they are no longer needed. This notification process is described in paragraph 9.6.5.

9.2.4 Retransmission Rates

Retransmission rates for S-Band telemetry are based on the available bandwidth between the ground station and the MOC during the planned retransmission. The maximum rates supported for this interface are the same as for original transmissions, 32 Kbps for real-time telemetry and tbd Kbps for playback telemetry.

9.3 Command Interface

9.3.1 General

The command data flow from the MOC to the ground stations is shown in Figure 9-1. Commands are transmitted as TDFs to the PTP resident at the supporting site. The PTP strips the TDF header from the CCSDS-formatted commands and transfers them to the uplink equipment chain. The MOC-to-ground station command format is described in paragraph 6.3.2. Following header checks and re-formatting, the sites throughput the command data stream to the spacecraft.

The command interface between the MOC and the ground stations is based on TCP/IP. Prior to each support, with the MOC acting as the server, the GN initiates a socket connection for command data.

Commands are sent by the ground stations to the spacecraft in the CCSDS CLTU format which is illustrated in Appendix B. The MOC and the ground stations use the TDF format for inter-facility command transfer.

9.4 Radiometric Data Interface

9.4.1 General

The MOC provides the requisite information for the ground stations to acquire EO-1. For the WGS sites, the data are sent to WOTIS, and from there, distributed to the ground station control systems. The MOC provides acquisition data files each day to ensure that acquisitions occur with only minimal delays. Each file contains 48 hours' worth of data to provide continuity between files and to mitigate any risk due to communications outages.

Exceptions to the acquisition data delivery schedule are the periods following orbital maneuvers. The MOC/FOT delivers normal no-maneuver products to the WGS. Following a successful maneuver, a second set of acquisition data are transmitted, reflecting the effects of the maneuver. Since acquisition data need to be updated rapidly, the FOT also sends a copy of the current daily schedule to WOTIS to trigger a database update at the WGS sites. The update ensures that the new acquisition data reaches the sites in the most expeditious manner. Section 9.4.2 provides more information on the data format used for WGS acquisition data.

Table 9-3. Acquisition Data File Name Definition

Filename Segment	Definition	Range	
		Minimum	Maximum
<type>	File type	EPHM	n/a
<project>	Mission identifier	EO-1	n/a
YYYY	Four-digit year identifier first day in file	1996	2100
MM	Two-digit month identifier	01	12
DD	Day of month identifier	01	31
V##	"V"ersion identifier, where ## is a two-digit counter	V00	V99

The WGS provide both one-way and two-way tracking support to EO-1. These data are generated during real-time support then transferred as a file post-pass to an FDF-supplied workstation in the MOC. Section 9.4.3 identifies the formats used for the tracking data interface between the ground stations and the MOC.

9.4.2 Station Acquisition Data Format

The selected method for distributing acquisition data to the ground stations is a file containing an Improved Inter-Range Vector (IIRV) message. The format for this message is given in tbd.

For WGS stations, the file naming convention is:

<type><project>YYYYMMDD.**V**##

where the definitions in Table 9-3 apply. As with file contents, the time in the file name is GMT-based.

An example of an acquisition data file name is: EPHMEO-119980619.V00 to indicate that the file covers 19 June 1998 and is the first version (V00) to be sent to WOTIS from the MOC.

9.4.3 Metric Tracking Data Format

Tracking data are transferred from the WGS collection site to the MOC as files containing Universal Tracking Data Format (UTDF) records. The UTDF definition is in STDN 724, *Tracking and Acquisition Handbook for the Spaceflight Tracking and Data Network*. A single file is generated for each scheduled tracking data session and is FTP'd to the MOC within ten minutes of the end of the contact.

The spacecraft and vehicle identification codes needed for the UTDF header appear in Table 9-4.

Table 9-4. EO-1 UTDF Values

Name	SIC	VIC
EO-1	8601	01

The file naming convention, which uses GMT for time stamps, is:

<type><project>DOYHHMM.**V**DOYHHMM

where the definitions in Table 9-5 apply.

An example of a tracking data file name is: TRK_EO-10051845.V0051855 which indicates that the file contains tracking data collected during a period starting at day 005 at 18:45 GMT and that the file was prepared for transmission to the MOC 10 minutes later.

Table 9-5. Tracking Data File Name Definition

Filename Segment	Definition	Range	
		Minimum	Maximum
<type>	File type	TRK_	n/a
<project>	Mission identifier	EO-1	n/a
DOY	Day of year of first data point in file	001	366
HH	Hours of day of first data point in file	00	23
MM	Minutes of hour of first data point in file	00	59
VDOY	"V"ersion identifier indicating day of year file was prepared for transmission	V001	V366
HH	Hours of day of file preparation time	00	23
MM	Minutes of hour of file preparation time	00	59

9.5 FDF Products and Formats

9.6 Scheduling Interface

9.6.1 General

Scheduling ground station support to meet EO-1 recovery needs is a responsibility of the FOT/MOC. The process and specifics for WGS scheduling are covered in the remainder of this section.

Approximately three weeks before the interval being scheduled, the scheduling process begins with the FOT/MOC sending a request file to WOTIS. The request file, which follows the same format used in all MOC-WOTIS schedule exchanges, is based on a general file containing view information for all EO-1 ground stations. The views for the WGS sites are filtered by the MOC and FOT based on several criteria, including coverage availability. These resulting views represent a more accurate prediction of actual EO-1 support needs and, therefore, are sent to WOTIS as the first step in the scheduling process. Once WOTIS receives the file, a preliminary schedule is generated based on the EO-1's views and the support requirements of other WGS-supported spacecraft.

This forecast schedule file, which is FTP'd to the MOC approximately 2.5 weeks before the target week, contains entries for each request that WGS resources can support. The entry types are based on defaults which represent the most common EO-1 support configurations. Based on agreements between WGS and the EO-1 project, support entries for both X-Band and S-Band are generated for SGS, WGS and AGS. The WOTIS scheduling system generates tags that are used to uniquely identify each X-Band and each S-Band support in a schedule. Any subsequent actions relevant to a given support by either the MOC/FOT or WGS make use of this tag.

Between one week and two weeks before the target week, the MOC/FOT returns a confirmed schedule to WOTIS in response to the forecast schedule. This schedule further refines the support that EO-1 needs from WGS by containing only the X-Band and S-Band entries that are required to meet mission objectives. This schedule is expected to contain a subset of the coverage that was originally listed in the strawman request file initially sent to WOTIS. Entries that were in the forecast schedule but do not appear in the confirmed schedule are effectively deleted. In addition to deleting contacts, the MOC/FOT can make any necessary changes to the support entries via the confirmed schedule. For example, specific on and off times for S-Band station resources can be given by adjusting the times associated with the contact and tracking support can be changed from one-way to two-way or vice versa.

Each day, the MOC/FOT sends a daily schedule file to WOTIS by 2000z. The file begins with the first support starting after 0000z and covers a 48-hour period. This schedule is based on the same format used for the other schedule files. The parameters that will be given at this time are X-Band frequency(tbd) and specific equipment on/off times. As with the other transmissions, FTP provides acknowledgment that the daily schedule arrived successfully at WOTIS. The transfer of the daily schedule is the final electronic exchange in the scheduling process. Any modifications after this point, including requests for emergency support, are accomplished via voice coordination between the FOT and WGS operations staff, with confirmation via electronic mail.

9.6.2 Support Requirements

The SGS is considered the primary S- and X-Band communications facilities for the mission.. AGS and AGS are considered backup ground stations.

SGS usage is a function of both orbital geometry and science data requests. Tracking data acquisition requirements are also a consideration in determining station coverage needs. An accurate orbit solution is predicated on sufficient tracking data collection at various geographic locations. MOC/FOT scheduling determines specific WGS support based on these factors.. The strawman request file that the MOC/FOT sends to WOTIS contains a best-guess estimate of support needs for the target week based on long-term science plans. The strawman will contain more than the essential contact times to give WOTIS some flexibility in meeting EO-1 needs in conjunction with those of other users. Once WOTIS responds with a forecast schedule, the FOT can eliminate any unnecessary supports by not including them in the confirmed schedule returned to WOTIS. If the forecast schedule contains insufficient WGS support, operator negotiation via voice and/or electronic mail is required.

Based on resource loading studies conducted prior to launch, WGS support is expected to total approximately two passes per day with average length of tbd minutes each.

9.6.3 Schedule File/Data Formats

This section gives the file formats and naming conventions for the data exchanged between WOTIS and the MOC. The FTP addresses for all of the files listed in this section and necessary account and password information are exchanged by representatives of each facility prior to launch and during the mission as necessary. Operations agreements between the FOT and WGS staff identify these representatives and provide the details for communicating this information in a safe, effective manner. All schedule file transfers between the MOC and WOTIS make use of a gateway mechanism to maintain security since WOTIS is on an "open" network.

9.6.3.1 Strawman Request File Format

The strawman request file uses the Request/Response Format given in Appendix C. Records are included for each requested S-Band and X-Band contact. The tag field in each record is set to zero by the MOC since this value is assigned by WOTIS later in the scheduling process. The period to be scheduled is Monday, 0000z, through Sunday, 23:59:59z. However, the file covers one week plus a day of overlap on each end to allow continuity from one scheduling period to the next. Thus, each file starts at the first request after 0000z on the Sunday of the target week and ends with the last LOS eight days later (i.e. a Monday). Supports that start in one week and end in the next (e.g. Sunday 23:55:00 to Monday 00:05:00) are requested and scheduled as part of the earlier week. Due to the overlap included in each file, such supports are listed in both weeks' files.

The following naming convention is used for the WGS strawman request file:

<type><project>WK##.**V**##

where the definitions in Table 9-6 apply.

An example of a request file name is: REQ_EO-101.V00 to indicate that the file includes 1 January and is the first version the MOC has sent to WOTIS.

Table 9-6. Strawman Request File Name Definition

Filename Segment	Definition	Range	
		Minimum	Maximum
<type>	File type	REQ_	n/a
<project>	Mission identifier	EO-1	n/a
WK##	Week number, two digits	01[1]	53[2]
V##	"V"ersion identifier, where ## is a two-digit counter	V00	V99

[1] Week 1 is defined as the week containing 1 January.

[2] Some years will contain 52 weeks then roll over to Week 01 while others will roll over after Week 53. This occurs because each week runs from Monday through Sunday and Week 01 may contain the end of December.

9.6.3.2 Forecast Schedule Format

The forecast schedule is FTP'd from WOTIS to the MOC on the Thursday which is 2.5 weeks before the first day of the week being scheduled. Like the strawman request file, the forecast file covers one Monday-through-Sunday scheduling week and runs from Sunday through Monday to provide overlap. This file contains two Request/Response Format records for each available AGS and SGS contact, one for S-Band and one for X-Band. WPS supports are represented by an S-Band record only. The Request/Response Format record format is given in C.

The filename for the forecast schedule follows this format:

<type><project>WK##.**V**DOYHHMM

where the name segments follow the definitions in Table 9-7.

An example of a forecast schedule file name is: RES_EO-101.V3531712 which indicates that the file includes 1 January and was assembled for transmission on day 353 at 17:12z.

9.6.3.3 Confirmed Schedule Format

The confirmed schedule covers the same time period as the forecast schedule. That is, it runs from Sunday through Monday. It contains a data- and requirements-driven list of events that EO-1 requires of the WGS sites, and is a subset of the contacts in the forecast schedule. Each event again is formatted as a Request/Response Format record, defined in C.

The naming convention for the confirmed schedule is:

<type><project>WK##.**V**##

where the definitions in Table 9-8 apply.

Table 9-7. Forecast Schedule File Name Definition

Filename Segment	Definition	Range	
		Minimum	**Maximum**
<type>	File type	RES_	n/a
<project>	Mission identifier	EO-1	n/a
WK##	Week number	01[1]	53[2]
VDOY	"V"ersion identifier indicating day of year file was prepared for transmission	V001	V366
HH	Hours of day of file preparation time	00	23
MM	Minutes of hour of file preparation time	00	59

1 Week 1 is defined as the week containing 1 January.

2 Some years will contain 52 weeks then roll over to Week 01 while others will roll over after Week 53. This occurs because each scheduling week runs from Monday through Sunday and if 1 January occurs on Week 01 may contain the end of December.

Table 9-8. Confirmed Schedule File Name Definition

Filename Segment	Definition	Range	
		Minimum	**Maximum**
<type>	File type	REQU	n/a
<project>	Mission identifier	EO-1	n/a
WK##	Week number	01[1]	53[2]
V##	"V"ersion identifier, where ## is a two-digit counter	V00	V99

[1] Week 1 is defined as the week containing 1 January.
[2] Some years will contain 52 weeks then roll over to Week 01 while others will roll over after Week 53. This occurs because each week runs from Monday through Sunday and Week 01 may contain the end of December.

An example of a possible file name for the confirmed schedule is:

REQUEO-101.V01, for a file containing 1 January and is the second version of the confirmed schedule sent from the MOC to WOTIS.

9.6.3.4 Daily Schedule Format

The daily schedule file covers a single day plus the following day for overlap and is transferred to WOTIS at least four hours before each day begins. Even though only X-Band supports may contain updates, the daily schedule file will include all supports at the WGS sites. The file is routinely used to specify actual X-Band frequencies that will be in use during X-Band events since the actual may differ from the default frequency used in the previous schedule files. The normal FOT/MOC procedure is to FTP the daily schedule as a matter of course, so that the update occurs even if no values are changed. Since only certain values are modifiable in the daily schedule, the FOT/MOC accomplishes other types of changes, such as support addition, via voice coordination with WGS operations personnel. This type of schedule file may also be used to trigger a database update at WOTIS, which in turn automatically updates the information at the ground stations. This allows the FOT to supply updated acquisition data for distribution to the sites without operator intervention by WGS personnel. This capability may be used around maneuver periods when updated tracking data may be needed. The daily schedule is based on the Request/Response Format record format, defined in Appendix C.

The filename for the daily schedule follows this format:

<type><project>DOY.**V**##

where the definitions in Table 9-9 apply.

Table 9-9. Daily Schedule File Name Definition

Filename Segment	Definition	Range	
		Minimum	Maximum
<type>	File type	REQF	n/a
<project>	Mission identifier	EO-1	n/a
DOY	Day of year covered by this schedule	001	366
V##	"V"ersion identifier, where ## is a two-digit counter	V00	V99

An example of a daily schedule file name is: REQFEO-1002.V00, indicating that the daily schedule is for 2 January and is the first version to be sent from the MOC to WOTIS.

9.7 Status Data and Report Interfaces

The GN provides status information to the FOT/MOC electronically. The WGS provides real-time contact status reporting and post-pass summary reporting. In addition to these electronic methods, voice communication takes place as necessary. The MOC provides reports on the receipt of and data recovery from X-Band tapes. This interface is covered in Section 9.6.5.

9.7.1 Real-time Status

For S-band data, RF equipment status information is provided by the GN sites. For S-band data, additional information is provided by the front end at the supporting station. Real-time status data sent by GN sites arrives at the MOC via TCP/IP Monitor Blocks. The data are also written to a file so they may be stored for subsequent review or analysis by the FOT.

9.7.1.1 Monitor Block Formats

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Format of Monitor Blocks TBD

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9.7.2 WGS Downlink Summary Report

Following every support taken at a WGS site, statistics are collected from various hardware and software station components. These data are transmitted to WOTIS, where they are stored and used in the generation of a downlink summary report which is subsequently transferred to the

MOC. This report is an ASCII file designed to be viewed with standard text editing tools. WOTIS-MOC connections make use of a gateway to preserve security.

The format for the report is given in Appendix D. The naming convention is: <type><project>DOYHH.VDOYHHMM, where the definitions in Table 9-10 are applicable.

Table 9-10. Downlink Summary Report File Name Definition

Filename Segment	Definition	Range	
		Minimum	Maximum
<type>	File type	DNL_	n/a
<project>	Mission identifier	EO-1	n/a
DOY	Day-of-year of contact start	001	366
HH	Hour of day of contact start	00	23
VDOY	"V"ersion identifier indicating day of year file was prepared for transmission	V001	V366
HH	Hours of day of file preparation time	00	23
MM	Minutes of hour of file preparation time	00	59

An example of a downlink summary report name is DNL_EO-116723.V1680012, indicating that it is for a pass that began during the 23rd hour of day 167 and was prepared for transmission on day 168 at 00:12z.

9.7.3 Tape Shipment Report from WOTIS

When tapes containing X-Band data are shipped from the AGS and SGS to the MOC, a report is sent electronically to notify the MOC that the tape(s) are en route and can be expected within the normal shipping time of a few days. This report is sent via open networks.

The format for this report is given in Appendix E. the naming convention is: <type><project>YYYYDOY.**V**DOYHHMM where the definition in Table 9-11 apply.

Table 9-11. Tape Shipment Report Naming Convention

Filename Segment	Definition	Range	
		Minimum	Maximum
<type>	File type	TSR_	n/a
<project>	Mission identifier	EO-1	n/a
YYYY	Year of Shipment	1996	2100
DOY	Day of year of shipment	001	366
VDOY	"V"ersion identifier indicating day of year file was prepared for transmission	V001	V366
HH	Hours of day of file preparation time	00	23
MM	Minutes of hour of file preparation time	00	59

An example of a possible file name is TSR_EO-12001327.V3271519, for a type shipment report that was shipped on day 327 of year 2001, after having been generated at 15:19z.

10 APPENDIX B. TCP/IP TRACE DELIVERY FORMAT (TDF) HEADER FOR EO-1 TELEMETRY & COMMAND

Tables 1 and 2 below describe the delivery header formats that shall be annotated to telemetry and command data units respectively.

Note: ‘word’ refers to 16 bits, an ‘octet’ or ‘byte’ refers to 8 bits.

Table B1. TRACE Telemetry Frame Delivery Header

Word	Bit(s)	Description
1	1-2	Version number of telemetry header
1	3-16	Length of frame in bytes (including header)
2	1	Annotation Flags: Reed-Solomon (RS) decoding enabled flag
2	2	RS decoding error flag
2	3	Frame CRC enabled flag
2	4	Frame CRC pass/fail flag
2	5	Master channel sequence (MCS) checking enabled flag
2	6	MCS number error
2	7-8	Data inversion flags
2	9-10	Frame sync mode flags
2	11	Data forward/reverse flag
2	12-16	Data Class
3	1	Earth received time of data (PB-5 format): flag bit
3	2-15	Earth received time of data (PB-5 format): truncated Julian day
3	16	Earth received time of data (PB-5 format): seconds of day
4	1-16	Earth received time of data (PB-5 format): seconds of day
5	1-10	Earth received time of data (PB-5 format): milliseconds of a second
5	11-16	Fill / spare

The fields in the LEO-T telemetry frame delivery unit are defined as follows. Bit 1 is the most significant bit and is transmitted first.

Word 1

Bits 1-2: Version number for header format is set to “01” for frame data
Bits 3-16: Length of frame in bytes, including frame delivery header.

Word 2

Bit 1: Reed-Solomon decoding: “0” disabled, “1” enabled
Bit 2: RS decoding error : “0” Frame was corrected, “1” Frame could not be corrected
Bit 3: Frame CRC checking: “0” disabled, “1”enabled
Bit 4: Frame CRC error - “0” pass, “1” fail
Bit 5: Master Channel Sequence (MCS) checking: “0” disabled, “1” enabled
Bit 6: MCS number error - “0” number increased monotonically, “1” number increased by 2 or more
Bits 7,8: Data inversion flags: “00” data true, “01” data inverted, “11” data inverted and corrected
Bits 9,10: Frame sync mode flags: “00” search frame, “01” check frame, “10” lock frame, “11” flywheel frame
Bit 11: Data forward/reverse flag: “0” forward, “1” reverse
Bits 12-16: Data Class 1=CCSDS Frame, 2 = CCSDS Packet, 3=TDM Frame, 4 = Stripped TDM frame

Words 3 - 5

Earth received time as defined below. This is the UTC time when the telemetry frame is received by the telemetry processor. The accuracy of the time is 1 millisecond.

Word 3

Bit 1: PB-5 flag bit, set to “0”
Bits 2-15: Truncated Julian day (14 bits). Truncate the most significant decimal digits, retaining only the four least significant decimal digits ranging from 0000 to 9999. The current Julian day epoch begins on October 10, 1995, and continues for a period of 27 years. Value is binary unsigned integer.
Bit 16: Seconds of day (17 bits), most significant bit.

Word 4

Bits 1-16: Seconds of day(17 bits), 16 least significant. Value is binary unsigned integer, ranging from 0 to 86,399.

Word 5
Bits 1-10: Milliseconds of the second. Value is binary unsigned integer from 0 to 999.
Bits 11-16: Fill/spares, set to zero's.

Table B2. TRACE (EOS) Command Delivery Header

BYTE(S)	Description
1	Message Type
2	Fill/Spare - Reserved for Future Use
3	Source Identification
4	Destination Identification
5	Fill/Spare - Reserved for Future Use
6-12	Message generation time - NASA PB-5 Time code format
13-14	Spacecraft Identification
15-16	Message Sequence Number
17-18	EDOS software version number
19-20	Message Length
21-24	Fill/Spare - Reserved for future use
Command data field.	

The fields in theTRACE command delivery header are defined as follows. Bytes are transmitted MSB first. Fields that are denoted with '*' are command validation parameters and shall be included in the configuration database. Remaining fields (except for Message Length) are not used by theTRACE and are for information purposes only.

Byte 1: * Message type is 03 hex (Command data block)
Byte 2: Fill/spares, set to zero's.
Byte 3: * Source Identification
Byte 4: Destination Identification
Byte 5: Fill/spares, set to zero's

Bytes 6-12:

Earth received time as defined below. This is the UTC time when the command ground transfer unit is generated.

Bytes 6,7

Bit 1: PB-5 flag bit, set to "0"
Bits 2-15: Truncated Julian day (14 bits). Truncate the most significant decimal digits, retaining only the four least significant decimal digits ranging from 0000 to 9999. The current Julian day epoch begins on October 10, 1995, and continues for a period of 27 years. Value is binary unsigned integer.
Bit 16: Seconds of day (17 bits), most significant bit.

Bytes 8,9
Bits 1-16: Seconds of day(17 bits), 16 least significant. Value is binary unsigned integer, ranging from 0 to 86,399.

Bytes 10,11
Bits 1-10: Milliseconds of the second (10 bits). Value is binary unsigned integer from 0 to 999.
Bits 11-16: Microseconds of milliseconds (10 bits), 6 most significant. Value is binary unsigned integer from 0 -999.

Byte 12
Bits 1-4: Microseconds of milliseconds, 4 least significant.
Bits 5-8: Fill, set to zero's.

Bytes 13,14: * Spacecraft ID
Bytes 15,16: Message sequence number
Bytes 17,18: EDOS software version number, set to TBD
Bytes 19,20: Message Length. Number of bytes in the message, including the LEO-T command delivery header and the command data. Range is 24 to 8192.
Bytes 21-24: Fill/spares, set to zero's

Table B-3. EO-1 TDF Source and Destination Codes

Source/Destination Name	Integer Code (1 byte, hexadecimal)	ASCII Station Designator
EO-1 MOC Greenbelt, MD	01	tbd
EOS-Alaska, S-Band/Generic Poker Flats, AK	03	AGS
EOS-Svalbard, S-Band/Generic Spitzbergen, Norway	04	SGS
Vandenburg AFB, CA	08	VAF
Wallops Orbital Tracking Station Wallops Island, VA	60	WPS

Table B-4. EO-1 TDF Data Types

Message Type	Corresponding Integer Code (8 bits) (hex)
Narrowband real-time telemetry	01
Narrowband spacecraft recorder telemetry	02
Command data message	03
Command echo message	04

Table B-5. NASA PB-5 Time Code Format (Option C)

Item No.	Field Name	Format & Size	Value
1	Flag bit	logical (1 bit)	1
2	Truncated Julian Day	unsigned integer (14 bits)	Truncate the most significant decimal digits, retaining only the four least significant ranging from 0 to 9999. The current Julian day epoch begins at midnight 1995, October 9, 10. October 10, 1995 is day 0.
3	Seconds of Day	unsigned integer (17 bits)	range = 0 to 86399
4	Milliseconds of Seconds	unsigned integer (10 bits)	range = 0 to 999
5	Microseconds of a Millisecond	unsigned integer (10 bits)	range = 0 to 999
6	Spare	(4 bits)	
	Total Length	**7 bytes**	

11 APPENDIX C. REQUEST/RESPONSE RECORD FORMATS

This appendix contains a description of the Request/Response format used in schedule files exchanged between the MOC and WOTIS. The record length varies, up to a maximum of 62 ASCII characters, including the record terminator, which is a single linefeed (ASCII 10_{10}) character. Fields within a record are always separated by commas (ASCII 44_{10}), even when fields are not used (e.g., the Tag field). The example records in Figure C-1 illustrate the Request/Response format.

Table C1. Request/Response Record Format

Item No.	Name	Format	Max Size (bytes)	Value(s)
1	Tag	ASCII	15	Empty[1] (strawman) or ID number assigned by WOTIS
2	Project	ASCII	2	"EO-1"
3	Facility	ASCII	3	one of the following: • "AGS" • "SGS" • "WPS"
4	Beginning of Track	GMT Field[2]	13	station equipment "on" time
5	End of Track	GMT Field[2]	13	station equipment "off" time
6	Activity Code	ASCII	3	empty (if X-Band) or one value from Table D-3
7	Orbit	ASCII	10	value from MOC planning aids
8	Band	ASCII	2	one of the following: • "X0" = delete request[3] • "X1" = 8225 MHz • "S1" = S-Band

1. This field is empty in the strawman request file that the MOC sends to WOTIS. For all other schedule files, a WOTIS-generated identification number is used.

2. See Table D-2 for format.

3. The value "X0" in this field indicates that the contact should be deleted from the schedule.

Table C-2. GMT Field Definition

Field: yyyydddhhmmss		Format (Size): ASCII (13 bytes)	Range
yyyy	Year	ASCII (4 bytes)	1996 through 2100
ddd	Day of Year	ASCII (3 bytes)	001 through 366
hh	Hour	ASCII (2 bytes)	00 through 23
mm	Minute	ASCII (2 bytes)	00 through 59
ss	Second	ASCII (2 bytes)	00 through 59

Table C-3. EO-1 WGS Activity Codes

Activity Code	Receive/ Record	Command	Tracking Data/ Mode	Data Forwarding
TR1		2 Kbps	2-Way/ Coherent	
TR2		2 Kbps	2-Way/ Coherent	
TR3		2 Kbps	1-Way/ Non-coherent	
TR4		2 Kbps	1-Way/ Non-coherent	
PBK			None/ Non-coherent	
SPC[1]				

1. SPC is used for testing and other special activities. Configuration will be arranged by the FOT and WGS personnel and documented in briefing messages as needed.

Figure B-1. Request/Response Record Examples

```
,EO-1,SGS,1999149135500,1999149140500,TR1,3056,S1<linefeed>
,EO-1,SGS,1999149135500,1999149140500,,3056,X1<linefeed>
W9821-1,EO-
1,SGS,1999149135500,1999149140500,TR1,3056,S1<linefeed>
W9821-2,EO-1,SGS,1999149135500,1999149140500,,3056,X1<linefeed>
```

12 APPENDIX D. DOWNLINK SUMMARY REPORT FORMAT

This appendix contains the format for the Downlink Summary Report. Each file consists of one or more records. Fields within a record (Items) are separated by a single comma (ASCII 44_{10}) and records are delimited by a linefeed (ASCII 10_{10}) character. Table D-1 lists the contents of each record.

Table D-1. Downlink Summary Report Record Format

Item No.	Name	Format	Max Size (bytes)	Meaning/Value(s)
1	Tag	ASCII	15	Support identifier assigned by WOTIS
2	Satellite	ASCII	15	”EO-1”
3	Ground Station	ASCII	10	Ground station receiving data
4	Operation	ASCII	8	“Support” or “Playback”
5	Tape #	ASCII	10	Volume label of tape[1]
6	Start Address	ASCII	10	Position on tape where support began
7	End Address	ASCII	10	Position on tape where support ended
8	Start Time	GMT Field[2]	13	Time when tape began to record
9	End Time	GMT Field[2]	13	Time when recorder stopped recording
10	Orbit	ASCII	10	S/C orbit number
11	Recorder ID	ASCII	10	Identifying number of recorder
12	Bit Sync Start	GMT Field[2]	13	Time when bit sync & demod both achieved lock status
13	Bit Sync Stop	GMT Field[2]	13	Time when bit sync & demod both lost lock status
14	Acquisition Status	unsigned fixed decimal percent	6	% of time bit sync and demod were both in lock status within customer support request

15	Recorded	ASCII	1	Indicates if support was recorded on tape, One of the following: • "Y" • "N"
16	Tracked	ASCII	1	Indicates if antenna system tracked S/C, One of the following: • "Y" • "N"

Table D2. Downlink Summary Report Record Format (Cont'd)

Item No.	Name	Format	Max Size (bytes)	Meaning/Value(s)
17	Antenna Statistics	TBD	TBD	TBD
18	PTP Frame Statistics	TBD	TBD	TBD
19	Recorder Node Statistics	TBD	TBD	TBD
20	Comments	ASCII	60	WGS comments relative to reported support

1. If a back-up tape was used, there will be two records with the same Tag #, one for each tape used.
2. Refer to GMT Time Format in Request/Response section above.

Date: Thu, 17 Sep 1998 13:12:40 -0400 (Eastern Daylight Time)
From: Administrator@hst-nic.hst.nasa.gov
Reply-to: (Nicholas Speciale)
Subject: CCR:0015 - DUE: 07/17/98 ROUTINE Level-2 Nicholas Special WWW-COMMENTS

USER : (Nicholas Speciale) sent the following comments on :

Date: 9/18/98
CCR Number: 0015
Sponsor: D. Mandl
Due Date: 07/17/98

CCR Title: BASELINE EO-1 S/C TO GROUND ICD-023

Remote host: 128.183.212.178 Email Address: speciale@pop500.gsfc.nasa.gov
----
APPROVAL STATUS: DISAPPROVED
Note:

COMMENTS: Section 6, WARP is being revised and will be available during the week of 9/21. Before signoff of the ICD this section should include the latest WARP information.

EO-1 CCR SPONSOR RECOMMENDATION FORM

CCR NUMBER: 0015

CCR TITLE: Baseline EO-1 S/C to Ground ICD-23

CCR SPONSOR: Dan Mandl

SUMMARY OF COMMENTS RECEIVED: (list Level 4 CCB and internal reviewers who had comments and address those comments)
None.

SPONSOR'S COMMENTS: No Comments received. Approve as written

CCB RECOMMENDATION: (check one)

APPROVE [**X**] APPROVE WITH CHANGE [] DISAPPROVE [ ]

SPONSOR/ORGANIZATION: Dan Mandl
DATE: 9/17/98