Consultative Committee for Space Data Systems

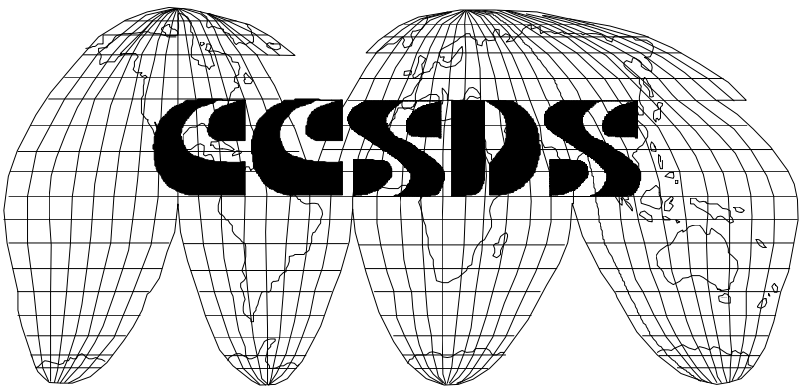
REPORT CONCERNING SPACE DATA SYSTEM STANDARDS

CCSDS-RELATED IMPLEMENTATIONS

CCSDS A12.0-G-1

GREEN BOOK

November 1996



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This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and reflects the consensus of technical panel experts from CCSDS Member Agencies. The procedure for review and authorization of CCSDS Reports is detailed in the Reference [13].

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FOREWORD

This document is a CCSDS Report which contains a registration of all CCSDS related technical implementations known to the CCSDS Secretariat at the time of publication.

The product information listed in this document may not include all CCSDS products offered in the countries whose CCSDS representatives have agreed to its publishing. Any corporation whose CCSDS-compatible products may have been inadvertently left out of this publication can register their products for listing in the next issue of this document by sending the product information to the CCSDS Secretariat.

Through the process of normal evolution and the progress in the build-up of implementations, it is expected that modifications and expansions of this report will occur. This Report is therefore subject to CCSDS document management and change control procedures which are defined in Reference [13].

Questions relative to the contents or status of this report should be addressed to the CCSDS Secretariat.

At time of publication, the active Member and Observer Agencies of the CCSDS were

Member Agencies

- British National Space Centre (BNSC)/United Kingdom.
- Canadian Space Agency (CSA)/Canada.
- Centre National d'Etudes Spatiales (CNES)/France.
- Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V. (DLR)/Germany.
- European Space Agency (ESA)/Europe.
- Instituto Nacional de Pesquisas Espaciais (INPE)/Brazil.
- National Aeronautics and Space Administration (NASA)/USA.
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- Russian Space Agency (RSA)/Russian Federation.

Observer Agencies

- Australian Space Office (ASO)/Australia.
- Austrian Space Agency (ASA)/Austria.
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- Indian Space Research Organization (ISRO)/India.
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- Institute of Space and Astronautical Science (ISAS)/Japan.
- Institute of Space Research (IKI)/Russian Federation.
- KFKI Research Institute for Particle & Nuclear Physics (KFKI)/Hungary.
- MIKOMTEK: CSIR (CSIR)/Republic of South Africa.
- Korea Aerospace Research Institute (KARI)/South Korea.
- Ministry of Communications (MOC)/Israel.
- National Oceanic & Atmospheric Administration (NOAA)/USA.
- National Space Program Office (NPSO)/Taiwan.
- Swedish Space Corporation (SSC)/Sweden.
- United States Geological Survey (USGS)/USA.

DOCUMENT CONTROL

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1 INTRODUCTION

The CCSDS has produced, since its foundation in the early eighties, a considerable number of recommendations. The member and observer agencies have since used these as the basis for creating agency standards and adapting their technical infrastructure. With the rising number of space projects requiring agency cross support and the complexity of space data systems, the acceptance of CCSDS products is growing. This positive development creates the need for design engineers to obtain up-to-date information on CCSDS-compatible implementations that can be procured off the shelf.

This Green Book offers this information in, for the time being, three registers[1] referring to:

a) CCSDS products belonging to Conventional Orbiting Systems (Register A);

b) CCSDS products belonging to Radio Frequency and Modulation System (Register E);

c) CCSDS products belonging to Advanced Orbiting Systems (Register F).

The book will eventually be organised in a loose-leaf fashion in order to allow insertion of new information without republishing the whole book.

In its present version this Green Book is limited to implementations developed according to Panel 1 products.

2 TESTING OF IMPLEMENTATIONS

The implementations registered in this book have not been tested folr compliance by CCSDS. Thus the relevant responsibility lies completely with the entities offering these implementations. CCSDS is proposing standardised test methods which are described in reference [14].

3 ORGANISATION OF THE REGISTERS

The implementation register references the agency standards and/or CCSDS Recommendations concerned and describes their realisations by technical facilities. Each entry into the register consists of four sections, namely, (1) agency and general information, (2) agency standard or CCSDS Recommedation, (3) on-board system components and operation procedures and (4) ground system components and operation procedures.

Figure 1 shows a template of the register entries with the necessary descriptions.

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[1] The designation of the registers follows those of the subpanels concerned.

TITLE

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	Gives the sponsoring agency or the agency of the country (or group of countries) where the developer is located.
1.2	Identification Number	Identification number in the format "Agency/Type of Space Data/Number of Implementation - Part of Implementation". Examples are for - Type of Space Data: COD (for Coding), TLM (for Telemetry), TLC (for Telecommand), TIM (for Time Coding), COB (for Combined Systems), etc. - Number of Implementation: Sequence number of Implementation - Part of Implementation: Sequence number of part of implementation (if the implementation consists of several parts).
1.3	General Description	Give a very brief description of the technical functions of the implementation.
2.	Standard	
2.1	Reference	Gives the reference of the Standard(s) or CCSDS Recommendation(s) according to which the implementation has been developed.
2.2	Title/Description	Gives the title of the Standard(s)/Recommendation(s) and any description, if necessary.
3.	On-Board Components and Operation Procedures	
3.1	System Description	Gives a concise description of the technical parameters. Reference should be made to the various items of the Standard(s)/Recommendation(s) applied, in particular to any options which are supported.
3.2	Sub-System Description	Provides details to 3.1 as appropriate.
4.	Ground Components and Operation Procedures	
4.1	System Description	Gives a concise description of the technical parameters. Reference should be made to the various items of the Standard/Recommendation applied, in particular to any options which are supported.
4.2	Sub-System Description	Provides details to 4.1 as appropriate.

Figure 1: Register Entry Template

4 REFERENCES

[1] *Telecommand Part 1 — Channel Service*. Recommendation for Space Data System Standards, CCSDS 201.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, January 1987.

[2] *Telecommand Part 2 — Data Routing Service*. Recommendation for Space Data System Standards, CCSDS 202.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, November 1992.

[3] *Telecommand Part 2.1 — Command Operation Procedures*. Recommendation for Space Data System Standards, CCSDS 202.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, October 1991.

[4] *Telecommand Part 3 — Data Management Service*. Recommendation for Space Data System Standards, CCSDS 203.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, January 1987.

[5] *Telecommand Summary of Concept and Rationale*. Report Concerning Space Data System Standards, CCSDS 200.0-G-6. Green Book. Issue 6. Washington, D.C.: CCSDS, January 1987.

[6] *Advanced Orbiting Systems, Networks and Data Links: Architectural Specification*. Recommendation for Space Data Systems Standards, CCSDS 701.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, November 1992.

[7] *Packet Telemetry Services*. Recommendation for Space Data System Standards, CCSDS 103.0-R-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, November 1995.

[8] *Packet Telemetry*. Recommendation for Space Data System Standards, CCSDS 102.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, November 1992.

[9] *Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft*. Recommendation for Space Data System Standards, CCSDS 401.0-B. Blue Book. Washington, D.C.: CCSDS, Current version.

[10] *Telemetry Channel Coding*. Recommendation for Space Data System Standards, CCSDS 101.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, May 1992.

[11] *Time Code Formats*. Recommendation for Space Data Systems Standards, CCSDS 301.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, April 1990.

[12] *Advanced Orbiting Systems, Networks and Data Links: Audio, Video and Still-Image Communications Services*. Recommendation for Space Data System Standards, CCSDS 704.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, May 1994.

[13] *Procedures Manual for the Consultative Committee for Space Data Systems*. CCSDS A00.0-Y-6. Yellow Book. Issue 6. Washington, D.C.: CCSDS, May 1994.

[14] *Product Testing*. Draft Report Concerning Space Data Systems Standards, CCSDS A11.0-G-0. Green Book. Washington, D.C.: CCSDS, March 1996.

REGISTER A
CONVENTIONAL ORBITING SYSTEMS - IMPLEMENTATIONS

A.1 INTRODUCTION

This register contains information on the technical implementations based on CCSDS Recommendations. This register is limited to Panel 1 products developed for the so-called conventional orbiting systems. These are those in the fields of:

a) Telemetry/Telecommand Coding;
b) Packet Telemetry;
c) Packet Telecommand;
d) Time Coding.

A.2 STATUS OF IMPLEMENTATIONS

The following implementations are available in Europe:

- Virtual Channel Assembler and Multiplexer (sponsored by ESTEC);
- Reed Solomon and Convolutional Encoder (one sponsored by ESTEC and one by CNES);
- 3 Packet Telecommand Decoders (sponsored by ESTEC);
- Local Time Management Chip (sponsored by ESTEC).

The following implementations have been reported recently as products of US industries:

- Reed-Solomon Decoding and Virtual Channel Demultiplexing I;
- Reed-Solomon Decoding and Virtual Channel Demultiplexing II;
- TDM and Packet Telemetry Coding and Virtual Channel Processing;
- Reed-Solomon Encoding and Virtual Channel Demultiplexing;
- Reed-Solomon and Convolutional En/Decoding;
- Telemetry Channel Coding I;
- Telemetry Channel Coding II;
- Telemetry Channel Coding III;
- Telemetry Channel Coding IV;
- Telemetry Channel Coding and Packet Telemetry Processing;
- Packet Telemetry Processing I;
- Packet Telemetry Processing II;
- Channel Coding and Telecommand Processing;
- Telecommand Processing.

Virtual Channel Assembler And Multiplexer (VCA/VCM)

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	ESA/ESTEC
1.2	Identification Number	ESA/TLM/1.0
1.3	General Description	Generates Packet Telemetry Transfer Frames for up to 8 Virtual Channels.
2.	Standard	
2.1	Reference	ESA PSS-04-106 Issue 1, January 1988
2.2	Title/Description	Packet Telemetry Standard, compliant with CCSDS Packet Telemetry Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	Functional Description • Generates Packet Telemetry Transfer Frame. • Consists of two chips: Virtual Channel Assembler (VCA) and Virtual Channel Multiplexer (VCM). • VCA chip accepts packets for a single virtual channel and performs lower level frame formatting; transfer frame length of 223, 446, 892 or 1115 octets; receives byte-wide parallel data and sends it to the VCM in serial form; can generate idle packets to fill up transfer frames. • VCM chip multiplexes up to 8 virtual channels and completes transfer frame formatting; generate transfer frames of 223, 446, 892 or 1115 bytes; trailer and Reed-Solomon codes are optional; provides two internal VC selection algorithms, and has a TTC-B-01 interface for the CLCW. Performance • Power: 60 mW/chip at 1 MHz, 5V Supply • Speed: 10 Mbps throughput • will be space qualified; will withstand > 100 krad total dose; high SEU immumity, latch-up free Technology • ABB Hafo SOS4A, 2 µm CMOS/SOS standard cell • flight design; built-in selftest (BIST) with ≥ 90% stuck-at fault coverage, production test stuck-at fault coverage ≥ 95% • package: 84 pin QFP Availability • 4th Quarter 1993 Developer/Source • Developer: CADIS (D) (contact: J.Stahl) and ESTEC (NL) (contact P.Sinander) • Source: ABB Hafo (S), system level support by ESTEC
3.2	Sub-System Description	

Reed Solomon And Convolutional Encoder (MA 1916)

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	ESA/ESTEC
1.2	Identification Number	ESA/COD/1.0
1.3	General Description	Performs Reed Solomon and Convolutional Encoding.
2.	Standard	
2.1	Reference	ESA PSS-04-103 Issue 1
2.2	Title/Description	Telemetry Channel Coding Standard, compliant with CCSDS Telemetry Coding Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	Functional Description • Contains a Reed Solomon Encoder (RSE), a Convolutional Encoder (CE) and a Test Pattern Generator (TPG) on a single chip. • RSE conforms to CCSDS Recommendation with RS(255,223) codeword and selectable interleave depth of 1,4 or 5 codewords. • CE conforms to CCSDS Recommendation with length = 7, rate = 1/2, G1 = 171 octal, G2 = 133 octal. • TPG generates Giotto test patterns to prove that RSE generates cyclic codewords. Performance • Power: 85mW at 10MHz, 5V Supply • Speed: Clock: 1kHz to 17 MHz • Radiation tolerance: 5 Mrad (Si) • Temparature Range: -55^0 to $+125^0$ Technology • 2.5 micron CMOS-SOS • 28 pin package Availability • 1st Quarter 1990 Developer/Source • Matra Marconi Space (MMS) (UK) • GEC Plessey Semiconductors (GPS) (UK)
	Sub-System Description	

Packet Telecommand Decoder (P-DEC)

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	ESA/ESTEC
1.2	Identification Number	ESA/TLC/1.0
1.3	General Description	Decoding and handling of telecommand link transfer blocks.
2.	Standard	
2.1	Reference	ESA-PSS-04-107, Issue 2
2.2	Title/Description	Telecommand Standard, compliant with CCSDS Telecommand Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	Functional Description • Automatic selection of input data stream (serial data, clock, sample) from 6 sources (demodulator outputs). • Decoding and handling of up to 256 byte command link transfer blocks. • Delivery of data blocks guaranteed in sequence and without error to up to 62 logical output channels. • Internal decoding of pulse commands (up to 256 programmable length). • Selectable ESA standard authentication check. • Comprehensive link and housekeeping reporting. Performance • Power: 300 mW at 4 MHz system clock, 5V Supply • Speed: Input data rate up to 500 kbps • Radiation tolerance: 50 krad (Si) Technology • 2 µm CMOS-EPI (process discontinued; a redisign to ABB Hafo CMOS/SOS is planned for 1994) • 132 pin flat pack Availability • Prototypes since 1st Quarter 1991 Developer • SAAB SPACE (S) • MATRA HARRIS (F) Source • SAAB SPACE (S), Contact: B. Linder.
.	Sub-System Description	

Packet Telecommand Decoder

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	ESA/ESTEC
1.2	Identification Number	ESA/TLC/2.0
1.3	General Description	Decoding and handling of telecommand link transfer blocks.
2.	Standard	
2.1	Reference	ESA-PSS-04-107, Issue 2
2.2	Title/Description	Telecommand Standard, compliant with CCSDS Telecommand Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	Functional Description • Eight input channels • up to 63 serial outputs (MAPs) • interface to external authentication unit. Performance • Power: information to be obtained from Alenia Spazio • Speed: Input data rate up to 66 kbps • Radiation tolerance: 200 krad total dose Technology • 1.5 µm HCMOS Availability • Information be obtained from Alenia Spazio Developer • Alenia Spazio • Design owned by Alenia Spazio Source • Alenia Spazio (Rome); contact: G. di Antonia; or J. Schmitt at ESTEC
3.2	Sub-System Description	

Packet Telecommand Decoder (PTD)

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	ESA/ESTEC
1.2	Identification Number	ESA/TLC/3.0
1.3	General Description	Implements the ESA Packet TC Standard (PSS-04-107), according to the PSS-04-151 TC decoder specification.
2.	Standard	
2.1	Reference	ESA-PSS-04-107, Issue 2
2.2	Title/Description	Telecommand Standard, compliant with CCSDS Telecommand Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	Functional Description • Six input channels. • outputs TC segments in serial form via a MAP or via optional parallel interface. • interfaces directly with VCM for CLCW retrieval. • interface to external authentication unit. Performance • Power: 250 mW, 5 V supply. • Speed: 50 Kbps. • Will be space qualified (?); will withstand > 100 krad total dose, high SEU immunity, latch-up free. Technology • GEC Plessey Semiconductors (GPS) MA9300, 1.5 µm CMOS/SOS gate array. • Package 132 pin QFP. Availability • Design work started in 1st quarter 93, device expected in 2nd quarter 1994. Developer • Matra Marconi Space (MMS) (Vélizy) using Mentor Ideastation v.8. • Flight design; production test stuck-at fault coverage ≥ 98% required. • GEC Plessey Semiconductors (GPS) will market the device. Source • GPS
3.2	Sub-System Description	

Local Time Management Chip

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	ESA/ESTEC
1.2	Identification Number	ESA/TIM/1.0
1.3	General Description	Remote recovery of centrally maintained time reference.
2.	Standard	
2.1	Reference	
2.2	Title/Description	
3.	On-Board Components and Operation Procedures	
3.1	System Description	Functional Description • Remote recovery of centrally maintained time reference according to CCSDS unsegmented time code (CUC) for high resolutions. • Local (independent from other system users) event latching and time reading. • Output can be memory mapped into user processor system. • Time maintenance is totally transparent to user. • Time reference input from OBDH bus or separate serial line. • Freewheeling during time reference input failure. • Anomaly detection and flag to user. Performance • Power: 100 mW, typical • Resolution: 0.3 milliseconds (LSB = 238 microseconds) • Wrap around time: 136 years Technology • ES2 EPCD10 1.0 µm CMOS-EPI • Prototype design (flight design is planned to start 4th quarter 1994; then in CMOS/SOS radiation hard technology) • Package: 84 pin PLCC Availability • 2nd Quarter 1992 Developer/Source • IMEC (B) using System Hilo; contact: B de Mey or at ESTEC D. Mäusli.
3.2	Sub-System Description	

Reed-Solomon Decoding And Virtual Channel Demultiplexing I

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/1.0
1.3	General Description	Performs Reed-Solomon (255,233) Decoding and Virtual Channel Demultiplexing.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2 and CCSDS 102.0-B-3
2.2	Title/Description	Telemetry Channel Coding and Packet Telemetry
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Accepts serial data and performs frame synchronization, deinterleaving, Reed-Solomon decoding, and virtual channel routing. Performance • up to 25 Mbps. Design and Technologies • 66 MHz MPC603 Power PC with Reed-Solomon decoder on PCI Mezzanin Card (PMC), 8 MB DRAM, A32/D64 VME interface, and optional SCSI or VSB interfaces. Availability • Since November 1995. Developer/Source • Avtec Systems, Inc. • Contact: Mary Ellen Orsino.
4.2	Sub-System Description	

Reed-Solomon Decoding And Virtual Channel Demultiplexing II

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/2.0
1.3	General Description	Performs Reed-Solomon (255,233) Encoding and Virtual Channel Demultiplexing.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2 and CCSDS 102.0-B-3
2.2	Title/Description	Telemetry Channel Coding and Packet Telemetry
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Accepts Virtual Channel Data Units (VCDUs) from VME and outputs coded VCDUs serially. • Performs CRC encoding, Reed-Solomon encoding, interleaving, synch marker insertion, pseudorandomization, and convolutional encoding. Performance • up to 25 Mbps. Design and Technologies • 66 MHz MPC603 Power PC with Reed-Solomon decoder on PCI Mezzanin Card (PMC), 8 MB DRAM, A32/D64 VME interface, and optional SCSI or VSB interfaces. Availability • 1st Quarter 1996. Developer/Source • Avtec Systems, Inc. • Contact: Mary Ellen Orsino.
4.2	Sub-System Description	

TDM And Packet Telemetry Coding And Virtual Channel Processing

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/3.0
1.3	General Description	Performs Reed-Solomon (255,223) Decoding and Virtual Channel Demultiplexing, CCSDS Reed-Solomon (255,223) Encoding and Virtual Channel Multiplexing, and bidirectional TDM telemetry.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-3 and CCSDS 102.0-B-3
2.2	Title/Description	Telemetry Channel Coding and Packet Telemetry
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Supports both CCSDS packetized and TDM telemetry. • Accepts serial data and performs frame synchronization, deramdomization, deinterleaving, Reed-Solomon decoding, and virtual channel routing. • Accepts Virtual Channel Data Units (VCDUs) from PCI and output coded VCDUs serially. • Performs CRC encoding, Reed-Solomon encoding, interleaving, synch marker insertion, pseudorandomization, and convolutional encoding. Performance • up to 25 Mbps Design and Technology • PCI Availability • July 1996 Developer/Source: • Avtec Systems, Inc. • Contact: Mary Ellen Orsino
4.2	Sub-System Description	

Reed-Solomon Encoding And VC Demultiplexing

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/4.0
1.3	General Description	Performs Reed-Solomon (255,223) Encoding and Virtual Channel Demultiplexing.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-3 and CCSDS 102.0-B-3
2.2	Title/Description	Telemetry Channel Coding and Packet Telemetry
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Accepts Virtual Channel Data Units (VCDUs) from VME and outputs coded VCDUs serially. • Performs CRC encoding, Reed-Solomon encoding, interleaving, synch marker insertion, preudorandomization, and convolutional encoding. Performance • Up to 25 Mbps Design and Technologies • 66 MHz MPC603 Power Pc with Reed-Solomon decoder on PCI Mezzanine Card (PMC), 8 MB CRAM, A3/D64 VME interface, and optional SCSI or VSB interfaces. Availability • August 1996 Developer/Source: • Avtec Systems, Inc. • Contact: Mary Ellen Orsino.
4.2	Sub-System Description	

Reed-Solomon and Convolutional En/Decoding

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COD/1.0
1.3	General Description	Performs Reed-Solomon (255,223) and Convolutional (7,1/2) Encoding/Decoding.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-3
2.2	Title/Description	Compliant with CCSDS Telemetry Channel Coding Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	Setup Software provided (no charge)
3.2	Sub-System Description	RS Decoder, NASA-GSFC (G1527604A)
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Front-End equipment including (optional) Bit/Symbol & Frame Synchronizers, Reed-Solomon and Convolutional Encoding/Decoding functions. • RS Codec with (255,223) codeword and programmable interleave depth of 1 - 8, programmable Virtual Fill (0 - 222), Dual Basis (Berlekamp). • Convolutional/Viterbi Encoding/Decoding (7, 1/2) hard or soft bit decisions (3 bit). Performance • Up to 25 Mbps for RS Codec functions. • Up to 25 Mbps for Convolutional Codec functions. Design and Technology • VME A16, A24, A32, D32, 256 BLT. • Codec ASIC (1.6 u CMOS) chips. • Surface Mount. Developer Source Berg Systems International, Inc. 2265, Camino Vida Roble Calrsbad, CA 92009, USA Contact: John Reeser, Bill Stahl Phone: +1-619-438-5656 Fax: +1-616-438-0058
4.2	Sub-System Description	

Telemetry Channel Coding I

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COD/2.0
1.3	General Description	DBS430 Digital Bit Sync Performs Bit Synchronization and Convolutional decoding (Viterbi).
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2
2.2	Title/Description	CCSDS Telemetry Channel Coding Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Digital Bit Sync, model 430, configurable ground front end equipment. • Multiple input codes selectable. • Available for standalone use or integrated in Loral 550 CCSDS system. • Convolutional (7, 1/2) decoding with maximum likelihood (Viterbi). Performance • Up to 20 Mbps. • Operates within 1 dB of theoretical using digital design. Design and Technology • Standalone rack mount chassis version; manual, RS-232 or IEEE-488 setup and control. • 6U VME card version. Availability • Since 1990 for DBS430 bit sync; (VME available 9/95). Developer Source • Loral Test & Information Systems, San Diego, CA US
4.2	Sub-System Description	

Telemetry Channel Coding II

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COD/3.0
1.3	General Description	DBS430 Digital Bit Sync Performs Bit Synchronization and Convolutional decoding (Viterbi).
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2
2.2	Title/Description	CCSDS Telemetry Channel Coding Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Digital Bit Sync, model 430, configurable ground front end equipment. • Multiple input codes selectable. • available for standalone use or integrated in Loral 550 CCSDS system. • Convolutional (7, 1/2) decoding with maximum likelihood (Viterbi). Performance • Up to 20 Mbps. • Operates within 1 dB of theoretical using digital design. Design and Technology • Standalone rack mount chassis version; manual, RS-232 or IEEE-488 setup and control. • 6U VME card version. Availability • Since 1990 for DBS430 bit sync; (VME available 9/95). Developer Source • Loral Test & Information Systems, San Diego, CA US
4.2	Sub-System Description	

Telemetry Channel Coding III

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COD/4.0
1.3	General Description	FPP3 processor module performs Reed-Solomon (255, 223) encoding and decoding.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2
2.2	Title/Description	CCSDS Telemetry Channel Coding Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • FPP3 Configurable VME Reed-Solomon (255, 223) processing module. • Programmable interleave depth of 1,2,3,4,5. • 100 to 1,275 octets with 255 octets codeword. • Modes: correct, decode, or pass. • Provides statistics of performance. Performance • Up to 800 Kbps (software version). • Up to 50 Mbps (hardware version). Technology • VME module with SPARC chip (software version). • VME module (hardware version). Availability • Since 1994 (software version). • January 1996 (hardware version). Developer Source • Loral Test & Information Systems, San Diego, CA US
4.2	Sub-System Description	

Telemetry Channel Coding IV

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COD/5.0
1.3	General Description	Performs Reed-Solomon (255, 223) encoding and decoding.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2
2.2	Title/Description	CCSDS Telemetry Channel Coding Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • FPP3 Processor module with optional hardware accelerator. • Configurable VME Reed-Solomon (255, 223) processing module. • Programmable interleave depth of 1,2,3,4,5. • 100 to 1,275 octets with 255 octets codeword. • Modes: correct, decode, or pass. • Error modes: discard, redirect, or pass. • Provides statistics of performance. Performance • Up to 800 Kbps (software version). • Up to 50 Mbps (hardware version). Technology • VME module with SPARC chip (software version). • VME module (hardware version). Availability • Since 1994 (software version). • January 1996 (hardware version). Developer Source • Loral Test & Information Systems, San Diego, CA US
4.2	Sub-System Description	

Telemetry Channel Coding and Packet Telemetry Processing

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/5.0
1.3	General Description	System 500 performs complete TM processing, including Frame Sync, Reed Solomon, CCSDS packet processing down to measurands; closed loop testing.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2 and CCSDS 102.0-B-3
2.2	Title/Description	Telemetry Channel Coding and Packet Telemetry
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description
		• System 500 Configurable front end system capable of all or part of CCSDS processing:
		  • Fill detect and discard.
		  • CLCW extraction.
		  • Segment recombining.
		  • Source packet delivery.
		  • Depacketization.
		• Physical layer support:
		  • Frame sync strategy.
		  • Polarity detect/correct.
		  • Bit slip detect/correct.
		• Reed-Solomon decode in software or hardware.
		• Color graphic displays for setup/control/monitor/data display.
		• Status and statistics gather/report.
		• Nascom blocking/deblocking, engineering unit conversions, real-time data processing, disk storage and LAN/DMA interfaces also available.
		
		Performance
		• Up to 10 Mbps.
		
		Design and Technology
		• VME modules.
		• Processing in coordinated set of real-time algorithms.
		• Workstation software provides setup/control/monitor/data display.
		• API interfaces provided for interface.
		
		Availability
		• Since June 1995.
		
		Developer Source
		• Loral Test & Information Systems, San Diego, CA, US

4.2	Sub-System Description	

Packet Telemetry Processing I

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/TLM/1.0
1.3	General Description	VME Telemetry Input/Output (TIO) module performs return Telemetry link synchronization strategy and serial-to-parallel octet conversion.
2.	Standard	
2.1	Reference	CCSDS 102.0-B-3
2.2	Title/Description	Packet Telemetry
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description
		• Telemetry I/O (TIO) configurable VME module for serial input:
		  • TIO module (10 MHz)
		  - 2 input channels; synchronize and serial-to-octet convert.
		  • High rate TIO module (50 MHz)
		  - 1 input channel; synchronize and serial-to-octet convert.
		
		Design and Technology
		• VME modules (9U size).
		
		Availability
		• Since 1993 (10 MHz version).
		• March 1996 (50 MHz version).
		
		Developer Source
		• Loral Test & Information Systems, San Diego, CA, US

4.2	Sub-System Description	

Packet Telemetry Processing II

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/TLM/2.0
1.3	General Description	FPP3 processor performs CCSDS processing in return Telemetry link from Transfer Frame down through measurands, with intermediate steps also available.
2.	Standard	
2.1	Reference	CCSDS 102.0-B-3
2.2	Title/Description	Packet Telemetry
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description
		• FPP3 configurable algorithms capable of all or part of CCSDS Telemetry processing:
		  • Fill detect and discard.
		  • CLCW extraction.
		  • Segment recombining.
		  • Source packet delivery.
		  • Depacketization.
		  • Embedded decom algorithm.
		  • Nascom block/deblock algorithm.
		  • Algorithms run in VME FPP3 processing module in Loral 550 or in UNIX-based workstation in Loral 540 configuration.
		
		Performance
		• Up to 10 Mbps.
		
		Design and Technology
		• Software algorithms in C.
		
		Availability
		• Since June 1995.
		
		Developer Source
		• Loral Test & Information Systems, San Diego, CA US

4.2	Sub-System Description	

Channel Coding And Telecommand Processing

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/6.0
1.3	General Description	System 500 performs complete TC processing, including segmentation, CLTU and transfer frame generation, BCH encoding, acquisition, fill insertion and clock generation.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2, 201.0-B-1, 202.0-B-2
2.2	Title/Description	Telemetry Channel Coding, Telecommand Parts 1 and 2
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description
		• System 500 Configurable front end system capable of all or part of CCSDS Telecommand processing:
		  • Segmentation layer.
		  • Transfer layer.
		  • Fill insertion.
		  • BCH coding layer.
		  • CLTU generation.
		  • PLOP-1&2.
		• Physical layer support:
		  • Clock generation.
		• Reed-Solomon decode in software or hardware.
		• Color graphic displays for setup/control/monitor/data display.
		• Status and statistics gather/report.
		• Nascom blocking/deblocking, engineering unit conversions, real-time data processing, disk storage and LAN/DMA interfaces also available.
		
		Performance
		• Up to 10 Mbps.
		
		Design and Technology
		• VME modules.
		• Processing in coordinated set of real-time algorithms.
		• Workstation software provides setup/control/monitor/data display.
		• API interfaces provided for interface.
		
		Availability
		• Since January 1996.
		
		Developer Source
		• Loral Test & Information Systems, San Diego, CA US.

4.2	Sub-System Description	

Telecommand Processing

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/TLC/1.0
1.3	General Description	FPP3 processor performs CCSDS processing in forward Telecommand link from commands and bitstreams up through CLTU and PLOP, with intermediate stages accessible.
2.	Standard	
2.1	Reference	CCSDS 201.0-B-1, 202.0-B-2
2.2	Title/Description	Telecommand Parts 1 and 2
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description
		• FPP3 processor configurable algorithms capable of all or part of CCSDS Telecommand processing:
		  • Segmentation layer.
		  • Transfer layer.
		  • Fill insertion.
		  • BCH coding layer.
		  • CLTU generation.
		  • PLOP-1&2.
		  • Nascom block/deblock algorithm.
		  • 140 other real-time processing algorithms.
		• Algorithms run in VME FPP3 processing module in Loral 550 or in UNIX-based workstation in Loral 540 configuration.
		
		Performance
		• Up to 10 Mbps.
		
		Design and Technology
		• Software algorithms in C.
		
		Availability
		• Since January 1996.
		
		Developer Source
		• Loral Test & Information Systems, San Diego, CA US

4.2	Sub-System Description	

REGISTER E
RF AND MODULATION SYSTEMS - IMPLEMENTATIONS

E.1 INTRODUCTION

This register will eventually contain information on CCSDS-related implementations concerning the Panel 1 products developed for Radio Frequency and Modulation Systems.

E.2 STATUS OF IMPLEMENTATIONS

No implementations have been reported yet.

REGISTER F
ADVANCED ORBITING SYSTEMS - IMPLEMENTATIONS

F.1 INTRODUCTION

This register contains information on the technical implementations based on the CCSDS Advanced Orbiting Systems (AOS) Recommendation. This register is limited to Panel 1 products developed for the Advanced Orbiting Systems. These provide the following services on the Space Link Subnet:

a) Virtual Channel Data Unit Service.

b) Insert Service.

c) Encapsulation Service (which includes also a Multiplexing Service).

d) Multiplexing Service.

e) Bitstream Service.

f) Virtual Channel Access Service.

F.2 STATUS OF IMPLEMENTATIONS

So far, six implementations, one each sponsored by CNES and ESTEC, and four from the US have been reported to the editor and could be included in this register. Four are available and two more will become available during the course of 1996 or early in 1997.

The following implementations have been reported from European industries:

- Ground MUX/DEMUX Front-End Space Link Subnet Gateway.
- AOS Telemetry Support Circuits.

The following implementations have been reported from US industries:

- AOS Telemetry Processor.
- Forward Link Packet Assembly and Return Link Packet Processing.
- Complete Return and Forward Link Processing.
- Return and Forward Link Ground Processing.

NASDA (Mr. Anegawa) informed the Sub-Panel 1F meeting in Greenbelt (see Panel 1 report) that NASDA has decided to implement the AOS Recommendations on the planned Japanese "Engineering Test Satellite" (ETS-VII), which will experiment with autonomous docking, advanced telerobotics and teleoperation in low earth orbit. Details of the respective onboard and ground systems are not available yet.

Ground Mux/Demux Front-End Space Link Subnet Gateway

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	CNES/CST
1.2	Identification Number	CNES/COB/1.0
1.3	General Description	Performs AOS Space Link Subnet Channel Access procedures and I/F with Ground LANs.
2.	Standard	
2.1	Reference	
2.2	Title/Description	Compliant with CCSDS 701.0-B-1 AOS Recommendation
3.	On-Board Components and Operation Procedures	
3.1	System Description	
3.2	Sub-System Description	
4.	Ground Components and Operation Procedures	
4.1	System Description	Functional Description • Ground configurable Front-End equipment including Bit and Frame Synchronisations, Convolutional and Reed-Solomon Encoding/Decoding functions. • Performs lower layer functions, i.e. VCDU Mux/Demux and Insert Zone inser tion/extraction. • Provides Grade 2 and/or Grade 3 Quality of Service • Provides ground LAN(s) I/F and VCDUs routing capability. • Based on mixed HW/SW functions for CADUs generation, for Insert Zone insertion/extraction and for VCDUs Mux/Demux. Performance: • Up to 10 Mbps for the prototype. • HW & SW architecture in order to be upgraded up to 150 Mbps (T.B.C.) Design and Technology: • VME Boards including HW + RISC processor(s) for Channel Access functions • Stds VME communication cards for Ground Network(s) I/F (Ethernet UDP/TCP-IP for prototype) • VME crate including system processor for set-up and controls via network management protocol Availability: • Mid 1993. Developer/Source: • Schlumberger Industries (F)
4.2	Sub-System Description	

AOS Telemetry Support Circuits

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	ESA/ESTEC
1.2	Identification Number	ESA/COB/1.0
1.3	General Description	Supports 6 CCSDS AOS services.
2.	Standard	
2.1	Reference	
2.2	Title/Description	
3.	On-Board Components and Operation Procedures	
3.1	System Description	Functional Description • A set of chips which supports six services defined by the CCSDS AOS Recommendation on the space link sub-network. It multiplexes the Virtual Channels and performs output formatting Performance • Flight design; production test stuck-at fault coverage ≥ 95% required • Minimum 20 kRad total dose required Design and Technology • CMOS/EPI or CMOS/SOS Availability • 2nd Quarter 1995 Developer/Source • Laben (I); contact E.Marelli (ESTEC)
3.2	Sub-System Description	

AOS Telemetry Processor

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/7.0
1.3	General Description	CCSDS Packet Processor performs complete return link processing, including frame synch, derondomization, CRC, Reed-Solomon decoding, and CCSDS packet processing.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-3 and CCSDS 701.0-B-2
2.2	Title/Description	Telemetry Channel Coding and Advanced Orbiting Systems: Networks and Data Links
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description:
		• CCSDS Packet Processor configurable front end Processing system capable of all or part of CCSDS processing
		  • Level 2 and Level 3 Service
		  • Path Service
		  • Multiplexing Service
		  • Bitstream Service
		• Physical Layer Support
		  • Frame sync strategy
		  • Polarity detect/correct
		  • Bit slip detect/correct
		• CADU processing
		  • Derandomization
		  • CRC check
		• Reed-Solomon decode in software or hardware
		• Color graphic displays for setup/control/monitoring/data display
		• Status and statistics gather/report
		• Nascom blocking/deblocking, engineering unit conversions, real time data processing, disk storage and LAN/DMA interfaces also available
		
		Performance:
		• Up to 50 Mbps
		
		Design and Technology:
		• Modules
		• Processing in coordinated set of real-time software
		• Workstation/PC software provides setup/control/monitor/data display
		• API interfaces provided for interface
		
		Availability:
		• 50 Mbps in January 1997
		
		Developer/Source:
		• Loral Test & Information Systems, San Diego, CA, USA

4.2	Sub-System Description	

Forward Link Packet Assembly And Return Link Packet Processing

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/8.0
1.3	General Description	CCSDS Algorithm set performs CCSDS packet assembly in forward link from datastreams and packets up through VCDU, and packet processing in return link from VCDU down through measurands, with intermediate steps also available.
2.	Standard	
2.1	Reference	CCSDS 701.0-B-2
2.2	Title/Description	Advanced Orbiting Systems: Networks and Data Links
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description:
		• System 500 CCSDS Processing algorithm
		  • Forward Link Packet multiplexing
		  • Forward Link B-PDU construction
		  • Forward Link VCDU construction Return Link VCDU algorithm
		  • Return Link M-PDU algorithm
		  • Return Link B-PDU algorithm
		  • Embedded decom algorithm
		  • Nascom block/deblock algorithm
		  • 140 other real-time processing algorithms
		• Algorithms run in VME FPP3 processing module in Loral 550 or in UNIX-based workstation in Loral 540 configuration
		
		Performance:
		• Up to 50 Mbps
		
		Design and Technology:
		• Software algorithms in C
		
		Availability:
		• Since 1994
		
		Developer/Source:
		• Loral Test & Information Systems, San Diego, CA, USA

4.2	Sub-System Description	

Complete Return And Forward Link Processing (System 500)

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/9.0
1.3	General Description	System 500 performs complete return link processing including Frame Sync, Derandomization, CRC, Reed-Solomon, CCSDS packet processing to measurand and bitstream; forward link processing including packetizing, Reed-Solomon, CRC, DES, fill insertion, and frame sync addition; closed loop testing.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-3 and CCSDS 701.0-B-2
2.2	Title/Description	TLM Channel Coding & Advanced Orbiting Systems Networks & Data Links
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description:
		• System 500 configurable front end Processing system capable of all or part of CCSDS processing
		  • Level 2 and Level 3 Service
		  • Path Service
		  • Multiplexing Service
		  • Bitstream Service
		  • Insert service
		  • Encapsulation service
		  • Fill insertion and discard
		• Physical Layer Support
		  • Frame sync strategy
		  • Polarity detect/correct
		  • Bit slip detect/correct
		• CADU processing
		  • Randomization/Derandomization
		  • CRC generate/check
		• Reed-Solomon decode in software or hardware
		• Data Encryption Standard encrypt/decrypt available
		• Measurand extraction from packets and bitstreams
		• Color graphic displays for setup/control/monitoring/data display
		• Status and statistics gather/report
		• Nascom blocking/deblocking, engineering unit conversions, real time data processing, disk storage and LAN/DMA interfaces also available
		Performance:
		• Up to 50 Mbps
		Design and Technology:
		• VME Modules
		• Processing in coordinated set of real-time algorithms
		• Workstation/PC software provides setup/control/monitor/data display
		• API interfaces provided for interface
		Availability:
		• Since 1993
		• 50 Mbps in January 1996
		Developer/Source:
		• Loral Test & Information Systems, San Diego, CA, USA

4.2	Sub-System Description	

Return And Forward Link Ground Processing

Number	Subject	Description
1.	Agency/Supplier and General Information	
1.1	Agency/Supplier and related Unit	NASA
1.2	Identification Number	NASA/COB/1.0
1.3	General Description	VME Telemetry Input/Output (TIO) module performs return link CADU sync strategy, derandomization, CRC; forward link CRC generation, sync marker insertion, clock generation.
2.	Standard	
2.1	Reference	CCSDS 101.0-B-2 and CCSDS 701.0-B-2
2.2	Title/Description	Telemetry Channel Coding and Advanced Orbiting Systems: Networks and Data Links
3.	On-Board Components and Operation Procedures	
3.1	System Description	None
3.2	Sub-System Description	None
4.	Ground Components and Operation Procedures	

4.1	System Description	Functional Description
		• TIO module (10 MHz)
		  • 2 input channels; CADU synchronize, derandomize, CRC
		  • 2 output channels, CRC generate, randomize, sync insert, clock generator
		• TIO module (50 MHz)
		  • 1 input channels; CADU synchronize, derandomize, CRC
		  • 1 output channels, CRC generate, randomize, sync insert, clock generator
		
		Design and Technology
		• VME modules (9U size)
		
		Availability
		• Since 1993 (10 MHz version)
		• March 1996 (50 MHz version)
		
		Developer Source
		• Loral Test & Information Systems, San Diego, CA US

4.2	Sub-System Description	