

Space data and information transfer systems — Telemetry channel coding

ICS 49.140

National foreword

This British Standard reproduces verbatim ISO 11754:2003 and implements it as the UK national standard. It supersedes BS Z 3:1997 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee ACE/68, Space systems and operations, to Subcommittee ACE/68/-/7, Space data and information transfer systems, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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Summary of pages

This document comprises a front cover, an inside front cover, the ISO title page, pages ii and iii, a blank page, pages 1 to 65 and a back cover.

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 15 May 2003

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ISBN 0 580 41856 1

Amendments issued since publication

Amd. No.	Date	Comments

INTERNATIONAL STANDARD

ISO 11754

Second edition
2003-02-15

Space data and information transfer systems — Telemetry channel coding

*Systèmes de transfert des informations et données spatiales —
Codage de canal pour télémesure*



Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11754 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 101.0-B-5, June 2001) and was adopted (without modifications except those stated in Clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

This second edition cancels and replaces the first edition (ISO 11754:1994), which has been technically revised.

Space data and information transfer systems — Telemetry channel coding

1 Scope

This International Standard specifies the requirements for telemetry channel coding of space data and information transfer systems used in civil space applications.

The scope and field of application are furthermore detailed in subclauses 1.2 and 1.3 of the enclosed CCSDS publication.

2 Requirements

Requirements are the technical recommendations made in the following publication (reproduced on the following pages), which is adopted as an International Standard:

CCSDS 101.0-B-5, June 2001, *Recommendation for space data system standards — Telemetry channel coding*.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 101.0-B-5.

Pages i to v

This part is information which is relevant to the CCSDS publication only.

Page 1-3

Add the following information to the references indicated:

[1] Document CCSDS 102.0-B-5, November 2000, is equivalent to ISO 13419:2003.

[2] Document CCSDS 701.0-B-3, June 2001, is equivalent to ISO 13420:—¹⁾.

3 Revision of publication CCSDS 101.0-B-5

It has been agreed with the Consultative Committee for Space Data Systems that Subcommittee ISO/TC 20/SC 13 will be consulted in the event of any revision or amendment of publication CCSDS 101.0-B-5. To this end, NASA will act as a liaison body between CCSDS and ISO.

1) To be published. (Revision of ISO 13420:1997)

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***Consultative
Committee for
Space Data Systems***

RECOMMENDATION FOR SPACE
DATA SYSTEM STANDARDS

**TELEMETRY
CHANNEL CODING**

CCSDS 101.0-B-5

BLUE BOOK

June 2001



DEDICATION

This document is dedicated to the memory of Mr. Warner H. Miller of NASA. Warner had been with the CCSDS since its beginning and throughout the years he was a major contributor to numerous standards for error control coding, radio frequency modulation, data architecture, and data compression. Warner was a superb technologist, a gentleman, and a friend always ready to help, especially young colleagues. Warner and his approach to work and life in general will be deeply missed by his many friends and colleagues in the CCSDS.

CCSDS RECOMMENDATION FOR TELEMETRY CHANNEL CODING

AUTHORITY

Issue:	Blue Book, Issue 5
Date:	June 2001
Location:	Oxfordshire, UK

This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS Recommendations is detailed in reference [D1], and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This Recommendation is published and maintained by:

CCSDS Secretariat
 Program Integration Division (Code MT)
 National Aeronautics and Space Administration
 Washington, DC 20546, USA

CCSDS RECOMMENDATION FOR TELEMETRY CHANNEL CODING

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of member space Agencies. The Committee meets periodically to address data systems problems that are common to all participants, and to formulate sound technical solutions to these problems. Inasmuch as participation in the CCSDS is completely voluntary, the results of Committee actions are termed **Recommendations** and are not considered binding on any Agency.

This **Recommendation** is issued by, and represents the consensus of, the CCSDS Plenary body. Agency endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

- o Whenever an Agency establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommendation**. Establishing such a **standard** does not preclude other provisions which an Agency may develop.
- o Whenever an Agency establishes a CCSDS-related **standard**, the Agency will provide other CCSDS member Agencies with the following information:
 - The **standard** itself.
 - The anticipated date of initial operational capability.
 - The anticipated duration of operational service.
- o Specific service arrangements shall be made via memoranda of agreement. Neither this **Recommendation** nor any ensuing **standard** is a substitute for a memorandum of agreement.

No later than five years from its date of issuance, this **Recommendation** will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or, (3) be retired or canceled.

In those instances when a new version of a **Recommendation** is issued, existing CCSDS-related Agency standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each Agency to determine when such standards or implementations are to be modified. Each Agency is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommendation.

CCSDS RECOMMENDATION FOR TELEMETRY CHANNEL CODING

FOREWORD

This document is a technical Recommendation for use in developing channel coding systems and has been prepared by the Consultative Committee for Space Data Systems (CCSDS). The telemetry channel coding concept described herein is the baseline concept for spacecraft-to-ground data communication within missions that are cross-supported between Agencies of the CCSDS.

This Recommendation establishes a common framework and provides a common basis for the coding schemes used on spacecraft telemetry streams. It allows implementing organizations within each Agency to proceed coherently with the development of compatible derived Standards for the flight and ground systems that are within their cognizance. Derived Agency Standards may implement only a subset of the optional features allowed by the Recommendation and may incorporate features not addressed by the Recommendation.

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document may occur. This Recommendation is therefore subject to CCSDS document management and change control procedures as defined in reference [D1]. Current versions of CCSDS documents are maintained at the CCSDS Web site:

<http://www.ccsds.org/>

Questions relating to the contents or status of this document should be addressed to the CCSDS Secretariat at the address indicated on page i.

CCSDS RECOMMENDATION FOR TELEMETRY CHANNEL CODING

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- Agenzia Spaziale Italiana (ASI)/Italy.
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- Swedish Space Corporation (SSC)/Sweden.
- United States Geological Survey (USGS)/USA.

CCSDS RECOMMENDATION FOR TELEMETRY CHANNEL CODING

DOCUMENT CONTROL

Document		Date	Status and Substantive Changes
CCSDS 101.0-B-1	Telemetry Channel Coding, Issue 1	May 1984	Original Issue
CCSDS 101.0-B-2	Telemetry Channel Coding, Issue 2	January 1987	1. Supersedes Issue 1. 2. Removes ASM from R-S encoded data space. 3. Specifies marker pattern for ASM. 4. Transfers Annex A (“Rationale”) to Green Book.
CCSDS 101.0-B-3	Telemetry Channel Coding, Issue 3	May 1992	1. Supersedes Issue 2. 2. Deletes Section 3 (“Convolutional Coding with Interleaving for Tracking and Data Relay Satellite Operations”). 3. Adds R-S interleave depths of I=2,3,4 to existing I=1 and 5. 4. Allows R-S code to be operated in “Standalone Mode” (i.e., not concatenated with the convolutional code). 5. Consolidates codeblock and transfer frame sync specifications (new Section 5). 6. Specifies a standard Pseudo-Randomizer to improve bit synchronization (new Section 6). 7. Corrects several editorial errors.
CCSDS 101.0-B-4	Telemetry Channel Coding, Issue 4	May 1999	1. Supersedes Issue 3. 2. Adds turbo code specification (new Section 4). 3. Moves normative references from front matter to Section 1. 4. Moves informative references to Annex D.
CCSDS 101.0-B-5	Telemetry Channel Coding, Issue 5	June 2001	1. Supersedes Issue 4. 2. Corrects misleading encoder diagrams. 3. Adds the following options to help near-earth users: – Reed-Solomon 8-error correcting code; – a set of punctured convolutional codes comparable to the DVB-S standard. 4. Specifies maximum frame lengths.

NOTE – Substantive technical changes from the previous issue are flagged with change bars in the right margin.

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CCSDS RECOMMENDATION FOR TELEMETRY CHANNEL CODING

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to establish a common Recommendation for space telemetry channel coding systems to provide cross-support among missions and facilities of member Agencies of the Consultative Committee for Space Data Systems (CCSDS). In addition, it provides focusing for the development of multi-mission support capabilities within the respective Agencies to eliminate the need for arbitrary, unique capabilities for each mission.

Telemetry channel coding is a method of processing data being sent from a source to a destination so that distinct messages are created which are easily distinguishable from one another. This allows reconstruction of the data with low error probability, thus improving the performance of the channel.

1.2 SCOPE

Several space telemetry channel coding schemes are described in this document. The characteristics of the codes are specified only to the extent necessary to ensure interoperability and cross-support. The specification does not attempt to quantify the relative coding gain or the merits of each approach discussed, nor the design requirements for encoders or decoders. Some performance information is included in Reference [D2].

This Recommendation does not require that coding be used on all cross-supported missions. However, for those planning to use coding, the recommended codes to be used are those described in this document.

The rate 1/2 convolutional code recommended for cross-support is described in Section 2, "Convolutional Coding". Depending on performance requirements, this code alone may be satisfactory.

For telecommunication channels which are bandwidth-constrained and cannot tolerate the increase in bandwidth required by the basic convolutional code specified in 2.1, the punctured convolutional code specified in 2.2 has the advantage of smaller bandwidth expansion. The Reed-Solomon code specified in Section 3 also has the advantage of smaller bandwidth expansion and has the capability to indicate the presence of uncorrectable errors.

Where a greater coding gain is needed than can be provided by the convolutional code or Reed-Solomon code alone, a concatenation of the convolutional code as the inner code with the Reed-Solomon code as the outer code may be used for improved performance. The turbo codes recommended in Section 4 may be used to obtain even greater coding gain where the environment permits.

The recommended methods for frame (or codeblock) synchronization are described in Section 5.

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To improve bit transition density as an aid to bit synchronization, a recommended method of pseudo-randomizing data to be sent over the telemetry channel is described in Section 6.

Annex A provides a discussion of the transformation between the Berlekamp and conventional Reed-Solomon symbol representations; Annex B provides a table showing the expansion of Reed-Solomon coefficients; and Annex C is a glossary of coding terminology used in this document.

1.3 APPLICABILITY

This Recommendation applies to telemetry channel coding applications of space missions anticipating cross-support among CCSDS member Agencies at the coding layer. In addition, it serves as a guideline for the development of compatible internal Agency Standards in this field, based on good engineering practice.

In addition to being applicable to conventional Packet Telemetry systems [1], the codes in this recommendation are applicable to the forward and return links of Advanced Orbiting Systems (AOS) [2]. For coding purposes, the terms “Transfer Frame” and “Reed-Solomon Codeblock” as used in this recommendation are understood to be equivalent to the AOS terms “Virtual Channel Data Unit” (VCDU), and “Coded Virtual Channel Data Unit” (CVCDU), respectively.

1.4 BIT NUMBERING CONVENTION AND NOMENCLATURE

In this document, the following convention is used to identify each bit in a forward-justified N -bit field. The first bit in the field to be transmitted (i.e., the most left justified when drawing a figure) is defined to be “Bit 0”; the following bit is defined to be “Bit 1” and so on up to “Bit $N-1$ ”, as shown in Figure 1-1. When the field is used to express a binary value (such as a counter), the Most Significant Bit (MSB) shall be the first transmitted bit of the field, i.e., “Bit 0”.

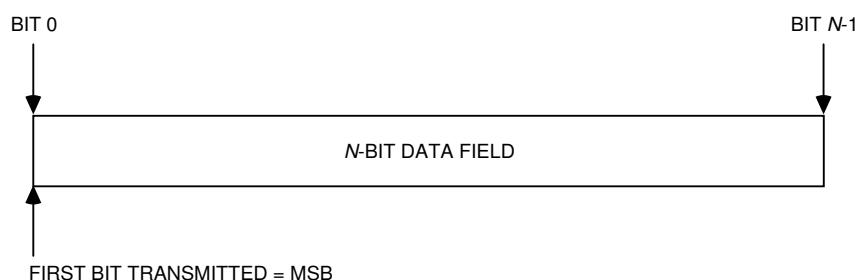


Figure 1-1: Bit Numbering

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In accordance with modern data communications practice, spacecraft data fields are often grouped into 8-bit “words” which conform to the above convention. Throughout this Recommendation, the following nomenclature is used to describe this grouping:

8-BIT WORD = “OCTET”

1.5 RATIONALE

The CCSDS believes it is important to document the rationale underlying the standards chosen, so that future evaluations of proposed changes or improvements will not lose sight of previous decisions. The concept and rationale for Telemetry Channel Coding may be found in Reference [D2].

1.6 REFERENCES

The following documents are referenced in this Recommendation. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommendation are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Recommendations.

- [1] *Packet Telemetry*. Recommendation for Space Data System Standards, CCSDS 102.0-B-5. Blue Book. Issue 5. Washington, D.C.: CCSDS, November 2000.
- [2] *Advanced Orbiting Systems, Networks and Data Links: Architectural Specification*. Recommendation for Space Data System Standards, CCSDS 701.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, June 2001.
- [3] Recommendation 2.4.9, “Minimum Modulated Symbol Transition Density on the Space-to-Earth Link” in *Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft*. Recommendations for Space Data System Standards, CCSDS 401.0-B. Blue Book. Washington, D.C.: CCSDS, June 2001.

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