

BS ISO 18381:2013



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Space data and information transfer systems — Lossless multispectral and hyperspectral image compression

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National foreword

This British Standard is the UK implementation of ISO 18381:2013.

The UK participation in its preparation was entrusted to Technical Committee ACE/68/-/7, Space systems and operations - Space data and information transfer systems.

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

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ISBN 978 0 580 79731 6

ICS 49.140

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2013.

Amendments issued since publication

Date	Text affected
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Space data and information transfer systems — Lossless multispectral and hyperspectral image compression

*Systèmes de transfert des informations et données spatiales —
Compression d'images multispectrales et hyperspectrales sans perte*





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Published in Switzerland

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

ISO 18381 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 123-0-B-1, May 2012) 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*.

Space data and information transfer systems — Lossless multispectral and hyperspectral image compression

1 Scope

This International Standard establishes a data compression algorithm applied to digital three-dimensional image data from payload instruments, such as multispectral and hyperspectral imagers, and specifies the compressed data format.

Data compression is used to reduce the volume of digital data to achieve benefits in areas including, but not limited to:

- a) reduction of transmission channel bandwidth;
- b) reduction of the buffering and storage requirement;
- c) reduction of data-transmission time at a given rate.

The characteristics of instrument data are specified only to the extent necessary to ensure multi-mission support capabilities. This International Standard does not attempt to quantify the relative bandwidth reduction, the merits of the approaches discussed, or the design requirements for encoders and associated decoders.

This International Standard addresses only lossless compression of three-dimensional data, where the requirement is for a data-rate reduction constrained to allow no distortion to be added in the data compression/decompression process.

The scope and field of application are furthermore detailed in subclause 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 123.0-B-1, May 2012, Lossless multispectral and hyperspectral image compression.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 123.0-B-1.

Pages i to vi

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

Page 1-4

Add the following information to the reference indicated:

- [1] Document CCSDS 121.0-B-2, May 2012, is equivalent to ISO 15887:2013.

Page C-1

Add the following information to the reference indicated:

[C2] Document CCSDS 133.0-B-1, September 2003, is equivalent to ISO 22646:2005.

[C3] Document CCSDS 727-0-B-4, January 2007, is equivalent to ISO 17355:2007.

[C4] Document CCSDS 732.0-B-2, July 2006, is equivalent to ISO 22666:2006.

3 Revision of publication CCSDS 123.0-B-1

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 123.0-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

Recommendation for Space Data System Standards

LOSSLESS MULTISPECTRAL & HYPER SPECTRAL IMAGE COMPRESSION

RECOMMENDED STANDARD

CCSDS 123.0-B-1

BLUE BOOK
May 2012

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CCSDS RECOMMENDED STANDARD FOR LOSSLESS MULTISPECTRAL &
HYPERSPECTRAL IMAGE COMPRESSION**AUTHORITY**

Issue:	Recommended Standard, Issue 1
Date:	May 2012
Location:	Washington, DC, USA

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 documents is detailed in *Organization and Processes for the Consultative Committee for Space Data Systems*, and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This document is published and maintained by:

CCSDS Secretariat
Space Communications and Navigation Office, 7L70
Space Operations Mission Directorate
NASA Headquarters
Washington, DC 20546-0001, USA

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of its members. 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 **Recommended Standards** and are not considered binding on any Agency.

This **Recommended Standard** is issued by, and represents the consensus of, the CCSDS members. Endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

- o Whenever a member establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommended Standard**. Establishing such a **standard** does not preclude other provisions which a member may develop.
- o Whenever a member establishes a CCSDS-related **standard**, that member will provide other CCSDS members 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 **Recommended Standard** nor any ensuing **standard** is a substitute for a memorandum of agreement.

No later than three years from its date of issuance, this **Recommended Standard** 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 **Recommended Standard** is issued, existing CCSDS-related member standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each member to determine when such standards or implementations are to be modified. Each member is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommended Standard.

CCSDS RECOMMENDED STANDARD FOR LOSSLESS MULTISPECTRAL &
HYPERSPECTRAL IMAGE COMPRESSION**FOREWORD**

This Recommended Standard specifies a method for lossless compression of multispectral and hyperspectral image data and a format for storing the compressed data.

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

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document may occur. This Recommended Standard is therefore subject to CCSDS document management and change control procedures, which are defined in *Organization and Processes for the Consultative Committee for Space Data Systems* (CCSDS A02.1-Y-3). 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.

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

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- Scientific and Technological Research Council of Turkey (TUBITAK)/Turkey.
- Space and Upper Atmosphere Research Commission (SUPARCO)/Pakistan.
- Swedish Space Corporation (SSC)/Sweden.

CCSDS RECOMMENDED STANDARD FOR LOSSLESS MULTISPECTRAL &
HYPERSPECTRAL IMAGE COMPRESSION

- United States Geological Survey (USGS)/USA.

DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 123.0-B-1	Lossless Multispectral & Hyperspectral Image Compression, Recommended Standard, Issue 1	May 2012	Current issue
EC 1	Editorial Change 1	May 2012	Corrects typographical anomalies.

CCSDS RECOMMENDED STANDARD FOR LOSSLESS MULTISPECTRAL &
HYPERSPECTRAL IMAGE COMPRESSION

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HYPERPECTRAL IMAGE COMPRESSION

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to establish a Recommended Standard for a data compression algorithm applied to digital three-dimensional image data from payload instruments, such as multispectral and hyperspectral imagers, and to specify the compressed data format.

Data compression is used to reduce the volume of digital data to achieve benefits in areas including, but not limited to,

- a) reduction of transmission channel bandwidth;
- b) reduction of the buffering and storage requirement;
- c) reduction of data-transmission time at a given rate.

1.2 SCOPE

The characteristics of instrument data are specified only to the extent necessary to ensure multi-mission support capabilities. The specification does not attempt to quantify the relative bandwidth reduction, the merits of the approaches discussed, or the design requirements for encoders and associated decoders. Some performance information is included in reference [C1].

This Recommended Standard addresses only lossless compression of three-dimensional data, where the requirement is for a data-rate reduction constrained to allow no distortion to be added in the data compression/decompression process.

1.3 APPLICABILITY

This Recommended Standard applies to data compression applications of space missions anticipating packetized telemetry cross support. In addition, it serves as a guideline for the development of compatible CCSDS Agency standards in this field, based on good engineering practice.

1.4 RATIONALE

The concept and rationale for the Image Data Compression algorithm described herein may be found in reference [C1].

1.5 DOCUMENT STRUCTURE

This document is organized as follows:

- a) Section 1 provides the purpose, scope, applicability, and rationale of this Recommended Standard and identifies the conventions and references used throughout the document. This section also describes how this document is organized. A brief description is provided for each section and annex so that the reader will have an idea of where information can be found in the document.
- b) Section 2 provides an overview of the lossless data compressor.
- c) Section 3 defines parameters and notation pertaining to an input image to be compressed.
- d) Section 4 specifies the predictor stage of the compressor.
- e) Section 5 specifies the entropy coding stage of the compressor and the format of a compressed image.
- f) Annex A provides the Protocol Implementation Conformance Statement (PICS) Requirements List (PRL) for implementations of this Recommended Standard.
- g) Annex B discusses security, Space Assigned Numbers Authority (SANA), and patent considerations.
- h) Annex C lists informative references.
- i) Annex D provides tables of symbols used in this document.
- j) Annex E expands abbreviations and acronyms used in this document.

1.6 CONVENTIONS AND DEFINITIONS

1.6.1 MATHEMATICAL NOTATION AND DEFINITIONS

In this document, for any real number x , the largest integer n such that $n \leq x$ is denoted by

$$n = \lfloor x \rfloor, \quad (1)$$

and correspondingly, the smallest integer n such that $n \geq x$ by

$$n = \lceil x \rceil. \quad (2)$$

The modulus of an integer M with respect to a positive integer divisor n , denoted $M \bmod n$, is defined to be

$$M \bmod n = M - n \lfloor M / n \rfloor. \quad (3)$$

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When it is stated that a value M is encoded modulo n , this means the number $M \bmod n$ is encoded instead of M .

For any integer x and positive integer R , the function $\text{mod}_R^*[x]$ is defined as

$$\text{mod}_R^*[x] = \left((x + 2^{R-1}) \bmod 2^R \right) - 2^{R-1}. \quad (4)$$

NOTE – The quantity $\text{mod}_R^*[x]$ is the R -bit two's complement integer that is congruent to x modulo 2^R . This is a natural result of storing a signed integer x in an R -bit register in two's complement form when overflow might occur.

The notation $\text{clip}(x, \{x_{\min}, x_{\max}\})$ denotes the clipping of the real number x to the range $[x_{\min}, x_{\max}]$, that is,

$$\text{clip}(x, \{x_{\min}, x_{\max}\}) = \begin{cases} x_{\min}, & x < x_{\min} \\ x, & x_{\min} \leq x \leq x_{\max} \\ x_{\max}, & x > x_{\max} \end{cases} \quad (5)$$

For any real number x , the function $\text{sgn}^+(x)$ is defined as

$$\text{sgn}^+(x) = \begin{cases} 1, & x \geq 0 \\ -1, & x < 0. \end{cases} \quad (6)$$

1.6.2 NOMENCLATURE

1.6.2.1 Normative Text

The following conventions apply for the normative specifications in this Recommended Standard:

- a) the words 'shall' and 'must' imply a binding and verifiable specification;
- b) the word 'should' implies an optional, but desirable, specification;
- c) the word 'may' implies an optional specification;
- d) the words 'is', 'are', and 'will' imply statements of fact.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.