

Space engineering - Space data links - Telecommand protocols, synchronization and channel coding

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 16603-50-04:2014 sisaldab Euroopa standardi EN 16603-50-04:2014 inglisekeelset teksti.	This Estonian standard EVS-EN 16603-50-04:2014 consists of the English text of the European standard EN 16603-50-04:2014.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 24.09.2014.	Date of Availability of the European standard is 24.09.2014.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 33.040.40, 49.090, 49.140

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:
Aru 10, 10317 Tallinn, Eesti; www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:
Aru 10, 10317 Tallinn, Estonia; www.evs.ee; phone 605 5050; e-mail info@evs.ee

ICS 33.040.40; 49.090; 49.140

English version

**Space engineering - Space data links - Telecommand protocols,
synchronization and channel coding**

Ingénierie spatiale - Liaisons de données spatiales -
Protocoles, synchronisation et codage canal des liaisons
télécommande

Raumfahrttechnik - Telekommando-Protokolle, -
synchronisation und -kanalkodierung

This European Standard was approved by CEN on 25 April 2014.

CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



**CEN-CENELEC Management Centre:
Avenue Marnix 17, B-1000 Brussels**

Table of contents

Foreword	10
1 Scope	11
2 Normative references	12
3 Terms, definitions and abbreviated terms	13
3.1 Terms from other standards	13
3.2 Terms specific to the present standard	13
3.3 Abbreviated terms	14
3.4 Conventions	15
3.4.1 Bit 0, bit 1, bit N-1	15
3.4.2 Most significant bit	15
3.4.3 Use of capitals for the names of data structures and fields	15
4 Overview	16
4.1 Presentation	16
4.2 Protocol profiles	16
4.3 Segmentation sublayer	17
4.4 Transfer sublayer	18
4.5 Synchronization and channel coding sublayer	18
4.6 Physical layer	18
4.7 Virtual channels	19
5 Segmentation sublayer	20
5.1 Overview	20
5.2 TC Segment	21
5.2.1 General	21
5.2.2 Segment Header	22
5.2.3 Segment Data Field	23
5.3 Transfer notification	23
5.3.1 Overview	23
5.3.2 Requirements	24
5.4 Blocking of packets	25

5.4.1	Overview	25
5.4.2	Virtual channels where TC Segments are used.....	25
5.4.3	Virtual channels where TC Segments are not used.....	26
5.4.4	Packet properties	26
5.4.5	Blocking function	27
5.4.6	Deblocking function.....	27
5.5	Segmentation	27
5.5.1	Overview	27
5.5.2	Segmenting function	28
5.5.3	Reassembly function.....	28
5.5.4	Packet assembly controller	29
5.6	MAP multiplexing	32
6	Transfer sublayer	33
6.1	Overview	33
6.1.1	Data structures in the transfer sublayer.....	33
6.1.2	Procedures in the transfer sublayer.....	33
6.2	TC Transfer Frame definition.....	35
6.2.1	General	35
6.2.2	Transfer Frame Primary Header.....	36
6.2.3	Transfer Frame Data Field	40
6.2.4	Frame Error Control Field.....	41
6.3	CLCW definition.....	43
6.3.1	General	43
6.3.2	Control Word Type	45
6.3.3	CLCW Version Number.....	45
6.3.4	Status Field	45
6.3.5	COP in Effect	45
6.3.6	Virtual Channel Identification.....	45
6.3.7	Reserved Spare	46
6.3.8	No RF Available Flag	46
6.3.9	No Bit Lock Flag.....	47
6.3.10	Lockout Flag	47
6.3.11	Wait Flag.....	48
6.3.12	Retransmit Flag.....	48
6.3.13	FARM-B Counter	48
6.3.14	Reserved Spare	48
6.3.15	Report Value	49

6.4	Frame header procedure	49
6.5	Frame error control procedure at the sending end	49
6.6	Frame delimiting and fill removal procedure.....	49
6.6.1	Overview	49
6.6.2	Actions	50
6.7	Frame error control procedure at the receiving end	50
6.8	Frame header validation procedure	50
6.8.1	Overview	50
6.8.2	Actions	51
6.9	Virtual channel multiplexing	51
6.9.1	Overview	51
6.9.2	Multiplexing mechanism.....	52
6.9.3	Demultiplexing	52
7	COP-1.....	53
7.1	Overview	53
7.1.1	Scope.....	53
7.1.2	Interfaces	53
7.1.3	Retransmission protocol.....	53
7.1.4	Frames.....	54
7.1.5	Services	54
7.1.6	Protocol machine	56
7.2	Internal variables	56
7.2.1	Overview.....	56
7.2.2	FOP-1 Variables	57
7.2.3	FARM-1 variables	64
7.3	Features of COP-1 interfaces	69
7.3.1	Overview.....	69
7.3.2	Parameters	70
7.4	Upper interface of COP-1 at the sending end	70
7.4.1	Overview.....	70
7.4.2	Sequence-controlled service management interface.....	71
7.4.3	Sequence-controlled service data transfer interface.....	77
7.4.4	Expedited service data transfer interface	80
7.5	Upper interface of COP-1 at the receiving end.....	82
7.5.1	Overview.....	82
7.5.2	Buffer management mechanism.....	82
7.5.3	The wait system	82

7.5.4	Single back-end buffer	83
7.5.5	FDU Arrived Indication	84
7.6	Lower interface of COP-1 at the sending end	84
7.6.1	Overview	84
7.6.2	Transmit Request for Frame signal	85
7.6.3	Abort request signal	85
7.6.4	Response signal	86
7.7	Lower interface of COP-1 at the receiving end.....	86
7.7.1	Overview	86
7.7.2	Valid Frame Arrived Indication	87
7.8	Format of COP-1 control commands	87
7.8.1	Overview	87
7.8.2	General	87
7.8.3	Unlock.....	87
7.8.4	Set V(R).....	88
7.9	Actions.....	88
7.9.1	Format of the state tables.....	88
7.9.2	FOP-1	89
7.9.3	FARM-1	96
8	Synchronization and channel coding sublayer	111
8.1	Overview	111
8.2	BCH codeblock	111
8.2.1	General	111
8.2.2	Information	112
8.2.3	Error Control	112
8.3	Communications link transmission unit (CLTU).....	113
8.3.1	General	113
8.3.2	Start Sequence	113
8.3.3	Encoded Data	114
8.3.4	Tail Sequence	114
8.4	Randomization procedure.....	115
8.4.1	Overview	115
8.4.2	General	115
8.4.3	Random sequence.....	115
8.4.4	Application of the randomizer	116
8.5	BCH codeblock encoding procedure.....	116
8.6	Fill bits	117

8.6.1	Overview	117
8.6.2	General	117
8.7	Channel logic at the receiving end	118
8.8	BCH codeblock decoding procedures	119
8.8.1	Overview	119
8.8.2	General	120
9	Physical layer.....	121
9.1	Overview	121
9.2	Physical layer data structures	121
9.2.1	Acquisition sequence	121
9.2.2	CLTU	122
9.2.3	Idle sequence.....	122
9.3	Physical layer procedures.....	122
9.3.1	Overview.....	122
9.3.2	Carrier modulation modes	122
9.3.3	Telecommand session	124
9.3.4	Physical layer operation procedure (PLOP)	124
Annex A	(informative) Frame error control	127
A.1	Overview	127
A.2	Encoding	127
A.3	Decoding	128
Annex B	(informative) Changes from ESA-PSS-04-107	129
B.1	Overview	129
B.2	Technical changes.....	129
Annex C	(informative) Differences from CCSDS recommendations.....	132
C.1	Overview	132
C.2	Differences	132
Annex D	(informative) Performance issues	135
D.1	Introduction.....	135
D.2	Performance components.....	136
D.3	Factors affecting frame rejection rate.....	136
D.3.1	Bit synchronization factor	136
D.3.2	CLTU Start Sequence factors	137
D.3.3	BCH Codeblock Factor	138
D.3.4	Tail Sequence factor	140

D.3.5	Frames and CLTUs.....	141
D.4	Factors affecting frame undetected error rate	143
Annex E (informative)	Mission configuration parameters	147
E.1	Introduction.....	147
E.2	Parameters of a physical channel	147
E.2.1	Overview	147
E.2.2	Fixed parameters	147
E.2.3	Length of the acquisition sequence	147
E.2.4	Physical layer operation procedure	148
E.2.5	Transfer Frame Version Number	148
E.2.6	Maximum length of a TC Transfer Frame	148
E.2.7	Virtual channels	148
E.2.8	Use of the expedited service	148
E.2.9	Multiplexing parameters	148
E.3	Parameters of a virtual channel	149
E.3.1	Overview	149
E.3.2	Spacecraft Identifier and Virtual Channel Identifier.....	149
E.3.3	Maximum length of a TC Transfer Frame.....	149
E.3.4	FOP-1 parameters	149
E.3.5	CLCW reporting rate	149
E.3.6	Status Field of CLCW.....	149
E.3.7	Fixed parameters	149
E.3.8	FARM-1 sliding window parameters.....	150
E.3.9	Use of TC Segments.....	150
E.3.10	Parameters of a virtual channel with TC Segments.....	150
E.3.11	Parameters of a virtual channel without TC Segments.....	150
E.4	Parameters of a MAP	151
E.4.1	Overview	151
E.4.2	MAP Identifier	151
E.4.3	Use of the blocking function	151
E.4.4	Segmentation function	151
E.5	Parameters for packet types	152
E.5.1	Overview.....	152
E.5.2	Valid packet version numbers	152
Bibliography.....		153

Figures

Figure 3-1: numbering convention	15
Figure 4-1: Layers and sublayers specified in this Standard	17
Figure 5-1: TC Segment	21
Figure 5-2: Example of blocking of packets	25
Figure 5-3: Example of segmentation of a user data unit	28
Figure 6-1: TC Transfer Frame format	36
Figure 6-2: Format of a CLCW	44
Figure 7-1: COP-1 sequence variables	55
Figure 7-2: FARM sliding window concept	67
Figure 7-3: State table format	89
Figure 7-4: Actions for look for directive	94
Figure 7-5: Actions for look for FDU	95
Figure 7-6: FOP-1 state transitions for main protocol	105
Figure 7-7: FOP-1 state transitions for initialisation protocol	106
Figure 7-8: FOP-1 state transitions	107
Figure 7-9: FARM-1 state transitions	110
Figure 8-1: BCH codeblock format	112
Figure 8-2: Format of a CLTU	113
Figure 8-3: Bit pattern of the Start Sequence	113
Figure 8-4: Bit transition generator logic diagram	116
Figure 8-5: (63,56) Modified BCH code generator	117
Figure 8-6: State diagram for the channel (receiving end)	119
Figure 9-1: Sequence of CMMs comprising PLOP-2	125
Figure 9-2: Sequence of CMMs comprising PLOP-1	126
Figure A-1 : Encoder	127
Figure A-2 : Decoder	128
Figure D-1 : Frame rejection probability, P_{FY} , in SEC mode using PLOP-2	143
Figure D-2 : Probability of undetected error in a frame in SEC mode	146

Tables

Table 6-1: Sending-end procedures in the transfer sublayer	34
Table 6-2: Receiving-end procedures in the transfer sublayer	35
Table 6-3: Combined Bypass Flag and Control Command Flag	38
Table 6-4: Fields in a CLCW	43
Table 7-1: COP-1 interfaces	70

Table 7-2: Signals for management interface	71
Table 7-3: FOP-1 directive types and qualifiers	73
Table 7-4: Reasons for an Alert notification	75
Table 7-5: Signals for sequence-controlled service data transfer interface	78
Table 7-6: Signals for expedited service data transfer interface.....	80
Table 7-7: Signals for the interface of FOP-1 to the lower procedures.....	84
Table 7-8: FOP-1 state table	98
Table 7-9: FARM-1 state table.....	108
Table 8-1: Channel states (receiving end)	118
Table 8-2: Channel events (receiving end)	119
Table 9-1: Carrier modulation modes	123
Table B-1 : Field name differences from ESA-PSS-04-107	131
Table B-2 : Names with “Communications” or “Command”	131
Table C-1 : Name differences from CCSDS recommendations	134
Table D-1 : Probability of not recognizing the Start Sequence	138
Table D-2 : Meaning of decoding values	138
Table D-3 : Decoding cases in SEC mode.....	138
Table D-4 : Probability of codeblock rejection for a CLTU during decoding in SEC mode...	140
Table D-5 : Parity and Syndrome when Tail Sequence has errors.....	141
Table D-6 : Probability of missing the Tail Sequence.....	141
Table D-7 : Frame rejection probability, P_{FY} (PLOP-2).....	142
Table D-8 : Sources of undetected errors (SEC mode).....	143
Table D-9 : Probability of n errors occurring in a codeblock.....	144
Table D-10 : Error detection performance when decoding a codeblock in SEC mode	144
Table D-11 : Probability of undetected error in a frame, SEC mode, with CRC	145

Foreword

This document (EN 16603-50-04:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-50-04:2014) originates from ECSS-E-ST-50-04C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2015, and conflicting national standards shall be withdrawn at the latest by March 2015.

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

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1

Scope

This Standard specifies the data structures and protocols for a telecommand space data link and the procedure for physical layer operation.

Usually, the source of data on a telecommand space data link is located on the ground and the receiver is located in space. However, the Standard may also be used for space-to-space telecommand data links.

Further provisions and guidance on the application of this standard can be found, respectively, in the following documents:

- The higher level standard ECSS-E-ST-50 “Communications”, which defines the principle characteristics of communication protocols and related services for all communication layers relevant for space communication (physical- to application-layer), and their basic relationship to each other.
- The handbook ECSS-E-HB-50 “Communications guidelines”, which provides information about specific implementation characteristics of these protocols in order to support the choice of a certain communications profile for the specific requirements of a space mission.

Users of this present standard are invited to consult these documents before taking decisions on the implementation of the present one.

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications, do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system - Glossary of terms
	CCSDS 135.0-B-3 Issue 3, October 2006	Space Link Identifiers – Blue Book