

STN	Kozmická technika Časovo spínaný Ethernet	STN EN 16603-50-16 31 0543
------------	--	--

Space engineering - Time triggered Ethernet

Táto norma obsahuje anglickú verziu európskej normy.
This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 04/22

Obsahuje: EN 16603-50-16:2021

134624



EUROPEAN STANDARD

EN 16603-50-16

NORME EUROPÉENNE

EUROPÄISCHE NORM

December 2021

ICS 49.140

English version

Space engineering - Time triggered EthernetIngénierie spatiale - Ethernet à déclenchement
temporel (TTE)

Raumfahrttechnik - Zeitgesteuertes Ethernet

This European Standard was approved by CEN on 5 December 2021.

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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



**CEN-CENELEC Management Centre:
Rue de la Science 23, B-1040 Brussels**

EN 16603-50-16:2021 (E)

Table of contents

European Foreword	8
1 Scope	9
2 Normative references	10
3 Terms, definitions and abbreviated terms	11
3.1 Terms from other standards.....	11
3.2 Terms specific to the present standard	11
3.3 Abbreviated terms.....	15
3.4 Nomenclature	17
4 Overview	18
4.1 Reference Model	18
4.2 Physical Layer	19
4.3 Data Link Layer	19
4.3.1 Data Link Layer Overview	19
4.3.2 Data Link Layer Functionalities	20
4.3.3 Time-Triggered Ethernet	21
4.4 Network Level.....	23
4.4.1 Network Level Overview.....	23
4.4.2 Message Processing at the Switch.....	24
4.4.3 Time-Triggered Ethernet Network Building Blocks	28
4.4.4 Virtual Link	29
4.4.5 Time-Triggered Traffic Policing	30
4.4.6 Rate-Constrained Traffic Policing.....	30
4.4.7 Clock Synchronization.....	31
4.5 Redundancy Concept	34
4.5.1 Introduction	34
4.5.2 TT traffic.....	35
4.5.3 RC traffic.....	35
4.6 Failure-modes.....	36
5 Network Architecture	37

EN 16603-50-16:2021 (E)

5.1	Overview	37
5.1.1	Introduction	37
5.1.2	Single Channel Network Topology	37
5.1.3	Dual Channel Network Topology	38
5.1.4	Triple Channel Network Topology	39
5.1.5	Mixed Network Topology	40
5.1.6	Multiple Networks Topology	41
5.1.7	Compatibility with standard Ethernet Network	42
5.2	Network Topology Requirements	43
5.2.1	Single Network Topology	43
5.2.2	Multiple Networks Topology	45
6	Device Services	46
6.1	Overview	46
6.2	Media Access Control (MAC) Sublayer	47
6.2.1	MAC sublayer functions	47
6.2.2	MAC Addressing	47
6.2.3	Traffic Classes	48
6.2.4	MAC Transmit	49
6.2.5	MAC Receive	50
6.2.6	Switch Traffic Policing	50
6.2.7	Switch Transmit	51
6.2.8	Switch Frame Routing	52
7	Interoperability Specification	53
7.1	Overview	53
7.2	Device Specification	54
7.2.1	Device Parameters Description	54
7.2.2	General Requirements	55
7.2.3	Switch Level Specification	55
7.2.4	End-System Level Specification	59
7.2.5	Clock Synchronization	60
7.3	Configuration Parameters	61
7.3.1	Device Level and Clock Synchronization Parameters	61
7.4	Configuration and Scheduling guideline	67
7.4.1	Overview	67
7.4.2	Delays	68
7.4.3	Latencies	69
7.4.4	Transparent clock	70

EN 16603-50-16:2021 (E)

7.5	Scheduling requirements	70
7.5.1	Delays to be identified	70
7.5.2	Delays compensation	70
7.5.3	PCF latency	71
7.5.4	Maximum transparent clock	72
7.5.5	PCF transparent clock jitter	72
7.5.6	Precision parameter	73
7.5.7	Time-Triggered minimum gap	73
7.5.8	Time-Triggered Switch receive window	73
7.5.9	Time-Triggered Switch minimum transmission	75
7.5.10	Time-Triggered End-System reception	75
8	Network Setup and Services	76
8.1	Overview	76
8.2	General Requirements	77
8.2.1	Overview	77
8.2.2	Internet Protocol (IP)	77
8.2.3	UDP	78
8.2.4	ICMP	79
8.3	Dataloading via TFTP	80
8.3.1	Trivial File Transfer Protocol (TFTP) Overview	80
8.3.2	Dataloading requirements	81
8.4	Diagnostics and Status-Information via SNMP	81
8.4.1	Simple Network Management Protocol (SNMP) Overview	81
8.4.2	SNMP requirements	83
8.4.3	Diagnostic and Status-Information requirements	84
8.4.4	Monitoring Mode	88
8.5	Error management in End-System and Switch	88
9	Test and verification	90
9.1	Test Specification	90
9.2	Test references	90
9.2.1	Overview	90
9.2.2	Requirements for implementation at system level	91
10	Tailoring	92
10.1	Scope	92
10.2	Tailoring options and parameters	92
10.2.1	Overview	92

EN 16603-50-16:2021 (E)

10.2.2	Step 1: Function and service selection	92
10.2.3	Step 2: Services configuration	92
10.3	IEEE 802.3 Tailoring	93
10.4	SAE AS6802 Tailoring	97
Bibliography.....		102
 Figures		
Figure 3-1:	Structure of a Packet	13
Figure 4-1:	OSI Reference Model	18
Figure 4-2:	Physical Layer Model	19
Figure 4-3:	Data Link Layer	20
Figure 4-4:	Time-Triggered Ethernet Services	21
Figure 4-5:	Traffic Partitioning	23
Figure 4-6:	Network Communication Channel	23
Figure 4-7:	A TTE example network	24
Figure 4-8:	Full Duplex Links	24
Figure 4-9:	Message Processing at the Switch	25
Figure 4-10:	Preemption	26
Figure 4-11:	Shuffling	27
Figure 4-12:	Media Reservation	27
Figure 4-13:	Network Building Blocks	28
Figure 4-14:	Network Building Blocks Examples	28
Figure 4-15:	Virtual Link	29
Figure 4-16:	Bandwidth Reservation	30
Figure 4-17:	Time-Triggered Ethernet two step clock synchronization algorithm	31
Figure 4-18:	Example of an integration PCF Frame exchange	34
Figure 4-19:	Redundancy Communication	34
Figure 4-20:	Redundancy Management at the Receiver	35
Figure 5-1:	Single Channel Network Topology	37
Figure 5-2:	Single Channel Network Topology – without cascaded Switches	38
Figure 5-3:	Single Channel Network Topology – with cascaded Switches	38
Figure 5-4:	Dual Channel Network Topology	38
Figure 5-5:	Dual Channel Network Redundancy without cascaded Switches	39
Figure 5-6:	Dual Channel Network Redundancy with cascaded Switches	39
Figure 5-7:	Triple Channel Redundant Network Topology	39
Figure 5-8:	Triple Channel Network Redundancy without cascaded Switches	40
Figure 5-9:	Triple Channel Network Redundancy with cascaded Switches	40

EN 16603-50-16:2021 (E)

Figure 5-10: Mixed Architecture.....	40
Figure 5-11: Multiple Networks Topology	41
Figure 5-12: Synchronization priority assignment recommendation	42
Figure 5-13: Time-Triggered Ethernet topology composed of standard Ethernet nodes	43
Figure 6-1: OSI Layer Services	46
Figure 6-2: Destination MAC Address	47
Figure 6-3: Source MAC Address	47
Figure 7-1: Configuration Interface Tool – IP	53
Figure 7-2: Example of delays at system level.....	68
Figure 7-3: Example of delays related to a device	69
Figure 7-4: Impact of delays on synchronization precision.....	69
Figure 7-5: Impact of delays on synchronization precision.....	71
Figure 7-6: Impact of delays on synchronization precision.....	71
Figure 8-1: Network Diagnostic and Monitoring Service Layers.....	77
Figure 8-2: FTP Message Types	81
Figure 8-3: Simple Network Management Protocol (SNMP)	82
Figure 8-4: Global SNMP architecture	83

Tables

Table 6-1: Interface ID.....	48
Table 7-1: General Interoperability Parameter Table	54
Table 7-2: Switch Interoperability Parameter Table	54
Table 7-3: End-System Interoperability Parameter Table	55
Table 7-4: End-System Schedule Parameters	61
Table 7-5: End-System Output VL Parameters.....	61
Table 7-6: End-System Input VL Parameters	62
Table 7-7: End-System Best-Effort Filtering Parameters	62
Table 7-8: End-System Clock Synchronization Parameters.....	62
Table 7-9: End-System General Parameters	64
Table 7-10: Switch Scheduling Parameters.....	64
Table 7-11: Switch Output VL Parameters.....	65
Table 7-12: Switch Input VL Parameters	65
Table 7-13: Switch Best-Effort Filtering Parameters	65
Table 7-14: Switch Clock Synchronization Parameters.....	65
Table 7-15: Switch General Parameter.....	67
Table 7-16: Max Transparent Clock parameter table	72
Table 7-17: Precision parameter Table.....	73

EN 16603-50-16:2021 (E)

Table 7-18: TT Switch Receive Window start and end time	74
Table 7-19: Time-Triggered Switch receive window Table.....	74
Table 10-1: Requirements selection	93
Table 10-2: Tailoring to [IEEE 802.3] - Part 3	93
Table 10-3: Tailoring to [SAE AS6802]	97
Table A-1 : Clock Synchronization.....	98
Table A-2 : Time-Triggered Communication	99
Table A-3 : Dependability	99

European Foreword

This document (EN 16603-50-16:2021) has been prepared by Technical Committee CEN-CENELEC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-50-16:2021) originates from ECSS-E-ST-50-16C.

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 June 2022, and conflicting national standards shall be withdrawn at the latest by June 2022.

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 standardization request 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, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

Using standard communication protocols for spacecraft communication links can provide interface compatibility between communication devices and components. Thus, it can improve the design and development process as well as integration and test activities at all levels and provide the potential of reusability across projects.

The aim of this space engineering standard is to define the interface services and to specify their corresponding network protocol elements for spacecraft using the Time-Triggered Ethernet data network. It also aims at defining requirements for the harmonisation of the physical interfaces and usage of the [IEEE 802.3] and [SAE AS6802] layer features.

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

Approach

The approach of the ECSS working group for defining this standard aims at identification of layers, services and functions of the typical Time-Triggered Ethernet communication network to ensure the use of the technology for various space projects. The standard aims at:

- Identifying Reference Architectures (Layers, Services, Functions and Elements of protocol) of typical Time-Triggered Ethernet communication network;
- Characterizing Services, Functions and Elements of Protocol of each Layer within identified Reference Architectures, using concrete project specifications;
- Define normative requirements rather than recommendations.

As far as possible, the defined communication requirements are extracted from the experience on existing spacecraft specifications.

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 revision 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 more 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
	ARINC 664 part 7, 23 September 2009	Aircraft Data Network Part 2: Avionic Full-Duplex Switched Ethernet Network
	IEEE 802.3, 28 December 2012	Ethernet Standard
	SAE AS6802, November 2011	Time-Triggered Ethernet
	RFC 768, 28 August 1980	User Datagram Protocol (UDP)
	RFC 791, September 1981	Internet Protocol (IP)
	RFC 792, September 1981	Internet Control Message Protocol (ICMP)
	RFC 1157, May 1990	A simple network management protocol (for SNMPv1)
	RFC 1350, July 1992	The TFTP Protocol (Revision 2)

koniec náhľadu – text ďalej pokračuje v platenej verzii STN