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Information technology – Fibre channel – Part 312: Avionics environment upper layer protocol (FC-AE 1553)

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FOREWORD

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- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where, for any other reason, there is the future but not immediate possibility of an agreement on an International Standard;
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Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of

type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/IEC TR 14165-312, which is a technical report of type 2, was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

This document is issued in the type 2 technical report series of publications (according to 16.2.2 of the Procedures for the technical work of ISO/IEC JTC 1 (5th edition, 2004)) as a prospective standard for provisional application in the field of avionics, because there is an urgent requirement for guidance on how standards in this field should be used.

This document is not to be regarded as an International Standard. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to IEC Central Office.

A review of this type 2 technical report will be carried out not later than three years after its publication with the option of extension for a further three years, conversion into an International Standard or withdrawal.

This Technical Report has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

INTRODUCTION

This part of ISO/IEC 14165 defines a set of features necessary to implement a real-time Fibre Channel network (point-to-point, switched fabric, or arbitrated loop) supporting the FC-AE-1553 Upper Level Protocol.

FC-AE-1553 is intended to support bi-directional communication between two or more N_Ports in a constrained and carefully defined environment, typical of avionics applications. The intended usage is avionic command, control, instrumentation, simulation, signal processing, file distribution, and sensor/video data distribution. These application areas are characterized by a variety of requirements, among them a need for high reliability, fault tolerance, and deterministic behavior to support real-time command/response.

The FC-AE-1553 protocol is based on MIL-STD-1553B Notice 2 with extensions in bandwidth, address space, and data transfer size in order to support low-latency, low overhead communication between elements of a mission-critical avionics system. Some of the key features of FC-AE-1553 are its command/response protocol; options for acknowledged or unacknowledged messaging, RDMA transfers, file transfers; along with the capability to bridge to legacy MIL-STD-1553 terminals.

This part of ISO/IEC 14165 is divided into 4 clauses:

Clause 1 is the scope of this part of ISO/IEC 14165.

Clause 2 enumerates the normative references that apply to this part of ISO/IEC 14165.

Clause 3 describes the definitions, abbreviations, and conventions used in this part of ISO/IEC 14165.

Clause 4 defines the FC-AE-1553 Upper Level Protocol. This clause indicates whether features are Required, Prohibited, Allowed, or Invocable in FC-AE-1553.

This part of ISO/IEC 14165 has three annexes:

Annex A is a normative annex which defines Process Login for the FC-AE-1553 upper layer protocol.

Annex B is an informative annex that contains a profile of the FC-FS and FC-AL-2 standards as an example for avionics Fibre Channel network which uses FC-AE-1553.

Annex C is an informative annex providing information regarding bridging between FC-AE-1553 Fibre Channel networks and MIL-STD-1553 buses.

INFORMATION TECHNOLOGY – FIBRE CHANNEL –

Part 312: Avionics environment upper layer protocol (FC-AE 1553)

1 Scope

This part of ISO/IEC 14165 is intended to serve as an implementation guide to maximize the likelihood of interoperability between conforming implementations. This part of ISO/IEC 14165 Prohibits or Requires features that are optional, and Prohibits the use of some non-optional features in the referenced specifications (see Clause 2).

In addition, this part of ISO/IEC 14165 simplifies implementations and their associated documentation, testing, and support requirements.

This Technical Report does not define internal characteristics of conformant implementations. This part of ISO/IEC 14165 incorporates features from the normative references in Clause 2.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

The provisions of the referenced specifications other than ISO/IEC, IEC, ISO and ITU documents, as identified in this clause, are valid within the context of this document. The reference to such a specification within this document does not give it any further status within ISO or IEC. In particular, it does not give the referenced specification the status of an International Standard.

ISO/IEC 14165-122, *Information technology – Fibre channel – Part 122: Arbitrated loop–2 (FC-AL-2)* [INCITS 332-1999]

ISO/IEC 14165-251, *Information technology – Fibre channel – Part 251: Framing and signalling (FC-FS)* [ANSI INCITS 373:2003]

ISO/IEC 14165-261, *Information technology – Fibre Channel – Part 261: Link Services (FC-LS)* (in preparation)

ANSI INCITS 424, *Information technology – Fibre channel – Framing and Signaling-2 (FC-FS-2)*

3 Terms, definitions and conventions

3.1 General considerations

For FC-AE-1553 (this document), the following terms and definitions, conventions, abbreviations, and acronyms apply. Words used that are defined in referenced standards shall use that definition. Words not defined here or in the referenced standards shall have the standard technical English meaning. See 3.3 for typographical conventions in order to distinguish words or phrases that have special definitions.

Some definitions from the glossary or body of other standards are included here for easy reference.

3.2 Terms and definitions

For the purposes of this document the following terms and definitions apply.

3.2.1
Command Sequence
FC-AE-1553 Fibre Channel Sequence that is always the first Sequence of any FC-AE-1553 Exchange and is always issued by a Network Controller (NC); Command Sequences always have the Information Category bits in the R_CTL field set to 0110'b

NOTE Some profiles may require that all Command Sequences be transmitted as single frames.

3.2.2
Data Sequence
FC-AE-1553 Fibre Channel Sequence that is sent by either an NT or NC; Data Sequences always have the Information Category bits in the R_CTL field set to 0100'b

3.2.3
exchange
basic mechanism which transfers information consisting of one or more related non-concurrent Sequences which may flow in the same or opposite directions

3.2.4
First/Middle/Last
FML
provides an indication of Sequence position within Exchange, where F = first, M = middle, and L = last

3.2.5
frame
information contained in a frame between its Start-of-Frame and End-of-Frame delimiters, excluding the delimiters

3.2.6
Information Category
frame header field indicating the category to which the frame payload belongs (e.g., Solicited Data, Unsolicited Data, Solicited Control and Unsolicited Control)

3.2.7
Network Controller
NC
Fibre Channel Node that transmits FC-AE-1553 Command Sequences (akin to a Bus Controller or BC in MIL-STD-1553)

3.2.8
Network Terminal
NT
Fibre Channel Node that responds to commands issued by the Network Controller (NC) using FC-AE-1553 protocol (akin to a Remote Terminal or RT in MIL-STD-1553)

3.2.9
sequence
set of one or more Data frames with a common Sequence_ID (SEQ_ID), transmitted unidirectionally from one N_Port to another N_Port with a corresponding response, if applicable, transmitted in response to each Data frame

3.2.10
Sequence Initiative
within an Exchange, a Sequence Initiator may either hold Sequence Initiative by transmitting the next Sequence in the Exchange, or transfer Sequence Initiative to the current Sequence recipient; in the latter case, the consecutive sequence recipient transmits the next Sequence in the Exchange

NOTE Abbreviations include: SI = Sequence Initiative, H = hold, and T = transfer. The Sequence Initiative is bit 16 in the Exchange/Sequence Control (F_CTL) field of the Fibre Channel header.

3.2.11
Status Sequence
FC-AE-1553 Fibre Channel Sequence that in most cases is the first Sequence transmitted by an FC-AE-1553 NT

NOTE 1 Status Sequences have the Information Category bits in the R_CTL field set to 0111'b. Some Status Sequences provide an indication of the maximum number of data bytes that the NT is able to receive in the next Data Sequence.

NOTE 2 Some profiles may require that all Status Sequences be transmitted as single-frame Sequences.

3.3 Conventions

3.3.1 General

In this document, a number of conditions, mechanisms, sequences, parameters, events, states, or similar terms that do not have their normal English meaning are printed with the following conventions.

- The first letter of each word in uppercase and the rest lowercase (e.g., Exchange, Class, etc.).
- A term consisting of multiple words, with the first letter of each word in uppercase and the rest lowercase, and each word separated from the other by an underscore (_) character. A word may consist of an acronym or abbreviation, which would be printed in uppercase. (e.g., NL_Port, Transfer_Length, etc.).

All terms and words not conforming to the conventions noted above have the normal technical English meanings.

Numbered items in this part of ISO/IEC 14165 do not represent any priority. Any priority is explicitly indicated.

In all of the figures, tables, and text of this Technical Report, the most significant bit of a binary quantity is shown on the left side. Exceptions to this convention are indicated in the appropriate subclauses.

The term "shall" is used to indicate a mandatory rule. If such a rule is not followed, the results are unpredictable unless indicated otherwise.

The fields or control bits that are not applicable shall be set as required by the appropriate technical report.

If a field or a control bit is specified as not meaningful, the recipient shall not check that field or control bit. The Sequence Initiator shall set all such fields or control bits to zero.

In several tables within this document, there is a column on the right side of the table labelled "Notes". These notes are NORMATIVE and shall be considered requirements of this Technical Report.

In the event of conflict between the text, tables, and figures in this document, the following precedence shall be used: tables (highest), text and figures (lowest).

3.3.2 Binary notation

Binary notation may be used to represent some fields. Single bit fields are represented using the binary values 0 and 1. For multiple bit fields, the binary value is enclosed in single quotation marks followed by the letter b. For example, a four-byte field containing a binary value may be represented as ‘00000000 11111111 10011000 11111010’b.

3.3.3 Hexadecimal notation

Hexadecimal notation may be used to represent some fields. When this is done, the value is enclosed in single quotation marks and preceded by the word hex. For example, a four-byte field containing a binary value of ‘00000000 11111111 10011000 11111010’b is shown in hexadecimal format as hex ’00 FF 98 FA’.

3.3.4 Abbreviations and acronyms

Abbreviations and acronyms applicable to this part of ISO/IEC 14165 are listed below. Abbreviations and acronyms for commonly used terms defined in referenced standards are not listed here (e.g., LIP is defined in FC-AL-2).

FC-AE-1553	The mnemonic used to define this FC-AE-1553 profile
NC	Network Controller
NC1 to NC7	Network Controller Information Units
NT	Network Terminal
NT1 to NT8	Network Terminal Information Units

3.4 Applicability and use of this document

Since the nature of this document is a profile, the usual definitions of the following words do not apply. These definitions need to be read carefully.

Required: If a feature or parameter value is Required, it means that it shall be used between compliant implementations. Compliant implementations are required to implement the feature. An implementation may use the feature or other features to communicate with non-compliant implementations. Interoperability is not guaranteed if Required features are not implemented. Each Required feature will include a note that describes the condition(s) in which the feature must be used.

Invocable: If a feature or parameter value is Invocable, it means that it may be used between compliant implementations. Compliant implementations are required to implement the feature. Invocable is different from Required in that an implementation may invoke the feature if needed, but is not required to invoke it. No discovery process is necessary prior to use of an Invocable feature.

Allowed: If a feature or parameter value is Allowed, it means that it may be used between compliant implementations. Compliant implementations are not required to implement the feature. Typically, the potential user of an Allowed feature may determine through a negotiation or discover process if an implementation supports it via an Invocable discovery process.

Prohibited: If a feature is Prohibited, it means that it shall not be used between compliant implementations. An implementation may use the feature to communicate with non-compliant implementations. This document **does not** Prohibit the implementation of features, only their use between compliant implementations. However, interoperability is not guaranteed if Prohibited features are used.

Table 1 summarizes the above definitions.

Table 1 – Summary and use of features

Term	Implementation	Use
Required	Shall	Shall
Invocable	Shall	May
Allowed	May	May
Prohibited	May	Shall Not

The tables in the following clauses list features described in the various technical reports specific to the operations described in the clause. These tables indicate whether the feature is Required, Prohibited, Invocable, or Allowed for compliance with this report; or whether a parameter is Required to be a particular value for compliance with this report. Features or parameters that are not listed do not affect the interoperability of FC-AE devices.

The following legend is used for table entries in these clauses:

‘R’ Required

‘I’ Invocable

‘A’ Allowed

‘P’ Prohibited

‘n’ the parameter shall be set to this value

‘X’ this parameter has no required value; any value is Allowed

‘-’ this parameter or feature is not meaningful

4 FC-AE-1553 profile

4.1 General

This clause describes an FC-4 mapping layer intended to provide a deterministic command/response protocol for use in real-time flight critical and mission critical avionics applications. One of the primary motivations for this ULP mapping is to enable the leveraging of existing system designs, hardware, and software written for MIL-STD-1553 avionics networks. The mnemonic for this upper layer protocol is FC-AE-1553.

This clause includes a description of the differences between MIL-STD-1553B and FC-AE-1553, information relating to mapping and bridging to legacy 1553 devices, a description of the FC-AE-1553 Exchange formats, a profile delineating the required and optional FC-AE-1553 features, a delineation of Exchange validation criteria, the mapping from the FC-AE-1553 ULP to Fibre Channel FC-FS and FC-AL-2, and a profile section specifying the required, optional and prohibited FC-FS and FC-AL-2 Fibre Channel features.

4.2 FC-AE-1553 elements

Some of the key FC-AE-1553 elements are the Network Controller or NC, the Network Terminal or NT, the Fibre Channel network itself; and in cases where legacy MIL-STD-1553 data buses are connected to the network, FC-AE-1553 to MIL-STD-1553 bridges, MIL-STD-1553 buses, and MIL-STD-1553 RT devices. There may be one or multiple active Network Controllers on an FC-AE-1553 network. One of the main functions of the Network Controllers is to provide the scheduling of all FC-AE-1553 transmissions on the network.

Like MIL-STD-1553, FC-AE-1553 defines a command/response protocol, with an added (controller) option to suppress status responses. The Network Terminal (NT) consists of a Fibre Channel interface located inside a subsystem or sensor connected to a Fibre Channel

network. The NT's primary function is to perform data transfers between the subsystem and the Fibre Channel network as directed by the Network Controller(s).

Individual nodes on an FC-AE-1553 network may function as NCs and NTs simultaneously.

While FC-AE-1553 is based largely on MIL-STD-1553B Notice 2 constructs, it includes extensions that provide capability beyond standard MIL-STD-1553. These extensions include the ability to allow for a substantially larger maximum number of terminals (2^{24}), increased word counts (2^{32} bytes), and a larger subaddress space (2^{32}).

FC-AE-1553 includes an option for RDMA (remote DMA) functionality, in which the subaddress field is used as the starting byte address for a transfer to or from a remote NT's address space. For an RDMA type of Exchange, the value of the subaddress represents an address on a 32-bit boundary. FC-AE-1553 also includes capabilities for file transfers. These include multiple options enabling NTs or NCs receiving files to be able to regulate the timing and size of individual transmitted Data Sequences.

Table 2 provides a comparison between terminology used in MIL-STD-1553 and FC-AE-1553.

Table 2 – Terminology equivalents between MIL-STD-1553 and FC-AE-1553

MIL-STD-1553	FC-AE-1553
Bus Controller (BC)	Network Controller (NC)
Remote Terminal (RT)	Network Terminal (NT)
RT Address	Network Terminal Address
RT Subaddress	NT Subaddress (NT_SA)
MIL-STD-1553 Message	FC-AE-1553 Exchange
Command Word	Command Sequence
Status Word	Status Sequence

FC-AE-1553 also takes full advantage of the network topology offered by Fibre Channel (as opposed to MIL-STD-1553's bus topology), allowing simultaneous data traffic across the network and multiple Network Controller entities. This mapping also supports the aggregation of multiple MIL-STD-1553 buses into a common FC-AE-1553 network, while maintaining an equivalent functionality of individual MIL-STD-1553 buses.

Unless otherwise stated, all references to data field sizes for FC-AE-1553 are in bytes, rather than 16-bit words. However, for FC-AE-1553 Exchanges which are bridged to MIL-STD-1553 messages, there are specific references to 16-bit words transmitted over MIL-STD-1553 buses.

4.3 Mapping legacy 1553 applications to FC-AE-1553

4.3.1 General

A fundamental purpose of the FC-AE-1553 mapping is to enable interoperability for interfacing legacy MIL-STD-1553 remote terminals to a Fibre Channel network.

The FC-AE-1553 protocol supports the mapping of legacy MIL-STD-1553 16-bit command words to FC-AE-1553 header extension fields (see Table 7). The use of the Fibre Channel frame header and FC-AE-1553 header extension fields in FC-AE-1553 applications supports larger RT address and subaddress spaces, and larger data payload sizes than MIL-STD-1553. These differences are summarized in Table 3.