Title

AS250

MIL-STD-1553 Bus Protocol Specification

CI CODE: T0039445

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SUMMARY

1. INTRODUCTION AND SCOPE

1.1 Background

This document specifies the protocol needs for the equipments and instruments controlled via the MIL-STD-1553 data bus.

1.2 Scope

This document is the basis for all subsystems connected to one of the MIL-STD-1553 data buses, which are used as common serial data bus for command and control of all instruments and part of platform equipment. The document comprises the contractually relevant technical requirements and constraints for the MIL-STD-1553B Data Bus so enabling the different parties involved designing, developing and testing their part with respect to the common data bus.

1.2.1 Basic MIL-STD-1553 History and Operational Principles

MIL-STD-1553 was originally developed to define a communication bus to interconnect different subsystems, which needed to share or exchange information. The primary requirements for the bus standard included the following:

•Information was to be transferred between bus terminals via a digital serial communication channel.

•Electrical interface requirements were to be defined by the standard for all bus terminals and bus terminal connections.

•Information has to be transferred in a reliable, deterministic, command/response fashion.

•Serial Transmission Rate : the serial transmission bit rate of the bus, 1 Mbps, was based upon several factors, including reliability, electrical interfaces, and hardware capabilities during the period of the original standard definition (the early 1970s). The transmission bit rate is not fast by modern standards. However, most 1553 terminal requirements operate well within this bandwidth limit.

1.2.2 Bus Terminal Characteristics and Connections

By defining the electrical characteristics of bus terminals, and connection standards of terminals to the bus, system architectures could be designed with a high level of operational confidence from an electrical interface standpoint. The system designer could design a reliable interface bus network given a set of rules and guidelines (outlined in the 1553 bus standard and in MIL-HDBK-1553) relating to terminal connections and communication formats. In the same respect, terminal designers had a set of standards to follow to ensure that their designs would be compatible with the system-level architecture.

1.2.3 Communications and Reliability

The third, and sometimes misunderstood, requirement was for a deterministic, reliable, command/response communication bus. It is important to understand that the 1553 bus standard was originally developed as a command and control bus standard. It was not envisioned as a “data transfer” network in the same fashion as most of today’s high-speed Local Area Networks (LANs). This is demonstrated by the fact that the protocol and message specifications allow for a maximum message data word package of 64 bytes (32 16-bit words), which is quite small by modern LAN standards. Packet size limitations are based on the standard’s emphasis on transferring packets of information in small, predefined windows of time to ensure message continuance and overall bus determinism. Unlike modern LANs, which typically have a low level of data transfer “determinism,” 1553 provides very deterministic data bus communications. All transfers of commands and data on the bus are initiated by a single Bus Controller (BC). No bus communications can be initiated by any terminal other than the BC. It is the BC’s responsibility to ensure that its message-scheduling scheme provides for all time-critical dependencies. With the exception of a few transaction types, bus terminals (Referred to as Remote Terminals (RTs)) provide a status response that indicates the success or failure of bus transactions. To add to overall bus determinism, the 1553 standard levies requirements on

RTs to respond to BC commands within specified time periods. If responses are not received within the specified times described by the standard, the BC has the right to consider the transaction in a “no response” state and proceed with its next course of action. This scheme provides a means to ensure that no transactions on the bus exceed a certain time limit, which would interrupt or suspend other time-dependent transactions from occurring.

1.2.4 Modifications to the Standard

Over the years since MIL-STD-1553 was introduced, there have been several modifications made to the standard. Most modifications were made to provide direction in ambiguous areas and to accommodate the specific needs of users. The Society of Automotive Engineers (SAE) is responsible for providing maintenance and any future modifications to the standard. Most modern systems employ the MIL-STB-1553B Notice 2 format. However, older platforms may still contain some MIL-STD-1553A and MIL-STD-1553 terminal mixes. In addition to the standard, most prime contractors for major platforms publish a document which outlines the specific implementation details that the platform employs. These details provide direction to system designers and terminal providers as to the specific implementations of the data bus standard when the standard provides leeway.

1.2.5 Who Uses MIL-STD-1553B

MIL-STD-1553B has evolved to become the predominant, internationally accepted data bus standard for many military platforms and is being used increasingly in non-military, space-based applications. MIL-STD-1553B has been adopted by the Air Force, Navy, Army, and space agencies of nations around the world. Platforms other than aircraft, which utilize 1553, include tanks, ships, missiles, satellites, and the International Space Station, to name a few. Accordingly, 1553 is also found in many ground-based support roles such as test equipment, ground support equipment, simulators, and trainers.

1.2.6 Protocol Layers

This Protocol Specification covers the **LEVELS 1 (Physical Layer), 2 (Data Link), 3 (Network)** and **4 (Transport)** of the OSI reference layer model.

Layer 5,6,7 (session, presentation and application layer) will be part of PUS and CSW specifications.

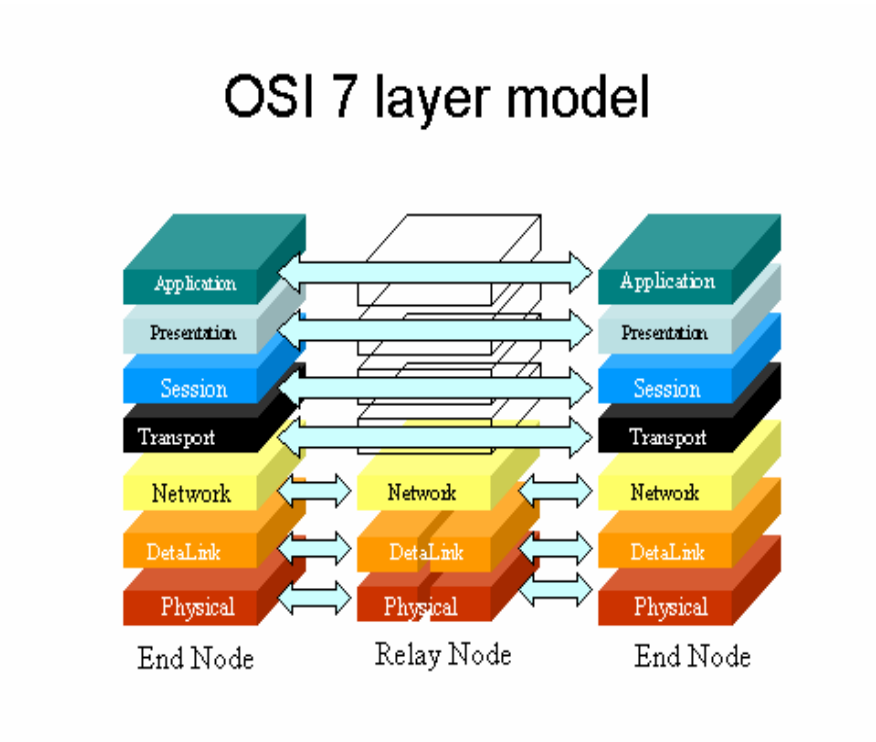


Figure 1.2-1: OSI Seven Layer Model

The three upper layers, session, presentation and application layers, are not in scope of this specification. Thus so called *Packet - and Non Packet Terminals* need not to be considered.

In any case a session layer is needed to present the received data to the application.

The ESA standard ECSS-E-50-13 Draft (April 2007) has been considered for preparation of this document.

1.2.7 Spacecraft MIL Bus Topology

The Astrosat 250 MIL-STD-1553B bus system implements two separate, each dual-redundant, data buses: one for the Astrobus 250 Payload Module (PLM), one for the Service Module (SVM). Depending upon the Remote Terminal (RT) design, two (externally-redundant terminals) or four (internally-redundant terminals) stubs connect the RT to the data bus through Inter-Connecting Stations (ICS).

The OBC comprises 2 independent Mil-Bus controllers dedicated for:

- Platform units command and control on SVM bus
- Payload units command and control on PLM bus

Nota : in order to balance the traffic budget, it is possible that platform units (resp. payload units) are connected to PLM bus (resp. SVM bus).

No electrical connection between these two Mil-Buses exists.

No functional connection between these two Mil-Buses exists within the scope of this protocol specification.

Unless specific items require distinction of the two buses, all definitions and requirements apply for both of them.

All data transfers are initiated by the OBC as Bus Controller. RTs only transfer data when requested by the BC.

Data entities transferred to and from “Packet Terminals” are termed “block” for distinction from CCSDS packets. The detailed structure of blocks is specified in this document.

The MIL-STD-1553 Data Bus topology is a dual redundant bus with a transfer bit rate of 1 Mbit/sec.

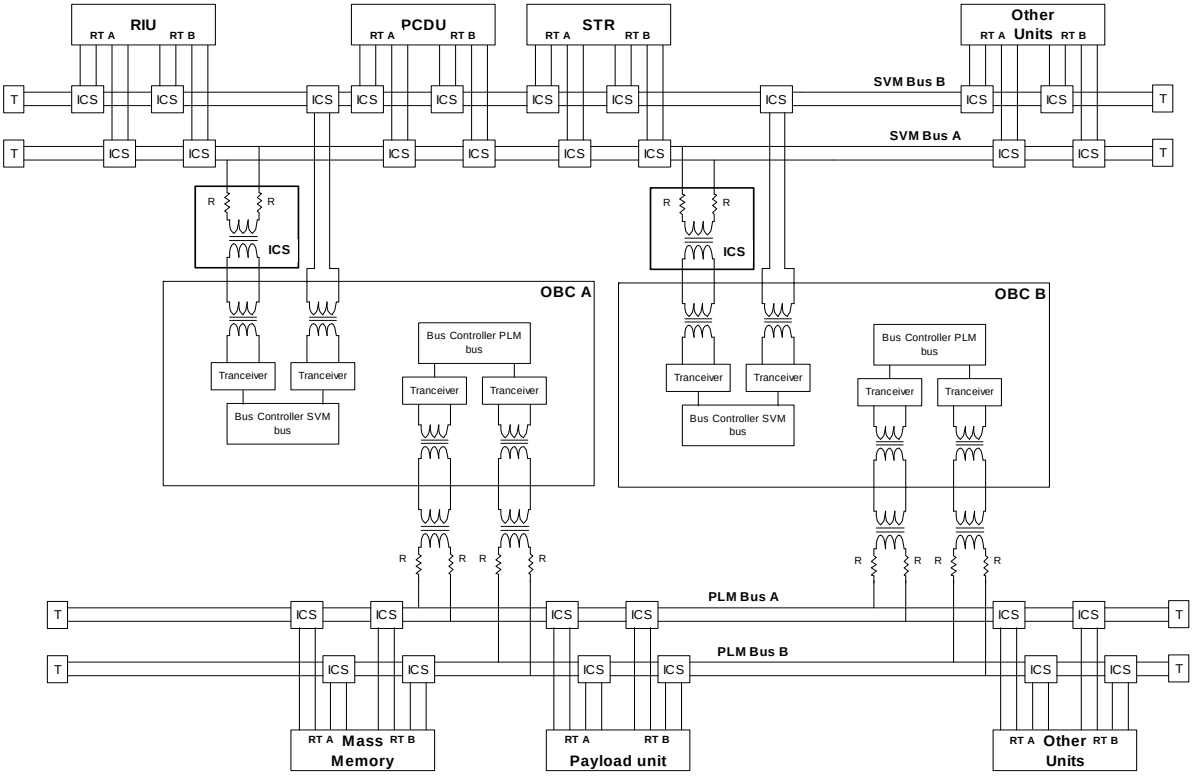


Figure 1.2-2: MIL-STD-1553 Bus Topology of a spacecraft

RT may be intelligent or non-intelligent units:

•Non-intelligent units may use single message BC - RT and RT - BC transfers via dedicated sub-addresses. (see chapter 7)

•Intelligent units will communicate via a Data Block Transfer protocol composed by one or several messages; the Block transfer may transport any Data-Blocks including PUS-Packets (see chapter 7)

1.3 Specification Scheme of Requirements

Each requirement is preceded by a summary line with the format:

MIL-XXXX//V

Where

XXXX is a unique number for the requirement assigned by DOORS

V is the intended Verification Method

The Intended Verification Methods are coded as follows:

- **A** - Analysis

- **I** - Inspection
- **R** - Review of design
- **T** - Test

All verification methods indicated for a dedicated requirement are applicable.

The requirement text follows the summary line. If tables are considered as part of the requirement they are referenced clearly in the text, inserted after, separated from the requirement and are managed as free text attached to the identifier requirement.

2. DOCUMENTS

The documents listed herein, at their latest issue, form part of this document and are applicable as a whole if not stated otherwise in this document. If any conflict occurs between this document and any other applicable document the contractor shall notify the discrepancy to the customer in order to resolve the conflict.

2.1 Applicable Documents

The following documents form part of this specification as specified herein.

In case that no issue of the applicable document is stipulated, the latest issue in effect has to be taken.

MIL-32 /

[AD1] AS250 DIV.SP.00027.T.ASTR Avionics equipment GDIR

2.2 Standards

The following documents form part of this specification as specified herein. The applicability of Level 1 ECSS Standards (Policy and Principles) extends implicitly to the lower level standards. In some cases, this document refers explicitly to lower level standards.

MIL-35 /

[SD1] MIL-STD-1553B Notice 4 Digital Time Division Command/Response Multiplex Data Bus

MIL-36 /

[SD2] MIL-HDBK-1553A Multiplex Applications Handbook, Department of Defense, that shall applied as follows :

- *Section 100 : RT Validation Test Plan shall apply and Remote Terminal Contractors shall use it to certify the conformance of their RTs.*
- *All the other sections contain guidelines and examples.*

3. TERMS AND DEFINITION

3.1 Definitions

TERM	*DESCRIPTION*
Bus Controller (BC)	The BC´s task is to initiate and control all data transfer on the 1553 Data Bus. It is the sole device allowed to transmit command words. Hence, the OBC is the BC. BC related functional requirements as described within this document are covered by H/W (controller H/W) as well as by application S/W.
Remote Terminal (RT)	The RTs are used to interface the subsystems to the 1553 Data Bus system and perform data transmissions on the 1553 Data Bus as controlled by the BC. The term relates not only to the 1553 Data Bus interface but also to the host controller and/or attached subsystem.
Bus Monitor	The bus monitor's task is to listen to the 1553 data bus traffic and to extract selected information to be used at a later time. Not implemented on Astrobus250.
MIL-STD-1553 Data Bus	All the hardware including cables, isolation resistors, transformers etc. required to provide a data path between the BC and all the associated RTs.
Message	A single message is the transmission of a command word, status and data words (if they are specified).
Mode Command	Command word in which the sub-address field is set to '00000' or ´11111´and a mode code is transferred from the BC to the RT. The sub-address used for mode code commands shall be ´11111´.
Receive Command	Command word in which the sub-address field is set different to '00000' or ´11111´ and the subsequent transfer of data word(s) from the BC to the RT is initiated.
Receive Message	Message with a data flow from the BC to the RT.
Transmit Command	Command word in which the sub-address field is set different to '00000' or ´11111´and the subsequent transfer of data word(s) from the RT to the BC is initiated.
Transmit Message	Message with a data flow from the RT to the BC.
Vector Word	Data word provided by the RT subsequent to the status word in answer to a mode command "Transmit Vector Word".
Instructor	Data word provided by the BC as data word subsequent to the mode command "Synchronize with Data Word".
Bit Order	The most significant bit shall be transmitted first with the less significant bits following in descending order of value in the Data Word. In the event that multiple precision quantities (information requiring more than 16 bits) are transmitted, the most significant bits shall be transmitted first, and followed by the word(s) containing the lesser significant bits in numerically descending order. Bit packing of multiple quantities in a single Data Word is permitted. Bit numbering shall start with 0, i.e. bit 0 = MSB Single bit data and other parameters which are characterized by bit patterns of fewer than 16 bits will not fill the 16 bits of data allowed in data word format. Two approaches can be adopted to use all the bits in a word: 1.) Packing multiple parameters in a word. 2.) Filling in zeros for all unused bits.
Bit Time	Bit time and bit numbering scheme are identical.
OBC	Onboard Computer. On a satellite generally the instance with highest priority, holds control over the BC.

Table 3.1-1: Definition of Terms

3.2 Abbreviations

E

EPROM	Erasable Programmable Read only Memory

F

FDIR	Fault Detection, Isolation and Recovery

H

HW	Hardware

I

ICD	Interface Control Document
ID	Identifier

L

LAN	Local Area Network
LSB	Least Significant Bit

M

MSB	Most Significant Bit

O

OBC	On-Board Computer Unit
OBT	On-Board Time

P

PCDU	Power Control & Distribution Unit
PUS	Packet Utilization Standard

R

RAM	Random Access Memory
RT	Remote Terminal

S

S/C	Spacecraft
STR	Star Tracker Unit
SW	Software

T

TBC	To be confirmed
TBD	To be defined
TC	Telecommand
TM	Telemetry

U

UART-TX	Universal Asynchronous Receiver/Transmitter – transmitter part
UART-RX	Universal Asynchronous Receiver/Transmitter – receiver part

3.3 Conventions

MIL-44 / T,R

The conventions set forth below shall be applicable to the Bus Controller hardware / basic software and Remote Terminals.

3.3.1 Bit Transmission & Numbering Conventions

MIL-46 / T,R

The convention used in this document is Big Endian as below. All ordering shall be according to the Big Endian convention.

The relation between a 20 bit Mil-Bus word and the bit position numbering is given below.

1553 Bit Times

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Bit # (Bit Position)

S	S	S	00	01	02	03	04	05	06	07	09	09	10	11	12	13	14	15	P
			MSB															LSB	

SSS : Sync
P : Parity

Figure 3.3-1: Bit Order Definition

3.3.2 WORD Transmission & Numbering Conventions

MIL-50 / T,R

In the event that multiple precision quantities - information accuracy or resolution requiring more than 16 bits - are transmitted, the most significant bits shall be transmitted first, followed by the word(s) containing the lesser significant bits in numerical descending order.

MIL-51 / T,R

For 2-byte information, "byte 0" shall represent the most significant byte and "byte 1" the least significant byte. "Byte 0" (starting from the left) shall be transmitted first.

MIL-52 / T,R

For 4-byte information, "byte 0" shall represent the most significant byte of the high order word, the low order word shall start at "byte 2" with the least significant byte being "byte 3". "Byte 0" (starting from the left) shall be transmitted first.

3.3.3 Floating point Data Transmission & Numbering Conventions

MIL-54 / T,R

For a 32-bit floating-point value, "byte 0" shall represent the byte containing the sign bit and the exponent most significant bits, "byte 3" shall represent the least significant bits of the mantissa (according to IEEE-STD-754).

MIL-55 / T,R

For a 64-bit floating-point value, "byte 0" shall represent the byte containing the sign bit and the exponent most significant bits, "byte 7" shall represent the least significant bits of the mantissa (according to IEEE-STD-754).

4. GENERAL

4.1 Bus Topology

MIL-58 / R

The 1553 bus architecture shall be dual standby redundant and shall be compliant to the related requirements of [SD1].

MIL-59 / T

Each Bus Controller (BC N and BC R) located in the on-board computer (OBC) shall control one redunded SVM bus and one redunded PLM bus.

MIL-60 / T

Each RT on the 1553 bus shall be connected to the two 1553 buses (N and R) through dedicated Remote Terminals.

MIL-61 / T

Communication to RT's, regardless on which layer, shall take place if the RT is in ON state only.

4.2 Protocol Stack

The MIL Bus system shall support the following layers of protocol:

- **Physical Layer:** cables, connectors, direct and transformer-coupled connection methods, RT address connector.
- **Data Link Layer:** 1553B word control, message transfer control, multiple message control, error notification and processing.
- **Network Layer:** initialization, (re)configuration, error notification, RT address allocation, redundancy management.
- **Transport Layer**: implementation of 1553B minor and major acquisition/distribution frames, synchronization, flow control, error management.
- **Session Layer:** handling of periodic and aperiodic messages, large data transfer protocol, communication slots handling, error and fault management.

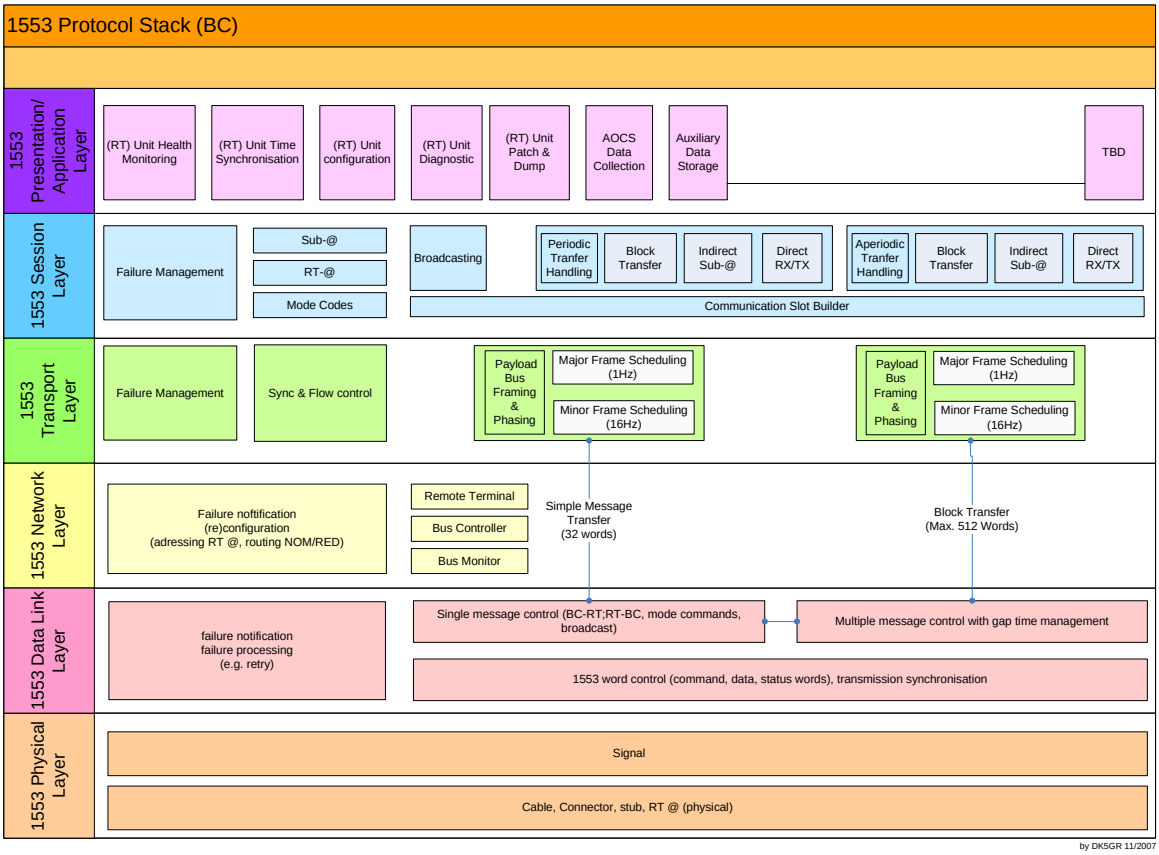


Figure 4.2-1: 1553 Protocol Stack (BC)

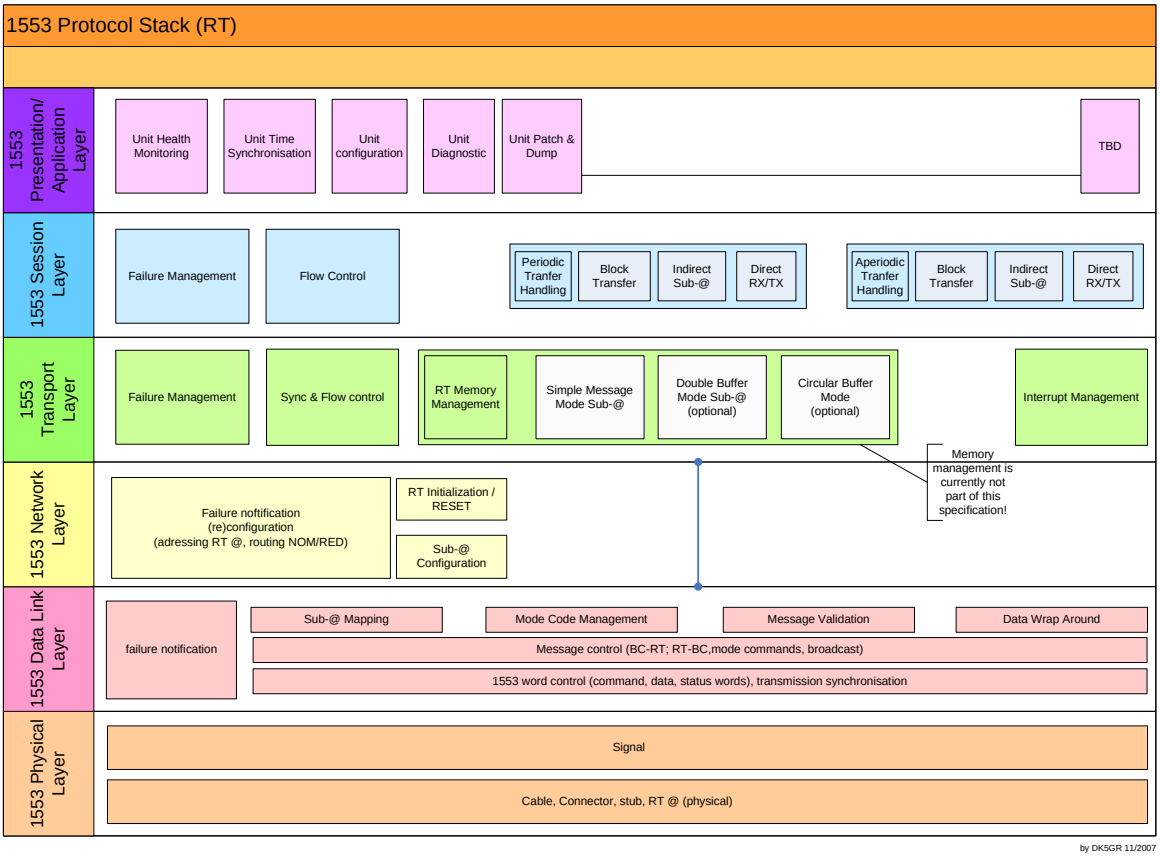


Figure 4.2-2: 1553 Protocol Stack (RT)

5. PHYSICAL LAYER

MIL-69 / T

The OBC shall perform the MIL-STD-1553B bus control as master of the bus.

MIL-70 / T

Only one Bus Controller (BC) per bus shall be active at a time.

MIL-71 / T

Nominal and Redundant units shall have different RT addresses. Exceptions have to be agreed with the customer.

MIL-72 / T

Messages shall be allowed to appear on one of the two 1553 buses at a time.

5.1 Remote Terminals (RT) physical address

MIL-74 / T

The following shall act as remote terminals (RT) on SVM MIL-STD-1553B bus :

DEC@	BIN@	BUS	RT NAME	NOTE
0-2		1	-	Free addresses
3	**00011**	1	**RIU A**	
4	**00100**	1	**RIU B**	
5-6		1	-	Free addresses
7	**00111**	1	**PCDU A**	
8	**01000**	1	**PCDU B**	
9-10		1		Free addresses
11	**01011**	1	**STR A**	
12	**01100**	1	**STR B**	
13-14		1	-	Free addresses
15	**01111**	1	**Unit 1 A**	
16	**10000**	1	**Unit 1 B**	
17-18		1	-	Free addresses
19	**10011**	1	**Unit 2 A**	
20	**10100**	1	**Unit 2 B**	
21-22		1		Free addresses
23	**10111**	1	**Unit 3 A**	
24	**11000**	1	**Unit 3 B**	
25-30		1	-	Free addresses
31	**11111**	1	**Broadcast**	**Reserved**

Table 5.1-1: Remote Terminal Addressing SVM bus

MIL-77 / T

The following shall act as remote terminals (RT) on PLM MIL-STD-1553B bus :

DEC@	BIN@	BUS	RT NAME	NOTE
0		2	-	Free addresses
1	**00001**	**2**	**Unit 1 A**	
2	**00010**	2	**Unit 1 B**	
3-4		2		Free addresses
5	**00101**	2	**Mass Memory A**	
6	**00110**	2	**Mass Memory B**	
7-8		2	-	Free addresses
9	**01001**	2	**Unit 2 A**	
10	**01010**	2	**Unit 2 B**	
11-12		2		Free addresses
13	**01101**	2	**Unit 3 A**	
14	**01110**	2	**Unit 3 B**	
15-16		2	-	Free addresses
17	**10001**	2	**Unit 4 A**	
18	**10010**	2	**Unit 4 B**	
19-20		2	-	Free addresses
21	**10101**	2	**Unit 5 A**	
22	**10110**	2	**Unit 5 B**	
23-24		2		Free addresses
25	**11001**	2	**Unit 6 A**	
26	**11010**	2	**Unit 6 B**	
27-28		2	-	Free addresses
29	**11101**	**2**	**Unit 7 A**	
30	**11110**	**2**	**Unit 7 B**	
31	**11111**	2	**Broadcast**	**Reserved**

Table 5.1-2: Remote Terminal Addressing PLM bus

MIL-80 / T

The RT shall sample the terminal address wires during power-on and after RESET.

MIL-81 / T

In case the parity of the wired terminal address is found incorrect, the RT shall stop initialization and no command message shall be responded.

6. DATA LINK LAYER REQUIREMENTS

MIL-83 / T

The data link layer shall follow the requirements defined in [SD1]

MIL-84 / R

RT to RT Transfers shall not be supported.

MIL-85 / R

Dynamic bus control shall not be used.

MIL-86 /

As much as possible, the number of words shall be constant for a given sub-address.

6.1 No response time

MIL-88 / T

The BC NO RESPONSE time out shall be 14 microseconds.

6.2 Automatic retry

MIL-90 / R

The automatic transfer repetition function shall not be used.

6.3 Mode codes

The MIL-STD-1553B protocol specification predefines mode codes. The Satellite Data Bus Protocol utilizes the MIL-STD-1553B and therefore includes the Mode Codes as described below, reference to [SD1]:

T/R BIT	MODE CODE	FUNCTION	ASSOCIATED DATA WORDS	BROADCAST COMMAND ALLOWED	HANDLED BY RT
1	00000	Dynamic Bus Control	No	No	No
1	00001	Synchronize	No	Yes	Optional
1	00010	Transmit Status Word	No	No	Yes
1	00011	Initiate Selftest	No	Yes	No
1	00100	Transmitter Shutdown	No	Yes	Yes
1	00101	Override Transmitter Shutdown	No	Yes	Yes
1	00110	Inhibit Terminal Flag Bit	No	Yes	Optional
1	00111	Override Inhibit Terminal Flag Bit	No	Yes	Optional
1	01000	Reset Remote Terminal	No	Yes	Yes
1	01001 to 01111	Reserved	No	TBD	TBD
1	10000	Transmit Vector Word	Yes	No	Optional
0	10001	Synchronize with Data Word	Yes	Yes	Optional
1	10010	Transmit Last Command Word	Yes	No	Optional
1	10011	Transmit Built-in Test Word	Yes	No	Optional
0	10100	Selected Transmitter Shutdown	Yes	Yes	No
0	10101	Override Selected Transmitter Shutdown	Yes	Yes	No
1 or 0	10110 to 11111	Reserved	Yes	TBD	TBD

Table 6.3-1: Mode Codes

MIL-95 / T

The mandatory mode codes shall be implemented onto Astrosat 250 MIL-STD-1553B bus system as specified "Yes" in the table.

MIL-96 / T,A

The mode codes specified as optional shall be used if and only if they are demonstrated as necessary for the BC-RT operations of a RT unit.

6.3.1 Synchronize (optional)

MIL-98 / T

If used, the RT shall implement and respond to valid "Synchronize" mode code as required by [SD1].

6.3.2 Transmit Status Word

MIL-100 / T

RTs shall implement and respond to valid "Transmit Status Word" mode code as required by [SD1].

6.3.3 RT Transmitter Shutdown

MIL-102 / T

RTs shall implement and respond to valid "RT Transmitter Shutdown" mode code as required by [SD1].

MIL-103 / T

If a RT transmitter is babbling on the "A" bus, the BC shall send the "RT Transmitter Shutdown" command to the terminal on the "B" bus.

MIL-104 / T

The shutdown transmitter shall not generate any bus activity until the mode code is overridden by either an "Override Transmitter Shutdown" mode code or a "Reset RT" mode code received on the non-shutdown bus.

6.3.4 Override Transmitter Shutdown

MIL-106 / T

RTs shall implement and respond to valid "Override RT Transmitter Shutdown" mode code as required by [SD1].

6.3.5 Inhibit Terminal Flag Bit (optional)

MIL-359 / T

If used, the RT shall implement and respond to valid "Inhibit Terminal Flag Bit" mode code as required by [SD1].

6.3.6 Override Inhibit Terminal Flag Bit (optional)

MIL-361 / T

If used, the RT shall implement and respond to valid "Override Inhibit Terminal Flag Bit" mode code as required by [SD1].

6.3.7 Reset Remote Terminal

MIL-108 / T

If used, the RT shall implement and respond to valid "Reset RT" mode code as required by [SD1].

MIL-109 / T

Receipt of the "Reset RT" mode code shall re-enable all shutdown transmitters. This reset shall apply to the RT electronics only: the host electronics or computer shall be unaffected.

MIL-110 / T

The RT shall ensure that no disturbances of message exchanges occur after the "Reset RT" because of residual RT data or flags.

6.3.8 Transmit Vector Word (optional)

MIL-112 / T

If "Service Request" bit and "Transmit Vector Word" mode code are necessary for asynchronous operations of an RT unit, the RT shall implement and respond to valid "Transmit Vector Word" mode code as required by [SD1].

MIL-113 / T

*The format of the Vector Word associated with an asynchronous **message** demand from the RT shall be as specified in the table below:*

Field Name	Bit No.	Description
Format Flag	0	Shall be set to logic "0" to indicate "asynchronous message demand"
Reserved	1	*reserved: shall be set to logic "0"*
	2	*reserved: shall be set to logic "0"*
	3	*reserved: shall be set to logic "0"*
	4	*reserved: shall be set to logic "0"*
T/R	5	Shall be set to a logic "1" to indicate that the requested message is a transmit command. (Logic "0" indicates a receive command request.)
Subaddress	6	*MSB*
	7	
	8	contain the subaddress of the required message
	9	
	10	*LSB*
Word Count	11	*MSB*
	12	
	13	contain the word count of the required message
	14	
	15	*LSB*

Figure 6.3-1*: Vector Word Format for Asynchronous Message Demand from RT*

MIL-116 / T

*The format of the Vector Word associated with an asynchronous **action** demand from the RT shall be as specified in the table below. Should a RT use this Vector Word format, the "User defined" bit content and meaning shall be specified by the RT supplier in the RT Unit Interface Control Document (ICD).*

Field Name	Bit No.	Description
Format Flag	0	Shall be set to logic "1" to indicate "asynchronous action demand"
Notification Flag	1	User defined
	2	User defined
	3	User defined
	,,,	,,,
	13	User defined
	14	User defined
	15	User defined

Figure 6.3-2*: Vector Word Format for Asynchronous Action Demand from RT*

6.3.9 Transmit Last Command Word (optional)

MIL-120 / T

If "Transmit Last Command Word" mode code is necessary for the operations of an RT unit, RTs shall implement and respond to valid "Transmit Last Command Word" mode code as required by [SD1].

6.3.10 Transmit RT Built-In-Test (BIT) Word (optional)

MIL-122 / T

If "Transmit RT BIT Word" mode code is necessary for the operations of an RT unit, RTs shall implement and respond to valid "Transmit BIT Word" mode code as required by [SD1].

6.4 Status Word

MIL-124 / T

Status words shall be as defined by [SD1].

MIL-125 /

The use of the Status Word bits shall be as specified in the table below:

RT Status Bits	Meaning	Use on AS250
Message Error bit	indicates that message failed to pass RT's validity tests	**yes**
Instrumentation bit	not used	no
Service Request bit	indicates that RT requests predefined action (see "Transmit Vector Word" mode	optional
Broadcast Command Received bit	indicates that preceding valid command w as a broadcast command	**yes**
Busy bit	indicates that the RT is unable to receive or transmit in response to a BC command	no
Subsystem Flag bit	indicates a subsystem fault	optional
Dynamic Control Acceptance bit	indicates acceptance by an RT to become BC	no
Terminal Flag bit	indicates an RT fault	optional

6.4.1 Message error bit

MIL-128 / T

The RT shall use the Message Error Bit *in the status word to indicate all errors as specified in chapter 4.3.3.5.3.3 of [SD1] (word validation, transmission continuity, illegal command, invalid data reception)*

MIL-129 /

The message error bit shall remain set to 1 until a new valid command, other than 'transmit last status', is received by this RT.

6.4.2 Instrumentation bit

MIL-131 / T

The instrumentation bit shall not be used and shall be set to logic 0.

MIL-132 / R

The flight software shall ignore the instrumentation bit.

6.4.3 Service Request bit (optional)

MIL-134 / T

If the Service Request bit is necessary for the operations of an RT unit, the Service Request bit shall be implemented and used as defined in [SD1].

MIL-135 / T

The Service Request bit shall not be used to identify service requests for periodic message transmissions.

MIL-136 /

The optional use of the "Service Request" bit shall be submitted to the same restrictions as those specified for the "Transmit Vector Word" mode code.

MIL-137 / R

If there is only one possible message or action for an RT that asserts the "Service Request" bit, then the flight software shall know what action is required without any need for "Transmit Vector Word" mode command. The RT Unit ICD submitted by the RT contractor shall specify that message/action.

MIL-138 / T

If there are multiple possible actions/messages for an RT that asserts the "Service Request" bit, then the flight software will use the "Transmit Vector Word" mode command. The vector word shall define the action requested by the RT unit. The RT Unit ICD submitted by the RT contractor shall specify vector word meaning.

6.4.4 Broadcast command received bit

MIL-140 / T

The Broadcast Command Received bit shall be set to a logic one to indicate that the preceding valid command word was a broadcast command and a logic zero shall indicate it was not a broadcast command.

MIL-141 / T

Note. The broadcast command received bit shall be reset when the next valid (non-broadcast) command is received by the remote terminal, unless the next valid command is a transmit status word or transmit last command mode command.

6.4.5 Busy bit

MIL-143 / T

The busy bit shall not be used and shall be set to logic 0.

6.4.6 Subsystem flag bit

MIL-145 / T

The use of the subsystem flag bit is optional and shall be cleared to a logic 0 if not used.

MIL-146 / T

The RT shall use the Subsystem Flag Bit *in the status word to indicate a RT subsystem fault condition as specified in chapter 4.3.3.5.3.9 of [SD1]*

MIL-147 / T

The flight software shall process the setting of the subsystem flag bit.

6.4.7 Dynamic bus control acceptance bit

MIL-149 / T

The Dynamic Bus Control bit shall not be used and shall be set to logic 0.

6.4.8 Terminal flag bit

MIL-151 /

The use of the terminal flag bit is optional and shall be cleared to a logic 0 if not used.

MIL-152 / T

The RT shall use the Terminal Flag Bit *in the status word to indicate a RT fault condition as specified in chapter 4.3.3.5.3.11 of [SD1]*

MIL-153 /

The flight software shall process the setting of the terminal flag bit.

6.5 Message Validation

MIL-155 / T

A Message, which fulfils one or more of the following criteria, is declared as invalid if:

- *One or more invalid words*
- *Discontinuous data (a condition where a gap exists between any two data words, between the command word and next data words, or between the status word and the last data words)*
- *Incomplete messages, i.e. a word count error occurred or the status word is not responded*
- *The structure of the message is not as defined in [SD1]*
- *Timeout occurred*

A message, for which none of the above criteria applies, is declared as valid.

6.6 Illegal Message

MIL-157 / T

An illegal message is a message that meets all word and message validation requirements but is not defined in this document, i.e. the command issued to the RT is not implemented.

The BC shall ensure that no illegal commands are sent out. The RT shall verify Mode Commands for illegal commands.

MIL-158 / T

In case a RT receives an illegal message it should neither fail nor act faulty. The illegal message shall be discarded and the event of its reception shall be reported to the application.

MIL-159 / T

A RT shall not be disturbed by the reception of a broadcast command if it does not handle this mode code.

6.7 Error handling

MIL-161 / T

The BC shall detect and signal a time-out condition in case of no or late response from the RT.

MIL-162 /

If a time-out condition is detected by the BC, the flight software shall report to higher level that the transfer has failed.

MIL-163 / T

The flight software shall evaluate the following bits of the status word of each Mil-Bus transfer and report to higher level that the transfer has failed :

- *message error bit*
- *subsystem flag bit*
- *terminal flag bit*

7. TRANSPORT LAYER REQUIREMENTS

The Transportation Layer will have two implementations to respect the specific needs of intelligent and non-intelligent RT's. Intelligent units will communicate via a Block Transfer protocol whereas non-intelligent units may use standard BC - RT and RT - BC transfers via dedicated sub-addresses.

MIL-166 / T

The sub-address assignment for units following the data exchange protocol shall be according to Table 6.7-1 :

SUB-ADDRESS		TRANSMITTED BY RT	RECEIVED BY RT
DEC	BIN		
0	00000	Not used	Not used
1	00001	Health Monitoring	Terminal Configuration
2	00010		
3	00011		
4	00100		
5	00101		
6	00110		
7	00111		
8	01000	Not used	Not used
9	01001		
10	01010		
11	01011	Acquisition Data Block 1	Distribution Data Block 1
12	01100	Acquisition Data Block 2	Distribution Data Block 2
13	01101	Acquisition Data Block 3	Distribution Data Block 3
14	01110	Acquisition Data Block 4	Distribution Data Block 4
15	01111	Acquisition Data Block 5	Distribution Data Block 5
16	10000	Acquisition Data Block 6	Distribution Data Block 6
17	10001	Acquisition Data Block 7	Distribution Data Block 7
18	10010	Acquisition Data Block 8	Distribution Data Block 8
19	10011	Acquisition Data Block 9	Distribution Data Block 9
20	10100	Acquisition Data Block 10	Distribution Data Block 10
21	10101	Acquisition Data Block 11	Distribution Data Block 11
22	10110	Acquisition Data Block 12	Distribution Data Block 12
23	10111	Acquisition Data Block 13	Distribution Data Block 13
24	11000	Acquisition Data Block 14	Distribution Data Block 14
25	11001	Acquisition Data Block 15	Distribution Data Block 15
26	11010	Acquisition Data Block 16	Distribution Data Block 16
27	11011	BC=>RT Distribution Transfer Confirmation	BC=>RT Distribution Transfer Descriptor
28	11100	RT=>BC Acquisition Transfer Requests	RT=>BC Acquisition Transfer Confirmations
29	11101		Time Message from OBC (broadcast mode)
30	11110	Data Wrap Read (MIL-STD-1553 chapter 30.0)	Data Wrap Write (MIL-STD-1553 chapter 30.0)
31	11111	Reserved for Mode Commands	Reserved for Mode Commands

Table 6.7-1: Sub-Address Usage for units following the data exchange protocol

MIL-169 / T

The sub-address assignment for non-intelligent units shall be according to the Table 6.7-2 :

SUB-ADDRESS		TRANSMITTED BY RT	RECEIVED BY RT
DEC	BIN		
0	00000	Not used	Not used
1	00001	Read user defined data block 0	Low level command or execute user defined action
2	00010	Read user defined data block 1	High power command or execute user defined action
3	00011	Read user defined data block 2	Execute user defined action
4	00100	Read user defined data block 3	Execute user defined action
5	00101	Read user defined data block 4	Send data block or execute user defined action
6	00110	Read user defined data block 5	Control data transfer or execute user defined action
7	00111	Read user defined data block 6	Execute user defined action
8	01000	Read user defined data block 7	Execute user defined action
9	01001	Send register(s) content	Read register
10	01010		Write register(s)
11	01011	Read data in memory block 0	Write data in memory block 0
12	01100	Read data in memory block 1	Write data in memory block 1
13	01101	Read data in memory block 2	Write data in memory block 2
14	01110	Read data in memory block 3	Write data in memory block 3
15	01111	Read data in memory block 4	Write data in memory block 4
16	10000	Read data in memory block 5	Write data in memory block 5
17	10001	Read data in memory block 6	Write data in memory block 6
18	10010	Read data in memory block 7	Write data in memory block 7
19	10011	Read data in memory block 8	Write data in memory block 8
20	10100	Read data in memory block 9	Write data in memory block 9
21	10101	Read data in memory block 10	Write data in memory block 10
22	10110	Read data in memory block 11	Write data in memory block 11
23	10111	Read data in memory block 12	Write data in memory block 12
24	11000	Read data in memory block 13	Write data in memory block 13
25	11001	Read data in memory block 14	Write data in memory block 14
26	11010	Read data in memory block 15	Write data in memory block 15
27	11011	Read checksum	Execute memory checksum
28	11100	Read user defined data block 8	Execute user defined action
29	11101		Time Message from OBC (broadcast mode)
30	11110	Data Wrap Read (MIL-STD-1553 chapter 30.0)	Data Wrap Write (MIL-STD-1553 chapter 30.0)
31	11111	Reserved for Mode Commands	Reserved for Mode Commands

Table 6.7-2: Sub-Address Usage for non intelligent units

7.1 MIL BUS Operation

MIL-173 / T

The OBC software shall implement a periodic, deterministic Mil-Bus scheduler supporting synchronous and asynchronous data transfers.

MIL-174 / T

The Mil-Bus scheduler shall implement major and minor frames synchronized to the on-board time OBT.

MIL-175 / T

Major frames shall have a period of 1 second, divided into 16 minor frames of 62,5 ms.

MIL-176 / T

Each minor frame shall provide a polling list of Mil-Bus messages. The polling list shall allow specification of delays between the different messages to support the implementation of low level protocols with non-intelligent remote terminals.

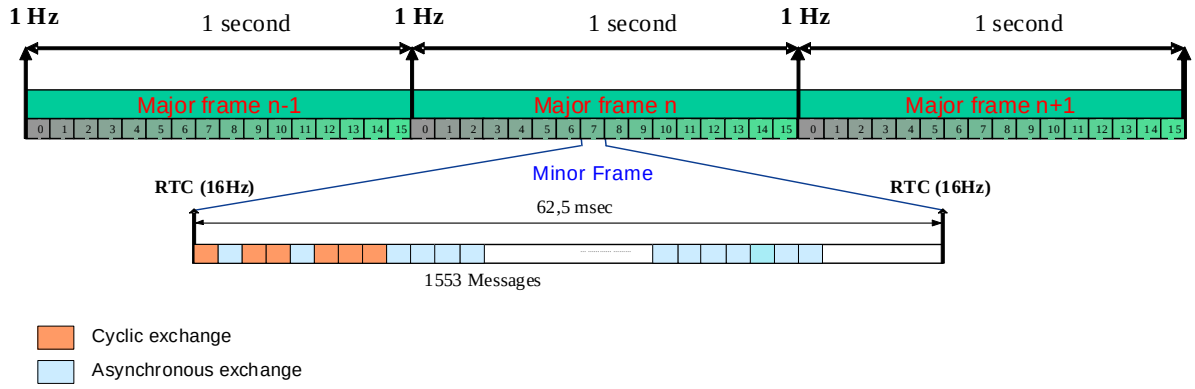


Figure 7.1-1: Major and Minor Slot timing

MIL-179 / T

The minor frame with number 0 shall be synchronized with the 1Hz system clock.

7.2 Services and Protocol specification

7.2.1 Synchronization of RT

Three schemes are possible on board for synchronising, from the BC, the RT local unit time reference:

- **"Sync" Mode Code procedure**, which is exclusively based on 1553 messages exchanges: a OBT distribution command followed by a "Synchronize" mode command. No discrete sync pulses (PPSn) here exist for the purpose of RT time reference synchronization to the central OBT.
- **"Sync with DW" Mode Code procedure**, which involves a periodic "Synchronization with Data Word" mode command issued by the BC upon occurrence of the 1 Hz or 16 Hz interrupt within the OBC.
- **SYNC-based procedure**, which involves a OBT distribution command followed by the generation of a sync pulse (SYNC) from the BC to the RT.

MIL-183 / R

Only the SYNC-based procedure shall be used on board Astrosat 250.

7.2.1.1 "Synchronize with Data Word" Mode Code procedure

MIL-185 / T

RTs that use the "Sync with DW" mode code for the synchronization shall implement and respond to valid "Synchronize with Data Word" mode code as required by [SD1].

MIL-186 / T

For OBT-synchronized RTs, the BC shall distribute the OBT at the specified subaddress of a RT such that the next "Synchronize without DW" mode code sent to this RT indicate the OBT of the mode code sending over the bus.

Nota : it is not required that the unit uses, if not necessary, the OBT distributed at the specified subaddress.

MIL-187 / R

The OBT shall be sent at minimum 30ms before the "synchronization with data word" mode code sending.

MIL-188 / R

When "Synchronize with Data Word" is used, the Synchronize with Data Word mode command shall be the first MIL-Bus message within each minor frame.

MIL-189 / T

Should "Synchronize with Data Word" be used for a given RT, the data word of the "Synchronize with Data Word" shall define the major frame or minor frame number in which the "Synchronize with Data Word" is transmitted.

MIL-190 / T

Should "Synchronize with Data Word" be used for a given RT, it shall be done in accordance with the format specified below:

MIL-191 /

WORD TYPE	FORMAT	MSB VALUE	LSB VALUE
TIME DATA	Unsigned integer	0	0: major frame 1: minor frame #1 2: minor frame #2 3: minor frame #3 4: minor frame #4 5: minor frame #5 6: minor frame #6 7: minor frame #7 8: minor frame #8 9: minor frame #9 10: minor frame #10 11: minor frame #11 12: minor frame #12 13: minor frame #13 14: minor frame #14 15: minor frame #15

Figure 7.2-1*: "Sync with Data Word" Time Data Format*

MIL-193 / T

On receipt of the "Synchronize with Data Word" mode code, the RT shall :

•either synchronize the unit with the OBT previously received

•or trigger a synchro signal to the unit depending on the attached data word content

7.2.1.2 "Synchronize" Mode Code Procedure

MIL-195 / T

For OBT-synchronized RTs, the BC shall distribute the OBT at the specified subaddress of a RT such that the next "Synchronize" mode code sent to this RT indicate the OBT of the mode code sending over the bus.

Nota : it is not required that the unit uses, if not necessary, the OBT distributed at the specified subaddress.

MIL-196 / R

The OBT shall be sent at minimum 30ms before the "synchronize" mode code sending.

MIL-197 / T

On receipt of the "Synchronize" mode code, the RT shall :

•either synchronize the unit with the OBT previously received

•or trigger a synchro signal to the unit

7.2.1.3 Synchronization with SYNC-based procedure

MIL-199 / T

For SYNC-synchronized RTs, the BC shall distribute the OBT at the specified subaddress of a RT such that the next SYNC is sent to this RT at the indicated OBT.

MIL-200 / R

The OBT shall be sent at minimum 30ms before the SYNC reception by this RT.

7.2.1.4 Time message

MIL-202 / T

*The BC shall send the OBT via broadcast receive command to **SA29R**.*

MIL-203 / T

The time information shall represent the OBT valid at the next SYNC or next message containing a "Synchronize' (with or without data)mode code.

MIL-204 / T,R

The time format shall be CUC with Agency defined epoch with Coarse Time (seconds) using 4 octets and three octets for fine time. (see Figure 7.2-2)

PTC=9; PFC=18;

The P-Field shall be 0010_1111bin.

p-field code:

•Bit 0 = extension bit (0=no extension)

•Bit 1-3 = Time code Id (001 - 1/1/1958 ; 010 - Agency defined epoch)

•Bit 4-5 = NbOf bytes of coarse time - 1

•Bit 6-7 = NbOf bytes of fine time

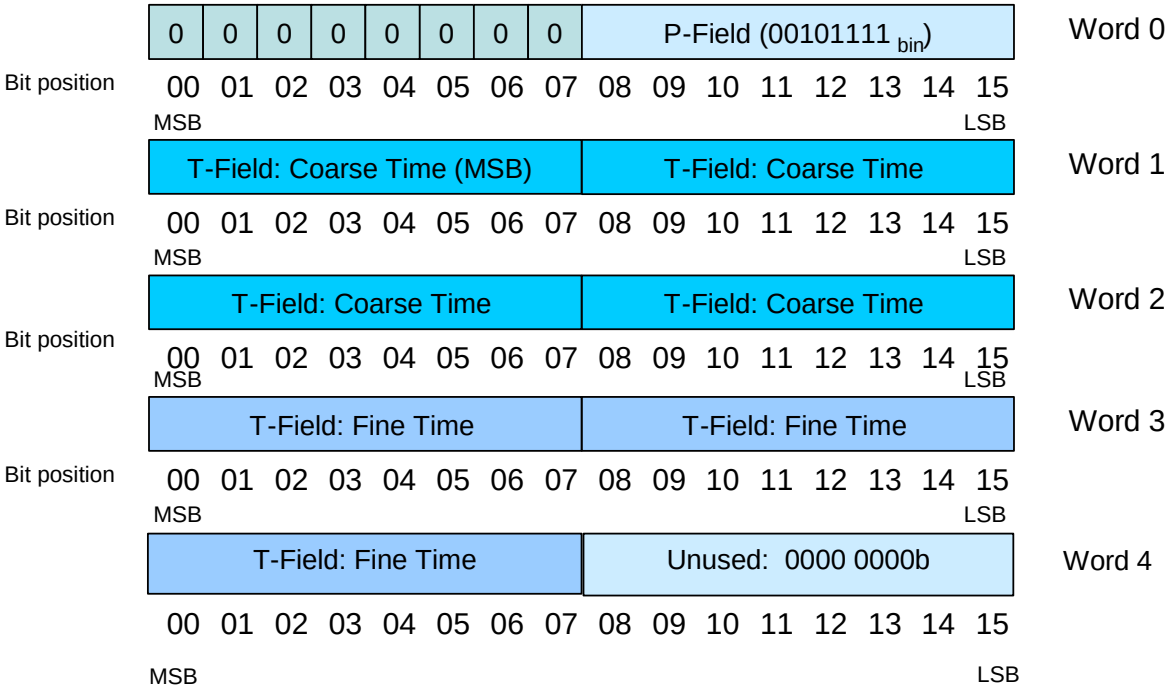


Figure 7.2-2: Data Word format of Time Distribution Message

7.3 Data Block Transfer

MIL-210 / T

Date block exchange shall be possible in both directions (BC => RT and RT=> BC) in quasi parallel.

Note that in parallel means from the application point of view, the physical bus access is serial interleaved.

For transfer of data, two ways of using the 1553 subaddresses are supported:

•"Flat" sub-addressing, where different subaddresses are used to transfer different sections of the transmitted data block. In this mode the maximum block length that can be transmitted is 1024 bytes and this standard defines the subaddresses to be used.

•"Deep" sub-addressing, where a single subaddress is used to transfer different sections of the transmitted data block. In this mode the maximum block length that can be transmitted is 4096 bytes and the subaddress usage is determined by the RT design.

MIL-214 / T

The transfer size for data transfers shall be in the range from 1..1024 bytes. All other values shall be rejected and the protocol error bit will be set in the confirmation. Transfer size shall be zero only in case of protocol reset.

Note: It is subject to application layer to handle this kind of error.

MIL-216 / T

All data blocks shall be aligned to 16-bit boundaries to fulfil the constraints derived from the Mil-Bus specification.

MIL-217 / T

If the transfer size specified in the transfer descriptor has an odd number of bytes, the sender shall automatically add a zero byte at the end of the data block. The receiver shall ignore this byte.

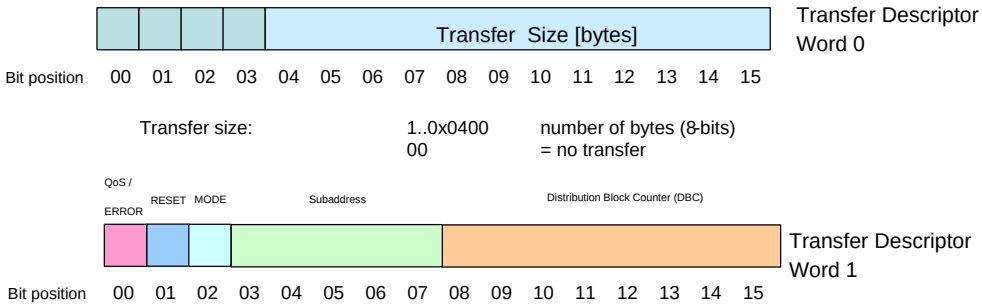
MIL-218 / T

The Transfer Descriptor format as shown in Figure 7.3-1 shall be used to exchange Acquisition Transfer Requests, Distribution Transfer Descriptors, Distribution Transfer Confirmations and Acquisition Transfer Confirmations.

Note: for acquisition/distribution transfer request, the receiver will not change the block number and the transfer size of the request in the confirmation to the request.

MIL-220 / T

Transfer Descriptors, Requests and Confirmations shall have the layout as shown in Figure 7.3-1.



QoS /Error:	***Q**uality **o**f **S**ervice:*	0x00 …. Best effort (not used)
	(for requests)	0x01 …. Verified data length (default)
	Error:	0x00 …. No error detected
	(for confirmations)	0x01 …. Incorrect number of bytes received
	Note: If RESET = 0x01, this bit is set to 0x00	
RESET:		0x00 …. Protocol carries ON
	(for requests)	0x01 …. Protocol with this RT is RESET
	(for confirmations)	0x01 …. Protocol RESET with this RT is carried out
MODE:	(for requests)	0x00 …. Multiple SA's are used for transfer
		0x01 …. Single SA used for transfer
	(for confirmatios)	This field is a copy from related request
	Note: If RESET = 0x01, this bit is set to 0x00	
SUBADDRESS:	(for requests)	In case the MODE flag is 0x01 this data field is used to indicate to which SA the data is written. Otherwise the field shall be set to 0x0B (SA11)
	(for confirmatios)	This field is a copy from related request
	Note: If RESET = 0x01, this bit is set to 0x00	
DBC:	(for requests)	This is field is a circular 8bit counter, identifying the current data block
	(for confirmatios)	This field is a copy from the related request
	Note: If RESET = 0x01, this bit is set to 0x00	

Figure 7.3-1: Transfer Descriptor, - Request and -Confirmation Format

MIL-223 / T

Two different transfer types shall be selectable:

•*If* MODE *is set to 0x01 all data are expected to be sent or received to/from the subaddress indicated by the SA field.*

•*If* MODE *is set to 0x00, the sub-address is incremented after each Mil-Bus message by 1 until maximum* ***SA26****, starting from* ***SA11***

MIL-224 / T

The MODE *= 0x00 shall be the default.*

MIL-225 / T

The BC shall support MODE *0x00 and 0x01.*

MIL-226 / T

RT's shall support at least the default.

MIL-227 / T

The MODE *shall be a configuration parameter and be fixed for a RT during the mission.*

MIL-228 / T

For Blocks with blockcount=*n,* RESET = *0x01 the protocol shall be reset.*

This means the receiver shall accept packet blockcount = *n+1 for the next request. The receiver shall answer to the reset request with a packet transfer confirmation { 0x0000, 0x8000 // 0x0<n>) }.*

MIL-229 / T

The BC shall issue a protocol reset to all RT's before starting communication to RT's.

MIL-230 /

The RT shall issue a protocol reset to the BC before starting nominal communication to BC.

MIL-231 / T

The receiver shall check the correct sequence of block counts. In case of mismatch it shall set the error bit in the confirmation.

Note: According to Figure 7.3-2 and Figure 7.3-4, requests with the same block count as the last accepted one are not considered as mismatch. In this case, the request is simply ignored.

Note: It is subject of the application layer to handle this kind of error.

MIL-234 / T

If data blocks are longer than 32 16-bit words, segmentation into different Mil-Bus messages shall be applied.

MIL-235 / T

Data blocks shall be segmented consecutively into Mil-bus messages of 32-words (64 bytes) as long as the remaining data are >= 32 words (64-bytes).

MIL-236 / T

If necessary the last message shall be shorter according to the remaining amount of data to be transferred.

MIL-237 / T

It shall be possible to schedule at least one data block transfer per minor frame in both directions (RT=>BC; BC=>RT) to all RT's.

MIL-238 / T

A read and write data block operation as shown in Figure 7.3-3 and Figure 7.3-5 shall always be finished within one minor-frame.

Note: This is guaranteed by the minor-frame utilization requirement of 75%.

MIL-240 / T

Block Transfer Data to be transferred in minor-frame i *shall be compiled in minor-frame* i-1.

MIL-241 / T

The ERROR *bit in the data structure as defined Figure 7.3-1 shall be used to signal error on data block level.*

MIL-242 / T

The BC shall count the number of status word responses to verify that the correct number of messages have been received/sent by the RT.

Any mismatch shall be reported to the applications.

MIL-243 / T

The RT shall verify that the correct number of data bytes have been received according the Distribution Transfer Descriptor.

MIL-244 / T

In case of a mismatch a protocol error shall be indicated in the Distribution Transfer Confirmation.

MIL-245 / T

The BC shall verify that the correct number of bytes have been received according the Acquisition Transfer Request.

MIL-246 / T

In case of a mismatch a protocol error shall be indicated in the Acquisition Transfer Confirmation.

MIL-247 / T

Inconsistent Acquisition Transfer Requests and Distribution Transfer Descriptors like:

- *Illegal* Transfer Size
- *Illegal* MODE
- *Block counter not in sync*

shall be ignored without any data transfer and reported to the application S/W.

The Error *flag within the* Transfer Confimation Structure *(Figure 7.3-1) shall be set accordingly.*

7.3.1 RT to BC Transfer Protocol

MIL-249 / T

RT to BC protocol shall be used to transfer data packets from RT's to BC.

Note: The protocol does not care of any format of the data to be transferred. This shall be handled on presentation/application layer.

MIL-251 / T

The data blocks from RT to BC shall be transferred according to the following procedure:

- *RT stores the telemetry packet into the sub address buffer(s).*
- *RT prepares the Acquisition Transfer Request (Figure 7.3-1), by first writing the number of bytes (excluding the zero fill byte) into* transfer_size. *Second writing* QoS, RESET, Mode, SA *and* DBC *into* ***SA28T****.*
- *BC polls the request by issuing a Transmit command to* ***SA28T*** *(2 words)*
- *BC checks for new requests by, checking* DBC *and by comparing the received block count against the previous one (n+1) | 256.*
- *If it is a new and valid request, BC reads the data by setting up transmit commands according to the number of bytes + optional fill byte in the transfer request. (according to the selected transfer* MODE*)*

•*BC evaluates the status words of the transmit commands, updates the status in the control word and set the* transfer control = transmission finished.

•*BC sends the Acquisition Transfer Confirmation to RT* ***SA28R*** *according to Figure 7.3-1.*

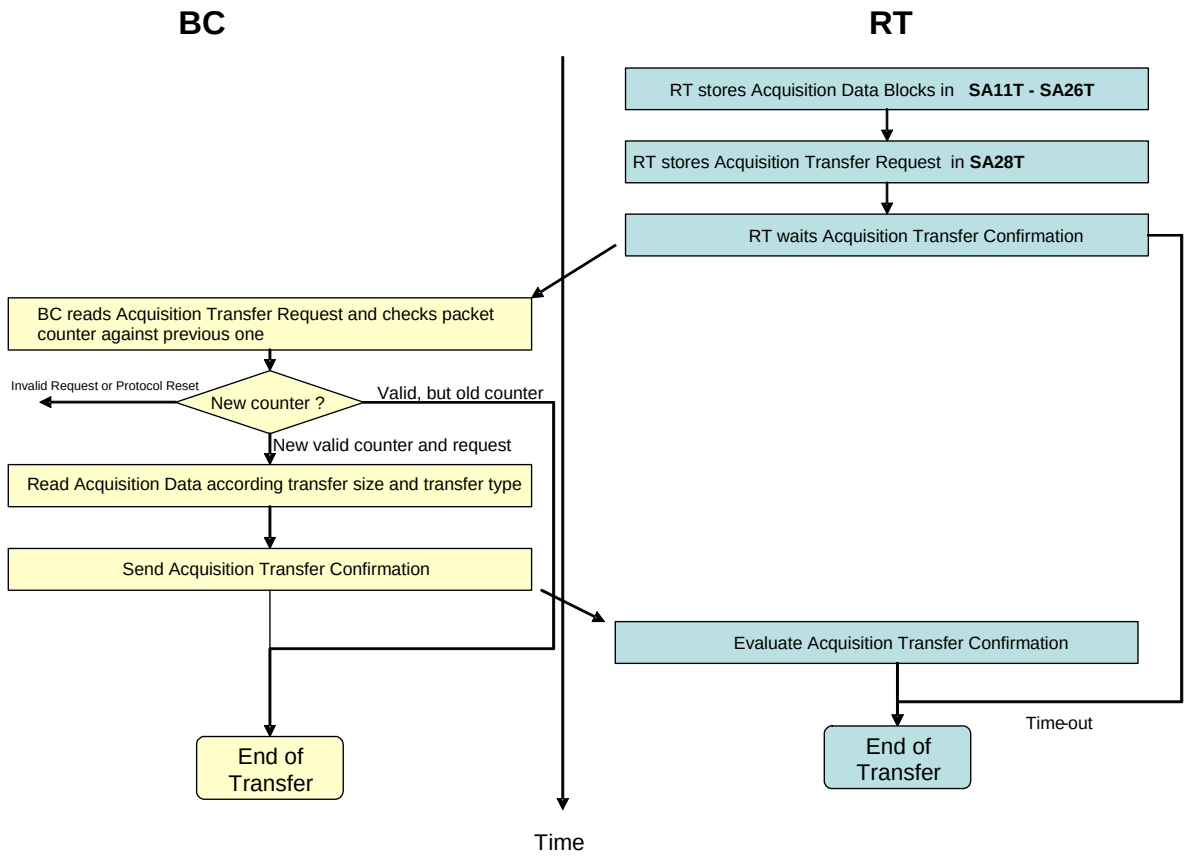


Figure 7.3-2: Control Flow RT to BC Data Block Transfer (simplified)

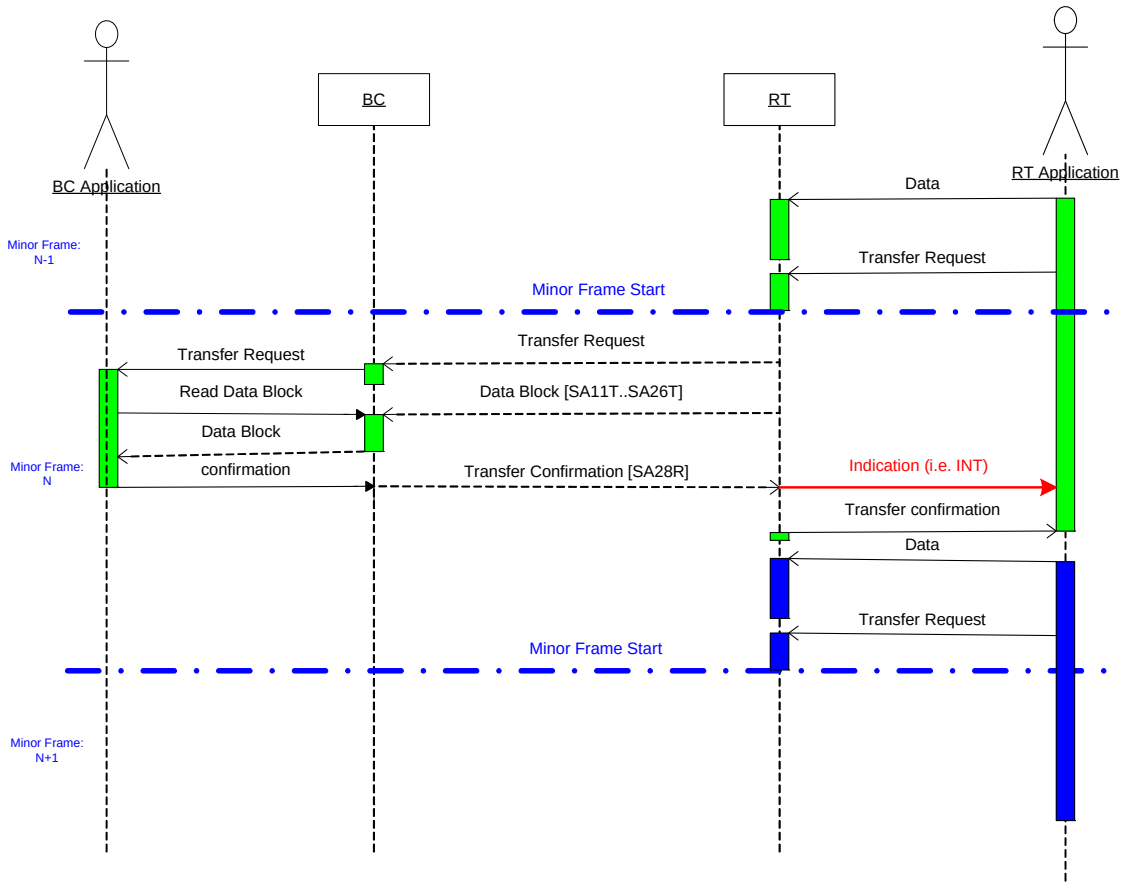


Figure 7.3-3: Sequence of RT to BC transfer (simplified)

MIL-256 / T

BC shall send the Transfer Confirmation for RT requests according to Figure 7.3-3 ***10msec*** *before start of the minor frame N+1 at latest.*

MIL-257 / T

The RT shall declare the Transfer Request as ***failed*** *if the Transfer Confirmation is not received at the beginning of minor frame N+1. (see Figure 7.3-3)*

7.3.2 BC to RT Transfer Protocol

MIL-259 / T

BC to RT protocol shall be used to transfer data blocks from BC to RT's.

Note: The protocol does not care of any format of the data to be transferred. This shall be handled on presentation/application layer.

MIL-261 / T

The data blocks shall be transferred according to the following procedure:

•*BC sends the data blocks to the RT by issuing a number of receive commands according to the selected transfer* MODE *for this RT.*

•*BC prepares the Distribution Transfer Descriptor (Figure 7.3-1), by first writing the* number of bytes *(excluding fill byte) into* transfer_size.*SSecond writing* QoS, RESET, Mode,SA *and* DBC *into* ***SA27R****.*

•*RT reads the request (interrupt or polling)*

•*RT checks if the request is a new one by comparing the received block count against the previous one (n+1) | 256.*

•*If it is a new request, RT reads the data from the internal Mil-bus buffers into memory*

•*RT updates the Distribution Transfer Confirmation (Figure 7.3-1) in* ***SA27T***

•*BC reads the Distribution Transfer Confirmation (Figure 7.3-1) sub-address* ***SA27T*** *to evaluate the transfer flow*

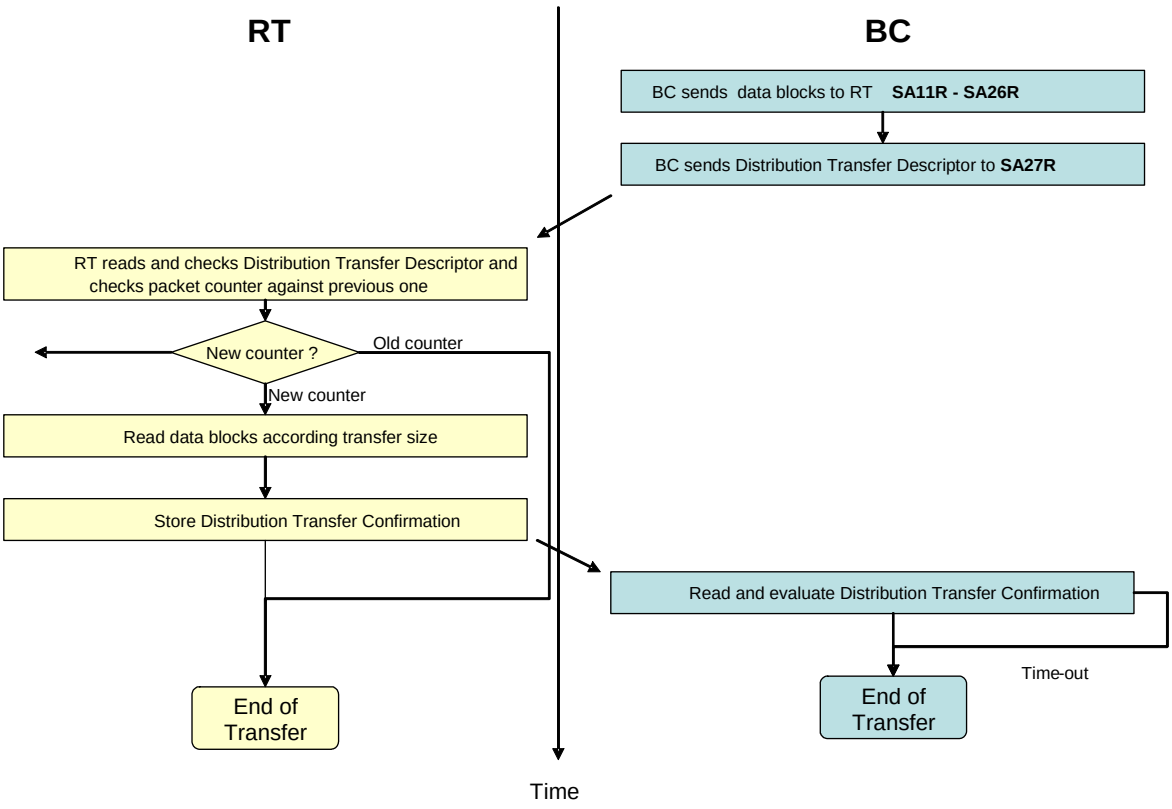


Figure 7.3-4: Control Flow BC to RT Data Block Transfer (simplified)

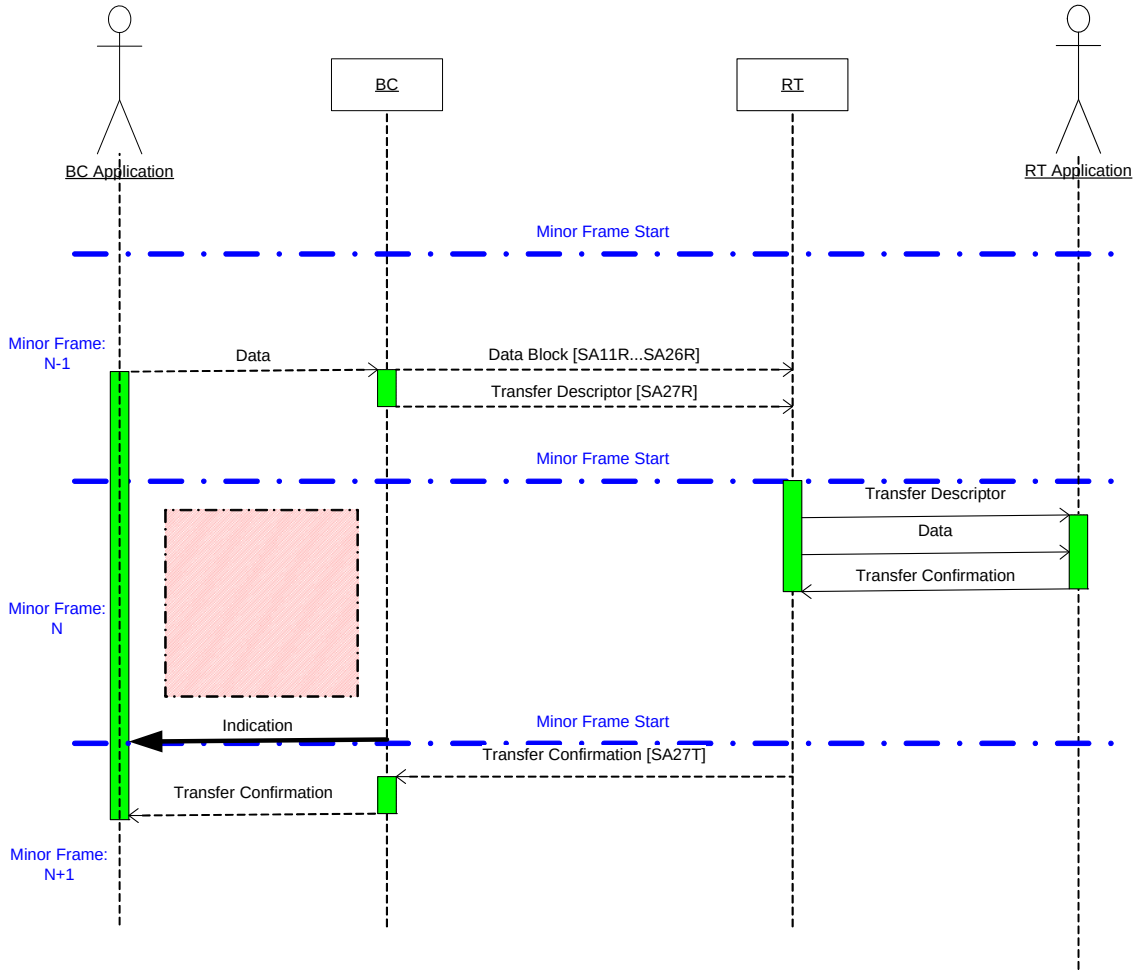


Figure 7.3-5: Sequence of BC to RT transfer (simplified)

MIL-266 / T

*The BC shall declare the transfer as **failed** if the Transfer Confirmation is not received at the beginning of the minor frame N+1 following the BC request. (see Figure 7.3-5)*

Note: The BC will poll for RT confirmation once at the beginning of each sub-frame. A transfer each cycle as required can only be achieved if the RT provides the confirmation at the **first** minor frame following the BC request.

MIL-268 / T

The receiving RT shall provide the Distribution Transfer Confirmation within minor frame N following the BC Distribution Transfer request. (see Figure 7.3-5)

7.4 SetData / GetData Service (Simple Subscribers)

MIL-270 / T

BC shall support the implementation of low level commanding and data acquisition from non-intelligent units by direct receiving or transmitting data from/to dedicated sub-addresses for simple and extended subscribers.

MIL-271 / T

The RT shall autonomously prepare the messages to be transferred to the BC, on BC request in the form of a receive command on a dedicated sub-address (data acquisitions not managed by BC at RT level).

MIL-272 / T

For simple subscribers the BC will write to the sub-address or read from the sub-address using simple MIL-STD-1553 BC-to-RT or RT-to-BC commands.

MIL-273 / T

The RT shall be responsible to provide the data within a specified time.

Note: Waiting times are expected to be specified in the unit ICD.

MIL-362 / R

If low level commands are generated by the unit, the sub-address 1 shall be used to control this action.

MIL-363 / R

If high power command are generated by the unit, the sub-address 2 shall be used to control this action.

MIL-364 / R

If data block of less than 60 bytes have to be sent to an external user, the sub-address 5 shall be used to control this action.

MIL-365 / R

If data transfer shall be controlled by the unit, the sub-address 6 shall be used to control this action.

Nota : if the number of sub-addresses reserved for user defined commands is not sufficient, sub-addresses reserved for the command 'write data in memory block N' can be used after authorization of the Prime.

7.4.1 Low level command

MIL-276 / T

The 'low level command' command shall be used to generate a low level command.

MIL-277 /

The 'low level command' command word shall contain a data word count equal to 1.

MIL-278 / T

The data word shall contain the following data fields :

- *bits 0-1 : type of the low level command*
  - *if equal to 00, it indicates a monostable command,*
  - *if equal to 11, it indicates a bistable command*
- *bits 2-3 : action to be done on the low level command*

- *if equal to 00, the action is to deactivate the monostable command*
- *if equal to 11, the action is, following the type of command, either to activate the monostable command or to start the bistable command*

- *bits 4-15 : number of the low level command to be issued, the bit 15 being an odd parity bit calculated on the bits 4 to 14 (i.e. equal to 1 if all the bits 4 to 14 are equal to 0)*

7.4.2 High power command

MIL-280 / T

The high power command' command shall be used to generate a high power command.

MIL-281 / T

The 'high power command' command word shall contain a data word count equal to 1.

MIL-282 / T

The data word shall contain the following data fields :

- *bits 0-3 : type of the high power command*
  - *if equal to 0000, it indicates a standard high power command,*
  - *if equal to 1111, it indicates an extended high power command*
- *bits 4-15 : number of the high power command to be issued, the bit 15 being an odd parity bit calculated on the bits 4 to 14 (i.e. equal to 1 if all the bits 4 to 14 are equal to 0)*

7.4.3 Read user defined data block N

MIL-367 / R

The 'read user defined data block N' command shall be used to read a defined data block, data being either memory content or register content, the number of words in the data block being maximum 32.

MIL-368 / T

The 'data word count' field of the command word shall indicate the number of memory contents or register contents to be sent.

MIL-369 /

The content of the data block read with the 'read user defined data block N' command shall be included in the unit ICD.

7.4.4 Execute user defined action

The sub-addresses of the 'execute user defined action' commands are reserved for commands specific to a dedicated unit.

MIL-372 /

The structure and the effect of these commands shall be included in the unit ICD.

7.4.5 Send data block

The 'send data block' command is used to send a limited number of data (up to 60 bytes) to an external user with a dedicated protocol (UART, memory load command ...).

MIL-285 / T

The 'distribute data block' command shall allow the sending of a data block to an external user.

MIL-286 / T

The 'distribute data block' command word shall contain a data word count equal to n with n≥3 :

- *the first data word shall contain the following fields :*
  - *Bits 0-3 : type of the link (UART, memory load command ...)*
  - *Bits 4-15 : number of the external link on which the data block shall be sent, the bit 15 being an odd parity bit calculated on the bits 4 to 14 (i.e. equal to 1 if all the bits 4 to 14 are equal to 0)*
- *the second data word shall contain the number of octets to transfer*
- *the following data words shall contain the data words to be sent on the external link.*

MIL-287 / T

The data shall be sent on the external link in the order they are received from the Mil-Std-1553 bus, i.e. :

- *if the transmission is done word after word, the first word sent on the external link shall be the third data word of the message and so on.*
- *if the transmission is done byte after byte, the first byte sent on the external link shall be the MSbyte of the third data word of the message, the second byte sent on the external link shall be the LSbyte of the second data word of the message, and so on.*

7.4.6 Control data transfer

MIL-289 / T

The 'control data transfer' command shall be used to control a data transfer (start of a data block transfer, reset a link, start the acquisition of a data list ...).

MIL-290 / T

The 'control data transfer' command shall contain n data words with n≥1.

MIL-291 /

The n data words shall indicate the action to execute.

MIL-292 / T

The first data word shall contain the following fields :

- *Bits 0-3 : type of action :*
  - *Start : bits 0-3 shall be equal to 1100*
  - *Stop : bits 0-3 shall be equal to 0011*
  - *Reset : bits 0-3 shall be equal to 0101*
- *Bits 4-7 : Type of transfer*
  - *Acquisition of a list of parameters : bits 4-7 shall be equal to 0101*
  - *Serial Data Transfer : bits 4-7 shall be equal to 0011*
  - *Memory load command : bits 4-7 shall be equal to 1001*
  - *UART-RX link : bits 4-7 shall be equal to 0110*

- *UART-TX link : bits 4-7 shall be equal to 1100*
- *UART-TX link : bits 4-7 shall be equal to 1010 (to be used when starting transmission if only the MSByte of the last word of a selected memory area shall be transmitted)*

- *Bits 7-15 : number of the link or parameter list to be controlled, the bit 15 being an odd parity bit calculated on the bits 4 to 14 (i.e. equal to 1 if all the bits 4 to 14 are equal to 0)*

7.4.7 Read register

MIL-295 / T

The 'read register' command shall be used to read the content of 32 registers having consecutive addresses.

MIL-296 / T

The 'read register' command word shall contain a data word count equal to 1.

MIL-297 / T

The 'read register' data word shall contain the address of the first register to be read.

MIL-298 / T

The content of the 32 registers shall be loaded in a dedicated memory block, the content of which being sent following the reception of the 'send register content'

MIL-299 / T

FFFFh shall be loaded in the memory block when there is no register at a given address.

7.4.8 Send register content

MIL-301 / T

The 'send register content' shall be used to transmit a part of the 32 registers loaded in a dedicated memory block by the 'read register' command.

MIL-302 / T

The 'data word count' field of the command word shall indicate the number of register contents to be sent.

7.4.9 Write register

MIL-304 / T

The 'write register' command shall be used to write the content of up to 31 registers having consecutive addresses.

MIL-305 / T

The write register' command word shall contain a data word count equal to n with $n \geq 2$:

- *the first data word shall contain the address ADR of the first register to be written*
- *the following data words shall contain the data words to be loaded at the addresses ADR, ADR+1...*

MIL-306 / T

The write access to a non existing register shall not disturb the functioning of the unit and the correct execution of the command.

7.4.10 Write data in memory block N

The command 'write data in memory block N' are used to store data in a memory pointed by a write pointer dedicated to this command. Having several commands of this type allows different OBC software applications running in parallel to write data in different part of the unit memory, each type of command being controlled by one software application.

MIL-309 / T

The 'write data in memory block N' command shall be used to load up to 32 16-bits words in the memory at the address ADR pointed by a write pointer dedicated to the memory block N.

MIL-310 / T

The 'write data in memory block N' command word shall contain a data word count equal to n with n≥1:

•the first data word shall contain either the information indicating if the LSByte of the last word has to be loaded (0000hexa indicates all the bytes shall be loaded and FFFFhexa indicates that only the MSbyte of the last word shall be loaded) if the memory is byte oriented or the data word to be written at the address ADR in case the memory is 16 bits word-oriented

•the following data words shall contain either the data words to be written at the addresses ADR, ADR+1 ...if the memory is byte oriented or the data words to be written at the addresses ADR+1, ADR+2 ... in case the memory is 16 bits word-oriented

*Nota : with a given 'write data in memory block N' command, it shall not be possible to load data in a memory which is byte-oriented **and** in a memory which is 16-bits word-oriented if the unit contains both memory types. In this case, the values of N allowing the loading of data in byte-oriented memory and the values of N allowing the loading of data in 16-bits word-oriented memory shall be indicated in the unit ICD.*

MIL-311 / T

The write pointer dedicated to the memory block N shall be incremented at the end of the execution of the command by the number of loaded bytes in case it is a memory which is byte-oriented or by the number of loaded data words in case it is a memory which is 16 bits word-oriented.

7.4.11 Read data in memory block N

The command 'read data in memory block N' are used to read data in a memory pointed by a read pointer dedicated to this command. Having several commands of this type allows different OBC software applications running in parallel to read data in different part of the unit memory, each type of command being controlled by one software application.

MIL-314 / T

The 'read data in memory block N' command shall be used to read up to 32 16-bits words in the memory at the address ADR pointed by a read pointer dedicated to the memory block N.

MIL-315 / T

Upon reception of such a command, the RT shall send the content of the memory cells at the addresses ADR, ADR+1 ...

MIL-316 / T

The read pointer dedicated to the memory block N shall be incremented at the end of the execution of the command by twice the number of words in case it is a memory which is byte-oriented or by the number of words in case it is a memory which is 16 bits word-oriented.

7.4.12 Execute memory checksum

MIL-318 / T

The 'execute memory checksum' command shall be used to request the calculation of the checksum on a part of the memory.

MIL-319 / T

The 'execute memory checksum' command word shall contain a data word count equal to 3 :

- *the first data word shall indicate the part of the last word to be checksummed :*
  - *if equal to 0000h, it indicates all the bytes shall be checksummed*
  - *if equal to FFFFh, it indicates that only the MSByte of the last word shall be checksummed, the LSByte taken into account for the calculation of the checksum being 00h*
- *the second data word shall indicate the first word to be checksummed*
- *the third data word shall indicate the number of words to be checksummed*

MIL-320 / T

Upon reception of this command, the RT shall calculate the checksum (XOR sum) and store the result in a dedicated register, the content of which being possible by the 'read checksum' command.

Note : for example, the checksum of the bytes 23, 69, BE, 34, 16 and B0 is equal to 8BED (=2369⊕BE34⊕16B0), the checksum of the bytes 23, 69, BE, 34 and 16 is equal to 8B5D (=2369⊕BE34⊕1600).

7.4.13 Read cheksum

MIL-322 / T

The 'read checksum' command shall be used to request the checksum on a part of the memory previously calculated after the reception of the 'execute memory checksum' command.

7.5 Health Status Messages

7.5.1 BC_Health Status to RT's

This option is not selected.

7.5.2 RT_Health Status to BC

MIL-327 / T

*The BC shall acquire health status information via MiL Bus message from the dedicated RT health status **sub-address 01 (SA01T)** from the RT's providing them.*

MIL-328 / T

The RT shall provide health status messages with configurable frequency up to 1Hz at maximum. The health status message of major-frame k *shall be compiled by the RT at major-frame* k-i *at latest. (i > 0).*

Values of i >1 shall be justified with Prime.

MIL-329 / T

The health status size shall fit into one Mil-Bus message. (max 32 16-bit words)

MIL-330 / T

The GetData service shall be used for acquisition of the RT_Health *and monitoring data.*

MIL-331 / T

The RT_Health *data shall be stored in Word 0 of* ***SA01T****.*

MIL-332 / T

Word 1 to 14 of ***SA01T*** *shall be reserved for complementary data, to be defined by the application.*

MIL-333 / T

Word 15 to 31 of ***SA01T*** *shall be reserved for RT configuration monitoring data, to be defined by the application.*

WORD N°	*DATA*
0	RT_Health Data Word
1	Latest Received Communication Frame Number (Minor Frame Number)
2 … 14	RT_Health & Monitoring Data
15 … … 31	RT configuration monitoring data

Table 7.5-1: SA24T *RT_Health* & Monitoring Data Definition

7.5.2.1 RT_Health data word definition

MIL-337 / T

A bit set to 1 in the RT_Health / BC_Health *data word shall indicate the presence of the specified failure report.*

MIL-338 / T

In case of no failure if a flag is not used or reserved, the bit shall have the value of '0'.

MIL-339 / T

Once set, a RT_Health *bit shall not be reset by the RT until reception of the terminal configuration command* Reset_RT_Health*.*

MIL-340 / T

The RT_Health *shall be defined as in Table 7.5-2.*

BIT	*REPORT*
0	Initialization completed
1	Initialization Failure
2	Inline Hardware test failure
3	SW failure
4	Real time execution failure
5	Watch dog set
6	Sensor Failure
7	Secondary voltage Failure
8	I/O failure
9	Internal I/F failure
10	Temporary failure on data
11	RT not synchronized
12	Reserved
13	Reserved
14	Reserved
15	Reserved

Table 7.5-2: *SA01T* ***RT_Health*** **data definition**

MIL-343 / T

The RT_Health *data definition shall be defined as:*

Initialization completed:
This bit shall be set after completion of an initialization of the RT.
Initialization Failure:
This bit shall be set after a failure during the initialization of the hardware or the software included in the remote terminal.
Inline Hardware test Failure :
This bit shall be set in case of detection of a RAM/EEPROM protection failure
Software Failure
This bit shall be set in case of detection of a software failure
Real time execution Failure :
This bit shall be set in case of detection of real time execution failure.
Watchdog Set :
This bit shall be set in case of a watch dog setting.
Sensor Failure :
This bit shall be set in case of failure detection on an external sensor connected to the Remote Terminal
Secondary Voltage Failure :
This bit shall be set in case of failure detection on the secondary voltage of the remote terminal.
I/O Failure :
This bit shall be set in case of failure detection on an I/O interface of the remote terminal.
Internal I/F Failure :
This bit shall be set in case of failure detection on internal interface of the remote terminal
Temporary failure on data :
This bit shall be set in case of failure detection on a data received and or managed by the remote terminal.
RT not Synchronized :
This bit shall be set by the application when errors are detected with time synchronization

7.5.2.2 Terminal Configuration Commands

MIL-345 / T

*The SetData service shall be used to send terminal configuration commands to **SA01R**.*

MIL-346 / T

Word 0 of **SA01R** *shall be reserved for the* Reset_RT_Health *command.*

WORD N°	*DATA*
0	*Reset_RT_Health* command
1	Not used
…	Not used
…	Not used
14	Not used
15	Not used
…	Not used
…	Not used
31	Not used

Table 7.5-3: *SA01R* ***Terminal Configuration Definition***

MIL-349 / T

The Reset_RT_Health *command shall reset the* RT_Health *data using mask bit pattern specified in the first word of* ***SA01R****.*

MIL-350 / T

The value '1' in a bit of the Reset_RT_Health *command word shall result in the reset of the corresponding bit of the* RT_Health *data.*

Note: A value of 'FFFF'H in the Reset_RT_Health command word results in the complete reset of the RT_Health data while a value '0000'H have no effect.

7.6 Data Wrap Around

MIL-353 / T

Each RT shall provide a service where the BC can issue a receive-command to ***SA30R*** *with one or N (n<=32) data words of any bit pattern.*

MIL-354 / T

A subsequent transmit-command from ***SA30T*** *with the same word count shall result in the transmission of the previously supplied data back to the BC.*

Note: No specific timing constraints shall be applied to this service. This feature is supported by some MIL-STD-1553 controller hardware.

8. ERROR HANDLING

MIL-357 /

TBD

CHANGE LOG

Note:

This log is autogenerated from Doors. Special symbols may not be rendered correctly and hence the main body of the document shall always take precedence for requirements. Thus it should only be used as a guide to the modifications in the document and not as a substitute.

Modified Objects

In the following table modifications to the Object Text attribute are shown using red line markup. For other attributes the new value and the old value are shown in separate columns.
The codes used in the object type (OT) column are: Rq = Requirement, Inf = Information, Hd = Heading, Ah = Applicability Matrix Heading, Ar = Applicability Matrix Requirement

Identifier	Attribute	OT	New Text	Old Text
MIL-22 section 1.2.7	Object Text	Inf	The Astrosat 250 MIL-STD-1553B bus system implements two separate, each dual-redundant, data buses: one for the Astrobus 250 Payload Module (PLM), one for the Service Module (SVM). Depending upon the Remote Terminal (RT) design, two (externally-redundant terminals) or four (internally-redundant terminals) stubs connect the RT to the data bus through Inter-Connecting Stations (ICS). The OBC comprises 2 independent Mil-Bus controllers dedicated for: Platform units command and control on SVM bus Payload units command and control on PLM bus Nota : in order to balance the traffic budget, it is possible that platform units (resp. payload units) are connected to PLM bus (resp. SVM bus). No electrical connection between these two Mil-Buses exists. No functional connection between these two Mil-Buses exists within the scope of this protocol specification. Unless specific items require distinction of the two buses, all definitions and requirements apply for both of them. All data transfers are initiated by the OBC as Bus Controller. RTs only transfer data when requested by the BC. Data entities transferred to and from “Packet Terminals” are termed “block” for distinction from CCSDS packets. The detailed structure of blocks is specified in this document. The MIL-STD-1553 Data Bus topology is a dual redundant bus with a transfer bit rate of 1 Mbit/sec.	
MIL-23 section 1.2.7	OLE	Inf	Figure/Table modified	
MIL-75 section 5.1	OLE	Inf	Figure/Table modified	
MIL-78 section 5.1	OLE	Inf	Figure/Table modified	
MIL-93 section 6.3	OLE	Inf	Figure/Table modified	

Identifier	Attribute	OT	New Text	Old Text
MIL-114 section 6.3.8	Object Type	Inf	Information	Requirement
MIL-117 section 6.3.8	Object Type	Inf	Information	Requirement
MIL-126 section 6.4	Object Type	Inf	Information	Requirement
MIL-126 section 6.4	Intended Verification Method	Inf		T
MIL-280 section 7.4.2	Object Text	Rq	The high power command' command shall be used to generate a ~~low~~high ~~level~~power command.	
MIL-319 section 7.4.12	Object Text	Rq	The 'execute memory checksum' command word shall contain a data word count equal to 3 : the first data word shall indicate the part of the last word to be checksummed : if equal to 0000h, it indicates all the bytes shall be checksummed if equal to FFFFh, it indicates that only the MSByte of the last word shall be checksummed, the LSByte taken into account for the calculation of the checksum being ~~0000h~~00h the second data word shall indicate the first word to be checksummed the third data word shall indicate the number of words to be checksummed	
MIL-320 section 7.4.12	Object Text	Rq	Upon reception of this command, the RT shall calculate the checksum (XOR sum) and store the result in a dedicated register, the content of which being possible by the 'read checksum' command. Note : for example, the checksum of the bytes ~~2~~23, ~~3~~69, ~~6~~BE, ~~9~~34, ~~B~~16 and ~~E~~B0 is equal to ~~F4~~8BED (=~~23Å69ÅBE~~2369ÅBE34Å16B0), the checksum of the bytes ~~2~~23, ~~3~~69, ~~6~~BE, ~~9~~34 and ~~B~~16 is equal to ~~FA~~8B5D (=~~23Å69ÅB0~~2369ÅBE34Å1600).	

Inserted Objects

Deleted Objects

11 differences found

Requirement/Section Cross Reference

Page numbers are the pages where the sections start

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