SUBJECT: **Test Facility FTS Data ICD**

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Change Record

Document Status Sheet

Issue	Date	Description
Draft 0.1	8 October 2002	Original Draft
Draft 0.2	13 November 2002	
Draft 0.3	14 November 2002	For distribution and review at the University of Lethbridge
Draft 0.4	9 December 2002	Final draft
Version 1.0	17 December 2002	First public version
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Version 1.3	05 January 2004	Revision of Version 1.2

Document Change Record

Changes in this document highlighted in red.

Section	Reason For Change
	Changes section removed – Document Change Record (this section) marks changes between versions.
1	Introduction: Test FTS used to test SPIRE FTS and photometer.
3, 4	Sections titled TBD or not used/applicable have been removed.
2.1.2, 2.1.3, 4.1.1.2.1	All references to checksum changed to CRC
2.1.2	Comprehensive description of the ACK bits in the telecommand header.
2.1.3	TIME field now refers to number of elapsed seconds since midnight, January 1, 1958.
2.1.4	Table 1 – names of TM acknowledgement /execution services corrected, HK packet labelled as running continuously. Removed mention of TFTS Status Report and TFTS Time Report (both of which have been removed due to being redundant with Housekeeping Report)
2.1.6.1 2.1.6.2	State diagrams of TC acknowledgements: changed to reflect correct acknowledgement behaviour.
2.1.6	In Long Duration Function Execution Stages, Table 3: perform_scan telecommand has 1 stage (formerly 3). This is due to repeating nature of program steps generated by this function, which SCOS cannot handle. Reset_TFTS and reset_limit telecommands are now considered a long-duration function (with no data returned).
3.2.1.1	Telecommand Packet Definition describes which telecommands can run concurrently with other select telecommands.
3.2.1.1.9	Perform Scan: changed size of comment field from 320 bytes to 80 bytes. Name of scan changed from single sided scan to simply "perform scan"
3.2.1.1.11	Abort sets Housekeeping Report TM(3,25) TASK_STATUS to state=ABORT
4.1.1.6	Telecommand Execution Report – Failed (1,8): added FAILURE_CODE field.
4.1.3.1 4.1.3.2	In housekeeping packet description: Housekeeping TM packets now sent continuously for duration of TFTS server run time. DPU_COUNTER_TIME field in Housekeeping Report TM(3,25) replaced with DPU_CNTR_RESET_TIME. New state for Housekeeping TASK_STATUS field added "ERROR" U500_SW_STATUS field added to Housekeeping Report TM(3,25) Tables 8 and 9, which describe contents of U500_HW_STATUS and U500_SW_STATUS (status fields for U500) have been moved to Housekeeping Report section.
4.1.3.3	SID field now added to exception report packets (TM 5,2,x).

4.1.3.3.1	DPU Counter Error Exception Report error codes (DPU_COUNTER_ERR) have been changed.
4.1.3.3.2	U500 Exception Report now has 3 varieties: Other Error, Feedback Error, and Limit Error.
4.1.5.1	Nominal Science Reports TM(21,1) now contain variable length data fields, instead of fixed length fields (which could be padded with zeros if not completely filled). SID defined as 0x2A.
5.2.1	DPU_CNTR_RESET_TIME added to TM Parameters: Parameter Definitions TIME_SINCE_DPU_COUNTER_RESET removed (redundant data field) DPU_CNTR_RESET_TIME field length changed from "4" to "32" (it is 32 bits wide) PC_SYSTEM_TIME removed due to redundancy.
4.1.5.2	Removed TFTS Time Report – no longer needed. Taken over by Housekeeping Report.
4.1.5.2	Removed TFTS Status Report – no longer needed. Taken over by Housekeeping Report

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Glossary

APID	Application ID
EGSE	Electrical Ground Support Equipment
SID	Structure ID
SPIRE	Spectral and Photometric Imaging Receiver
TBD	To Be Determined
TBW	To Be Written
TFTS	Test Fourier Transform Spectrometer
TC	Telecommand Packet
TM	Telemetry Packet
U500	Unidex 500
ULONG	Unsigned 32 bit integer
USHORT	Unsigned 16 bit integer
UINT	Unsigned integer (generic term)
UU	Unidex units (10 nm units)

1 INTRODUCTION

The Test Facility FTS (TFTS) is a Fourier Transform Spectrometer, which will be used for instrument-level testing of the SPIRE FTS and photometer. The Unidex 500 (U500), a motion controller card that plugs into the TFTS PC's PCI bus, controls the Aerotech linear translation stage on which the spectrometer's scanning mirror is attached. The TFTS PC, running under Windows 2000, hosts the TFTS control software. The control software listens for instructions from the SPIRE EGSE to initialize the TFTS and take interferogram scans. The resulting data sets are packetized and sent back to the SPIRE EGSE. Commands are formatted and sent as telecommand (TC) packets, while data is returned to the EGSE as telemetry packets ™. Both TM and TC packets are carried over an Ethernet-based local area network.

All telemetry data produced by the SPIRE EGSE systems will follow the same standards used in the Herschel Spacecraft and Ground Segment systems. This will ease transition from testing to the operational environments. TM and TC packets conform to the ESA Packet Utilisation Standards (RD01, RD02, and RD03), and the Herschel Packet Structure ICD (AD01) subset. The TFTS reduced set of telemetry packet types are detailed herein.

1.1 Scope

This document defines the packet types and contents that will be accepted and generated by the Test Facility FTS (TFTS). These packets conform to the formats given in the Herschel/Planck Packet Structure Interface Control Document (AD01) and the Herschel Science Ground Segment to Instruments Interface Control Document (AD03).

1.2 Structure of the Document

Section 2 describes the packet interface used between the SPIRE instrument and the SPIRE EGSE, including the Test Facility Control System and test equipment. This includes the general format of the packets used by the SPIRE instrument for telecommands and telemetry (from AD01), the allocation of Application Ids used by the instrument, and the functionality of the packet transfer protocol of the instrument/spacecraft interface (from AD01, appendix 9) that is used by the instrument.

Section 3 defines the format and content of each of the telecommand packets accepted by the TFTS. Section 4 defines the corresponding information for the telemetry packets generated by the TFTS. A description of how these packets are handled by the TFTS is given in RD04. Section 5 defines in detail the parameters used within the telecommand and telemetry packets.

1.3 Documents

1.3.1 Applicable Documents

AD01 Herschel/Planck Packet Structure Interface Control Document
(SPIRE-ESA-DOC-000433), Issue 2.0 (draft2)

AD02 Herschel/Planck Operations Interface Requirements Document
(SPIRE-ESA-DOC-000188), Issue 2.0 (draft3)

AD03 Herschel Science Ground Segment to Instruments Interface Control Document
(FIRST-FSC-DOC-0200), Issue 1.0

AD04 Packet Router ICD
(SRON-G/HIFI/ICD/2001-001), Issue 1.1

AD05 FIRST/Planck CDMS Simulator Requirements
(SRON-U/HIFI/SP/2000-004), Issue 1.1

1.3.2 Reference Documents

RD01 Packet Telemetry Standard
(ESA PSS-04-106), Issue 1, 1998

RD02 Packet Telecommand Standard
(ESA PSS-04-107), Issue 2, 1992

RD03 Telemetry and Telecommand Packet Utilisation Standard
(ECSS-E-70/41), Draft 04, April 1999

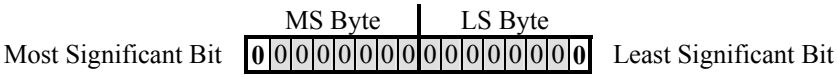
RD04 Test Facility FTS User's Manual
TBW

RD05 UNIDEX 500 Motion Controller and Windows Software Operation & Technical Manual
(SPIRE-UOL-DOC-001519), February 3, 2003

2 THE PACKET INTERFACE

2.1 Packet Structures

The following packet structures are shown as a set of 16 bit words, contained in two consecutive bytes in the packet structure (all packets are composed of an even number of bytes). The most significant byte of each word comes before the least significant in the packet. The least significant bit of each word is on right of each field:



2.1.1 Fields

Within a field (of any length) the most significant bit is designated bit (0); the least significant bit is bit (length-1).

2.1.2 Telecommand Packets

The following figure gives the general structure of a TC Packet (after AD01)

Packet Header	Packet ID	0 0 0 1 1 APID
	Sequence Control	1 1 Src Count
	Length	Length
Data Field	Data Field Header	0 0 0 0 0 0 0 1 Type
		Sub-Type 0 0 0 0 0 0 0 0
	Source Data	D A T A
	Error Control	CRC

- Src, Count, Length, and CRC are defined in AD01.
- Ack (in the first byte of the Data Field Header – in white letters) is defined in AD01, page 16. A series of 4 bits, when set in the incoming telecommand, determine the method of acknowledgement the TFTS must make.
    - 0 0 0 1 (bit 4): Acknowledge the received telecommand with a Telecommand Acceptance Report – Success TM(1,1). This bit is set in all incoming telecommands.
    - 0 0 1 0 (bit 3): Acknowledge the start of the function's execution with a Telecommand Execution Report – Started TM(1,3).
    - 0 1 0 0 (bit 2): Acknowledge the requested function's execution stages with a Telecommand Execution Report – Progress TM(1,5).
    - 1 0 0 0 (bit 1): Acknowledge the requested function's completion with a Telecommand Execution Report – Completed TM(1,7).

  Multiple bits can be logically Orred together, thus requiring the TFTS reply with any of the requested acknowledgements. The TFTS must acknowledge all failures; TM(1,2) if the incoming TC was not properly formed, and TM(1,8) if the function fails during execution.
    - Short duration functions will have ACK bits set to 0 0 0 1
    - Long duration functions will have ACK bits set to 1 1 1 1
- Type and Sub-Type define the packet type and are also defined in AD01

2.1.3 Telemetry Packets

The following figure gives the general structure of a TM Packet (after AD01)

Packet Header	Packet ID	0 0 0 0 1 APID
	Sequence Control	1 1 Count
	Length	Length
Data Field	Data Field Header	0 0 0 0 0 0 0 0 Type
		Sub-Type 0 0 0 0 0 0 0 0
		TIME
	Source Data	D A T A
	Error Control	CRC

- Count, Length, TIME and CRC are defined in AD01. TIME refers to the time the TM packet was created and is obtained from the PC's clock. In the Nominal Science Report, each data sample is associated with its own timestamp, obtained from the DPU counter.
- TIME field refers to the number of elapsed seconds since midnight, January 1, 1958.
- Type and Sub-Type define the packet type and are also defined in AD01

2.1.4 Telecommands and Telemetry Responses

Below is the mapping between telecommands and telemetry packets. FID=FUNCTIONID, AID=ACTIONID.

Telecommand	Service	FID	AID	Telemetry	Service	FID	AID
Set OBSID	(8, 4)	0xC1	0x01				
Set BBID	(8, 4)	0xC1	0x02				
Reset TFTS	(8, 4)	0xF1	0x01				
Home TFTS	(8, 4)	0xF1	0x02				
Reset Limit	(8, 4)	0xF1	0x04				
Move Table	(8, 4)	0xF2	0x01				
Read U500 Parameter	(8, 4)	0xF4	0x01	Diagnostic Science Report	(21, 3)	N/A	N/A
Write U500 Parameter	(8, 4)	0xF4	0x02				
Perform Scan	(8, 4)	0xF8	0x01	Nominal Science Report	(21, 1)	N/A	N/A
Run U500 Program	(8,4)	0xF8	0x02				
Abort Scan	(8, 4)	0xF8	0x04				
Truncate Scan	(8, 4)	0xF8	0x08				
Perform Connect Test	(17, 1)	N/A	N/A	Link Connection Report	(17, 2)	N/A	N/A
				Telecommand Acceptance / Execution Reports	(1, X)*	Sent after received telecommands, depending on ACK bits in incoming TC * x = 1, 2, 3, 5, 7, 8. See Telecommand Behavioural Description	
				Housekeeping Report	(3, 25)	Sent continuously	
				Exception Report	(5, 2)	Sent during function failures	

Table 1: Telecommands and their Responses

2.1.5 DPU Counter Reset Command

The TFTS DPU counter electronics allows the TFTS instrument to be synchronized with the SPIRE DPU. This is accomplished by driving the TFTS DPU counter with the DPU 312.5 kHz clock line. The TFTS DPU counter is reset upon receipt of a 32-bit counter-reset command on the DPU low speed bi-directional serial bus.

2.1.6 Telecommand Behavioural Description

Telecommands used to control the TFTS can be categorized into four distinct behavioural groups. Short duration telecommands take less than one quarter second to execute. Long duration telecommands, on the other hand, take one quarter second or more to execute.

Function Type	Applicable Function
Short Duration Function – No Data Returned	Set_OBSID
	Set_BBID
	Write_U500_Parameter
	Abort_Scan
	Truncate_Scan
Short Duration Function – Data Returned	Read_U500_Parameter
	Perform_Connection_Test
Long Duration Function – No Data Returned	Home_TFTS
	Move_Table
	Run_U500_Program
	Reset_TFTS
	Reset_Limit
Long Duration Function – Data Returned	Perform_Scan

Table 2: Telecommand Behavioural Description

The execution of long duration functions can be broken up into multiple stages. Transitions from stage to stage, which marks the progress of the function, is reported by the TFTS by sending Telecommand Execution Report – Progress packets (service 1,5). The following table shows the stages for each long duration function. Short duration functions are not listed because they do not transmit progress reports.

Function	Stage Number	Stage Description
Home_TFTS	1	Homing stage
Move_Table	1	Moving Aerotech stage
Run_U500_Program	TBD	TBD Note: this function used for debugging, configuring and troubleshooting the TFTS, and won't be used during normal usage of the TFTS.
Perform_Scan	1	Scanning

Table 3: Long Duration Function Execution Stages

2.1.6.1 Short Duration Function – No Data Returned

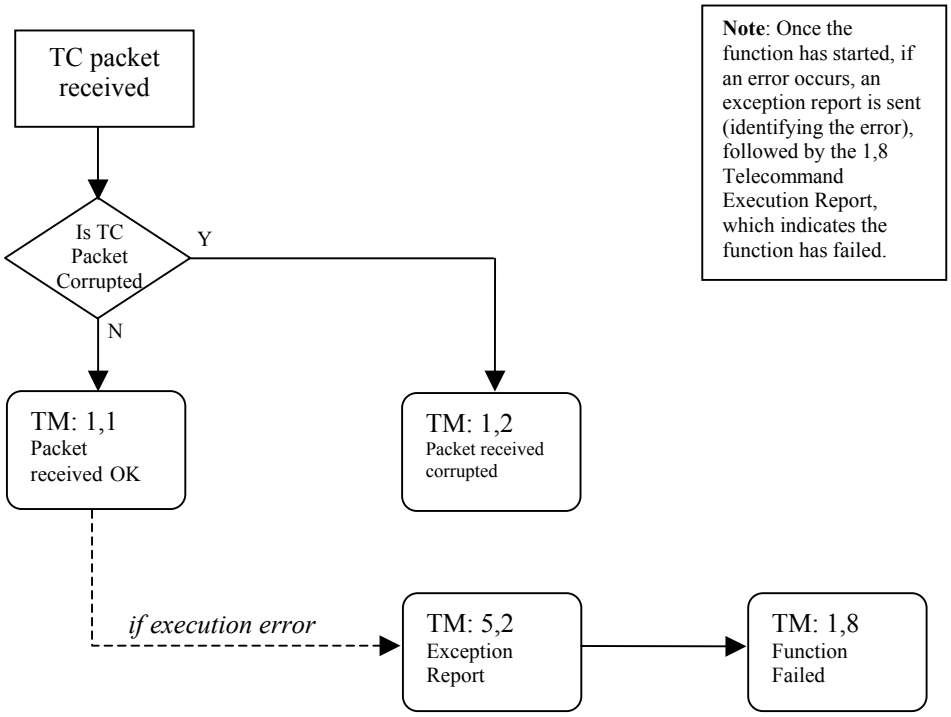


Figure 1: Execution of Short Duration Function (no data TM packets returned)

2.1.6.2 Short Duration Function – Data Returned

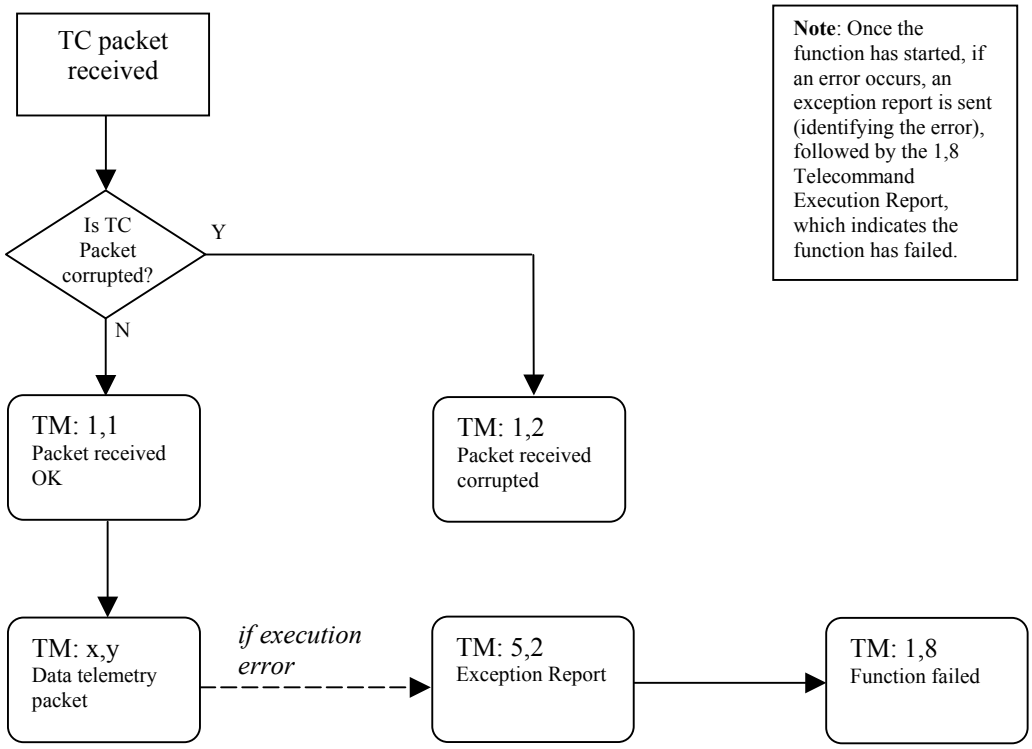


Figure 2: Execution of Short Duration Function (data TM packets returned)

2.1.6.3 Long Duration Function – No Data Returned

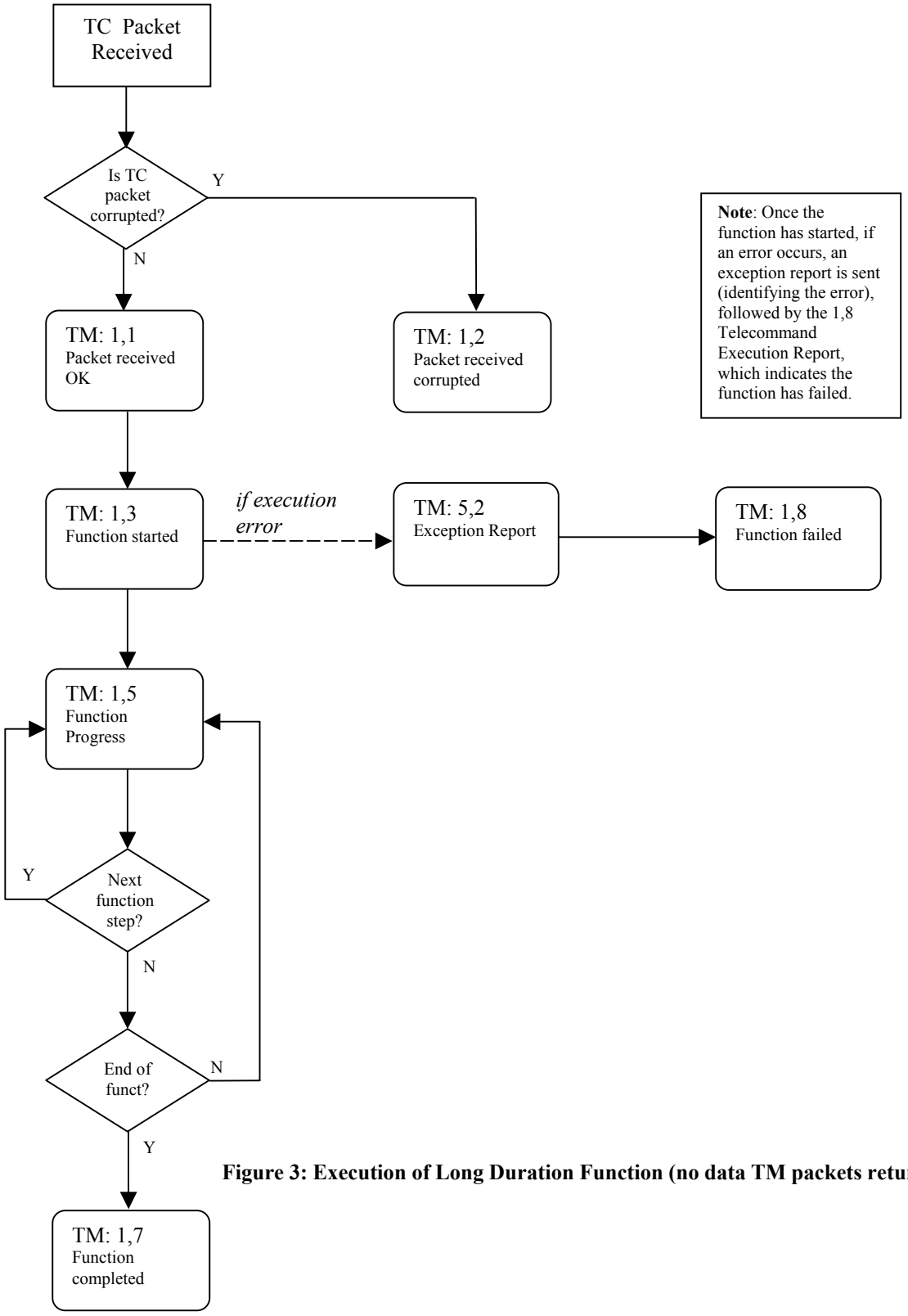


Figure 3: Execution of Long Duration Function (no data TM packets returned)

2.1.6.4 Long Duration Function – Data Returned

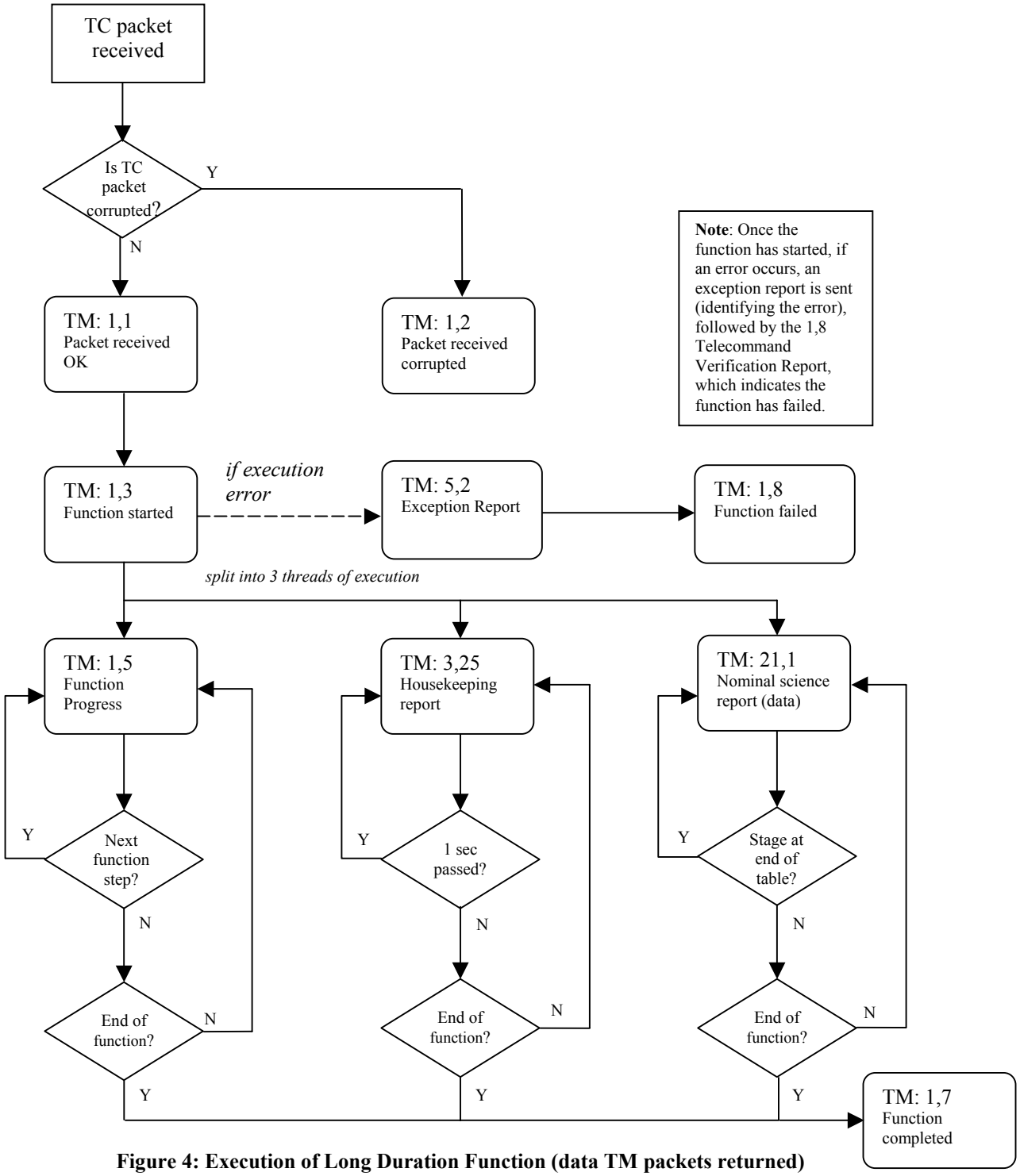


Figure 4: Execution of Long Duration Function (data TM packets returned)

2.2 APIDs

The Application ID is used to identify the source or destination of a telemetry packet. SPIRE has been allocated APIDs for different types of packets (see AD01) as well as for EGSE equipment. The APID to be used by the TFTS is given in the following table:

ID	Telemetry types	APID (hex)
APID	Telecommands, Telecommand Verification, Events, housekeeping, and science data.	7F5

Table 4: Table of APIDs

2.3 Packet Transfer Protocol

The packets are transferred between the TFTS and the EGSE following the Packet Router ICD (AD04).

3 TELECOMMAND PACKETS

This section defines all the telecommand packets accepted by the TFTS Simulator.

3.1 Telecommand Packet Types

The Packet Structure ICD (AD01) defines many types of service that can be provided by an application. The following table shows the telecommand packet types that will be accepted by the TFTS.

Description	Service Type	Service Sub-Type	Comments
Telecommand Verification Service	1		N/A
Device Command Distribution	2		Not Used
Housekeeping and Diagnostic Data Reporting	3		Not Used
Event Reporting	5		N/A
Memory Management	6		Not Used
Function Management			
Start Function	8	1	Not Used
Stop Function	8	2	Not Used
Perform Activity of Function	8	4	
Report Function Status	8	5	Not Used
Time Management	9		Not Used
On-Board Scheduling	11		Not Used
On-Board Monitoring	12		Not Used
Packet Transmission Control	14		Not Used
On-Board Storage and Retrieval	15		Not Used
On-Board Traffic Management	16		Not Used
Test Service			
Perform Connection Test	17	1	
On-Board Control procedures	18		Not Used
Action/Event Service	19		Not Used
Information Distribution Service	20		Not Used
Science Data	21		N/A
Context Saving Service	22		Not Used

Table 5: Telecommand Packet Definitions

3.2 Telecommand Packet Definition

3.2.1 Function Management

3.2.1.1 Perform an Activity of a Function (Service 8,4)

The TFTS server is a multi-threaded application; it can handle two concurrent executing telecommands, not including the abort telecommand, which can override everything (except itself). The following rules determine what telecommands can run concurrently with others:

- No two identical commands can run simultaneously (including abort).
- Abort can override one or two concurrently running telecommands (except itself).
- If two telecommands are executing, a third telecommand is not allowed to run.
- The connection_test telecommand can run concurrently with home_TFTS, move_table, and perform_scan.
- Truncate_scan can run concurrently with perform_scan.
- All other combinations are illegal.

When an illegal telecommand request occurs, the TFTS responds with a Telecommand Acceptance Report – Failure TM(1,2), with error code TFTS_BUSY (value = 16).

All command packets of this type and subtype may give rise to the following Errors:

Error	TM Service	Error Code	Description
Illegal_Function_ID	(1, 2)	0x0801	Function ID not known
Illegal_Activity_ID	(1, 2)	0x0802	Activity ID not known

3.2.1.1.1 Function: Set Observation ID

This command sets the value for the Observation ID, which is included in all telemetry packets to allow them to be ingested into the HCSS database.

<table>
<tr><td colspan="1">0</td><td>0</td><td>0</td><td>1</td><td>1</td><td colspan="11">APID</td></tr>
<tr><td>1</td><td>1</td><td colspan="3">Src</td><td colspan="11">Count</td></tr>
<tr><td colspan="16">Length = 11</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="8">FUNCTIONID</td><td colspan="8">ACTIVITYID</td></tr>
<tr><td colspan="16">OBSID</td></tr>
<tr><td colspan="16">CRC</td></tr>
</table>

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xC1	1
ACTIVITYID	0x01	1
OBSID	Observation ID	4
CRC	Cyclic Redundancy Check	2

3.2.1.1.2 Function: Set Building Block ID

This command sets the value for the Building Block ID, which is included in all telemetry packets to allow them to be ingested into the HCSS database.

0	0	0	1	1	APID										
1	1	Src			Count										
Length = 11															
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
FUNCTIONID								ACTIVITYID							
BBID															
CRC															

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xC1	1
ACTIVITYID	0x02	1
BBID	Building Block ID	4
CRC	Cyclic Redundancy Check	2

3.2.1.1.3 Function: Reset TFTS

This command performs the selected type of reset on the TFTS. Type 0x0001 resets the TFTS system: the U500, DPU counter, network communications, and TFTS software state (IDLE = listen for new TC commands). Type 0x0002 performs a hardware-level reset on the U500 device, while type 0x0004 performs a software-level reset on the Undex 500 only. Typically, only the type 0x0001 reset will needed to be performed; the other two types are available for system troubleshooting. Upon reset, the TASK_STATUS field of the TM(3,25) Housekeeping Report is set to IDLE.

0	0	0	1	1	APID										
1	1	Src			Count										
Length = 9															
0	0	0	0	1	1	1	1	0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
FUNCTIONID								ACTIVITYID							
RESET_MODE															
CRC															

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF1	1
ACTIVITYID	0x01	1
RESET_MODE	Type of reset to perform RESET_TFTS: 0x0001 RESET_U500_HARD: 0x0002 RESET_U500_SOFT: 0x0004	2
CRC	Cyclic Redundancy Check	2

3.2.1.1.4 Function: Home TFTS Stage

This command instructs the TFTS to send the stage on a "homing cycle" (where the stage finds the centre calibration marker), then moves the stage to a default starting position – a position from which all scans start from. This point can be any position on the table, and is defined by setting a Unidex 500 parameter.

0	0	0	1	1	APID										
1	1	Src			Count										
Length = 7															
0	0	0	0	1	1	1	1	0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
FUNCTIONID								ACTIVITYID							
CRC															

Parameters	Value and Comments	Size (bytes)
FUNCTIONID	0xF1	1
ACTIVITYID	0x02	1
CRC	Cyclic Redundancy Check	2

3.2.1.1.5 Function: Reset Table After Limit Fault

If the stage has moved beyond the acceptable CW (top of table) and CCW (bottom of table) limits of the table (which is triggered by optical switches in the table), the U500 signals this error and halts the table, disallowing any further motion commands until the stage is moved back into the safe region of the table (between the optical limit switches). This command calls the U500 command to move the stage into the safe region, reset the U500 card, and perform a homing cycle, which moves the stage back into starting position. Confirmation that the limit error has been cleared is shown in the U500_HW_STATUS field, contained in the TM(3,25) Housekeeping packet.

0 0 0 1 1	APID
1 1 0 0 0	Count
Length = 7	
0 0 0 0 1 1 1 1 0 0 0 0 1 0 0 0	
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0	
FUNCTIONID	ACTIVITYID
CRC	

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF1	1
ACTIVITYID	0x04	1
CRC	Cyclic Redundancy Check	2

3.2.1.1.6 Function: Move Table

Move the Aerotech stage a defined distance, direction, velocity and acceleration. Acceleration is an optional parameter, and refers to the maximum allowable acceleration of the table. The distance is relative to its initial position. Therefore, it may be necessary to read the stage's position before invoking the move command. Typical values for these parameters are described in the TFTS Users Manual.

0 0 0 1 1	APID
1 1 0 0 0	Count
Length = 21	
0 0 0 0 1 1 1 1 0 0 0 0 1 0 0 0	
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0	
FUNCTIONID	ACTIVITYID
DISTANCE	
DIRECTION	
VELOCITY	
ACCELERATION	
CRC	

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF2	1
ACTIVITYID	0x01	1
DISTANCE	Table travel distance (uu)	4
DIRECTION	Move stage in the direction towards TOP or BOTTOM UP 0x0000 DOWN 0x0001	2
VELOCITY	Velocity of table (uu s^{-1})	4
ACCELERATION	Max acceleration of table (uu s^{-2})	4
CRC	Cyclic Redundancy Check	2

3.2.1.1.7 Function: Read Unidex 500 Parameter

Return the value of a specified Unidex 500 parameter or variable. The response to this telecommand is the Unidex 500 Parameter Report.

0	0	0	1	1	APID											
1	1	0	0	0	Count											
Length = 9																
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
FUNCTIONID								ACTIVITYID								
PARAM_NUM																
CRC																

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF4	1
ACTIVITYID	0x01	1
PARAM_NUM	Parameter number	2
CRC	Cyclic Redundancy Check	2

Parameter Number Summary

Parameter	Comments	Value (decimal integer)
Unidex 500 Parameter Numbers	ID number of U500 parameter	1 thru 501

3.2.1.1.8 Function: Write Parameter to Unidex 500

Write a value to a specified Unidex 500 Parameter. Consult the Unidex 500 Manual (RD05) to specify the correct datatype of the parameter.

0	0	0	1	1	APID											
1	1	0	0	0	Count											
Length = 59																
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
FUNCTIONID								ACTIVITYID								
PARAM_NUM																
DATATYPE																
PARAM_VALUE																
CRC																

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF4	1
ACTIVITYID	0x02	1
PARAM_NUM	Parameter number	2
DATATYPE	Datatype of value to write to U500 0x0001 Char string 0x0002 32 bit integer 0x0004 Double Float	2
PARAM_ VALUE	Value to populate U500 parameter (null terminated string)	48
CRC	Cyclic Redundancy Check	2

3.2.1.1.9 Function: Perform Scan

The response to this telecommand is the Nominal Science Report. A scan involves going "down" some distance, then back "up" the equivalent distance. One can request the TFTS to perform 1 or more scans. Multiple scans can be interrupted by issuing the truncate_scan or abort_scan telecommands. Scans start at some user-definable starting position, which by default is the top (position 0) of the stage. Please refer to the TFTS Users Manual.

0	0	0	1	1	APID										
1	1	0	0	0	Count										
Length = 105															
0	0	0	0	1	1	1	1	0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
FUNCTIONID								ACTIVITYID							
DISTANCE															
ITERATIONS															
SAMPLING_INTERVAL															
VELOCITY															
ACCELERATION															
COMMENTS															
CRC															

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF8	1
ACTIVITYID	0x01	1
DISTANCE	Distance stage is to travel (uu)	4
ITERATIONS	Number of interferograms to acquire in a scan sequence	2
SAMPLING INTERVAL	Repeatedly sample the DPU counter every n units (uu) of distance along the stage's path of travel	4
VELOCITY	Stage velocity (uu s^{-1})	4
ACCELERATION	Stage acceleration (uu s^{-2})	4
COMMENTS	Comments describing this scan. This field is optional, and is zero-filled if not populated. If populated, the slack space in this field is also zero-filled.	80
CRC	Cyclic Redundancy Check	2

3.2.1.1.10 Function: Run Unidex 500 Script

Execute a sequence of events on the Unidex 500. Is analogous to running a script. Only one script can run at a time. It is used for TFTS configuration and troubleshooting (particularly during set-up of the TFTS system), and likely will not be used during normal operation of the TFTS.

0 0 0 1 1	APID
1 1 0 0 0	Count
Length = 9	
0 0 0 0 1 1 1 1	0 0 0 0 1 0 0 0
0 0 0 0 0 1 0 0	0 0 0 0 0 0 0 0
FUNCTIONID	ACTIVITYID
SCRIPT_ID	
CRC	

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF8	1
ACTIVITYID	0x02	1
SCRIPT_ID	ID number of script to run on U500 (TBD)	2
CRC	Cyclic Redundancy Check	2

3.2.1.1.11 Function: Abort Scan

Halt the Aerotech stage and feed back any collected data in Nominal Science Report packets TM(21,1). The stage is left at the position it was halted at. A subsequent command (such as home or move_stage) will be necessary to reset the stage to some starting position. An abort sets the TASK_STATUS field of the TM(3,25) Housekeeping Report to ABORT.

0 0 0 1 1	APID
1 1 0 0 0	Count
Length = 7	
0 0 0 0 0 0 0 1	0 0 0 0 1 0 0 0
0 0 0 0 0 1 0 0	0 0 0 0 0 0 0 0
FUNCTIONID	ACTIVITYID
CRC	

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF8	1
ACTIVITYID	0x04	1
CRC	Cyclic Redundancy Check	2

3.2.1.1.12 Function: Truncate Scan

While performing a batch of multiple scans, do not perform any further scans after the currently running one. In other words, truncate the current multiple-scan session. This command does not halt the stage – the stage returns to its starting position upon conclusion of its currently running scan.

0 0 0 1 1	APID
1 1 0 0 0	Count
Length = 7	
0 0 0 0 0 0 0 1	0 0 0 0 1 0 0 0
0 0 0 0 0 1 0 0	0 0 0 0 0 0 0 0
FUNCTIONID	ACTIVITYID
CRC	

Parameter	Value and Comments	Size (bytes)
FUNCTIONID	0xF8	1
ACTIVITYID	0x08	1
CRC	Cyclic Redundancy Check	2

3.2.2 Test Service

3.2.2.1 Perform Connection Test (Service 17,1)

This telecommand requests the TFTS to echo back the Link Connection Report packet. This test is used to determine if the EGSE network connection is up.

0	0	0	1	1	APID										
1	1	0	0	0	Count										
Length = 5															
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
CRC															

Parameter	Value and Comments	Size (bytes)
CRC	Cyclic Redundancy Check	2

4 TELEMETRY PACKETS

This section defines all the TM packets that will be produced by the TFTS.

4.1 Telemetry Packet Types

The Packet Structure ICD (AD01) defines many types of service that can be provided by an Application. The following table shows the telemetry packet types that will be produced by the TFTS.

Description	Service Type	Service Sub-Type	Comments
Telecommand Verification Service			
Telecommand Acceptance Report - Success	1	1	
Telecommand Acceptance Report - Failure	1	2	
Telecommand Execution Report - Started	1	3	
Telecommand Execution Report - Progress	1	5	
Telecommand Execution Report - Completed	1	7	
Telecommand Execution Report - Failure	1	8	
Telecommand Contents Report	1	9	Not Used
Device Command Distribution	2		N/A
Housekeeping and Diagnostic Data Reporting			
HK Parameter Report Definitions Report	3	10	Not Used
Diagnostic Parameter Definitions Report	3	12	Not Used
Housekeeping Parameter Report	3	25	
Diagnostic Parameter Report	3	26	Not Used
Event Reporting			
Event Report	5	1	Not Used
Exception Report	5	2	
Error/Alarm Report	5	4	Not Used
Memory Management	6		Not Used
Function Management	8	4	Not Used
Time Management			
Central Time Reference	9	8	Not Used
Time Verification Report	9	9	Not Used
On-Board Scheduling	11		Not Used
On-Board Monitoring	12		Not Used
Packet Transmission Control	14		Not Used
On-Board Storage and Retrieval	15		Not Used
Test Service			
Link Connection Report	17	2	
On-Board Control procedures	18		Not Used
Action/Event Service	19		Not Used
Information Distribution Service	20		Not Used
Science Data			
Nominal Science Data Report	21	1	
Science Type B Data Report	21	2	Not Used
Diagnostic Science Data Report	21	3	
Auxiliary Science Data Report	21	4	Not Used
Context Saving Service	22		Not Used

Table 6: Telemetry Packet Definitions

Telemetry Packet Definitions

4.1.1 TC Verification Service

4.1.1.1 Telecommand Acceptance Report – Success (1,1)

Upon receipt of a telecommand, the TFTS will send this packet to the EGSE (the TC sender) if there are no errors detected. The errors are listed in the packet control error table shown below.

0	0	0	0	1	APID											
1	1	Count														
Length = 15																
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
TIME																
TC_Packet_ID																
TC_Packet_Sequence_Control																
CRC																

Parameter	Value and Comments	Size (bytes)
TIME	Time of TM creation	6
TC_Packet_ID	Telecommand Packet ID from TC	2
TC_Packet_Sequence_ Control	Copy of the TC's packet header sequence control bytes	2
CRC	Cyclic Redundancy Check	2

4.1.1.2 Telecommand Acceptance Report – Failure (1,2)

If errors are detected in the telecommand (sent by the EGSE to the TFTS), the TFTS will respond with this packet. Two additional data fields, the Failure Code and Parameter fields, describe the type of error experienced. The structure of this packet depends on the type of error found in the telecommand.

4.1.1.2.1 Packet Control Errors

The following TM packet is returned if FAILURE_CODE 0 through 4 is encountered.

0	0	0	0	1	APID											
1	1	Count														
Length = 19																
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
TIME																
TC_Packet_ID																
TC_Packet_Sequence_Control																
FAILURE_CODE																
Parameter																
CRC																

Error	FAILURE_CODE *Size=2 bytes*	*Parameter*
Illegal APID	0	TC_PACKET_APID
Incomplete Packet or invalid Length	1	TC_PACKET_ LENGTH
Incorrect CRC	2	TC_PACKET_CRC
Illegal Packet Type	3	TC_PACKET_TYPE
Illegal Packet Sub-Type	4	TC_PACKET_ SUBTYPE

Note: The parameter is placed in the least significant bits of the16 bit 'parameter' field and the most significant bits are padded with zeros

Packet Content Error (continued)

A TM packet in the form shown below is what would be returned if FAILURE_CODE = 5, or codes 16 through 255 are encountered.

0	0	0	0	1	APID											
1	1	Count														
Length = 57																
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TIME																
TC_Packet_ID																
TC_Packet_Sequence_Control																
FAILURE_CODE																
TC Source Data Field																
CRC																

Error	FAILURE_ CODE	*Parameters*
Illegal or inconsistent Application Data	5	See Note
TFTS busy	16	
Other TBD errors	17-255	See Note

Note: The **TC Source Data Field** contains the first 40 bytes from the 'source data' field of the received telecommand packet. If this field is less than 40 bytes in length, all bytes from the 'source data' field will be included, and the rest will be filled with zeros (0x00).

4.1.1.3 Telecommand Execution Report – Started (1, 3)

This telemetry packet is sent to alert the EGSE that the requested telecommand has started.

0	0	0	0	1	APID											
1	1	Count														
Length = 15																
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
TIME																
TC_Packet_ID																
TC_Packet_Sequence_Control																
CRC																

Parameter	Value and Comments	Size (bytes)
TIME	Time of TM packet creation	6
TC_Packet_ID	Telecommand Packet ID from TC	2
TC_Packet_Sequence_ Control	Copy of the TC's packet header sequence control bytes	2
CRC	Cyclic Redundancy Check	2

4.1.1.4 Telecommand Execution Report – Progress (1, 5)

This telemetry packet is sent to the EGSE to indicate that some long-running telecommand (taking approximately ten seconds or more) is running.

0	0	0	0	1	APID											
1	1	Count														
Length = 17																
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
TIME																
TC_Packet_ID																
TC_Packet_Sequence_Control																
STEP_NUMBER																
CRC																

Parameter	Value and Comments	Size (bytes)
TIME	Time of TM packet creation	6
TC_Packet_ID	Telecommand Packet ID from TC	2
TC_Packet_Sequence_ Control	Copy of the TC's packet header sequence control bytes	2
STEP_NUMBER	Stage of execution in a currently running function	2
CRC	Cyclic Redundancy Check	2

4.1.1.5 Telecommand Execution Report – Completed (1,7)

This telemetry packet is sent to alert the EGSE that the requested telecommand has completed execution.

0	0	0	0	1	APID											
1	1	Count														
Length = 15																
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
TIME																
TC_Packet_ID																
TC_Packet_Sequence_Control																
CRC																

Parameter	Value and Comments	Size (bytes)
TIME	Time of TM packet creation	6
TC_Packet_ID	Telecommand Packet ID from TC	2
TC_Packet_Sequence_ Control	Copy of the TC's packet header sequence control bytes	2
CRC	Cyclic Redundancy Check	2

4.1.1.6 Telecommand Execution Report –Failed (1,8)

This telemetry packet is sent to alert the EGSE that the requested telecommand has failed. An explanation of the failure can be derived from the TC Source Data Field, or by examining the U500_HW_STATUS and U500_SW_STATUS field of the Housekeeping Report packet.

0 0 0 0 1	APID
1 1	Count
Length = 57	
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0	
TIME	
TC_Packet_ID	
TC_Packet_Sequence_Control	
FAILURE_CODE	
TC Source Data Field	
CRC	

Parameter	Value and Comments	Size (bytes)
TIME	Time of TM packet creation	6
TC_Packet_ID	Telecommand Packet ID from TC	2
TC_Packet_Sequence_ Control	Copy of the TC's packet header sequence control bytes	2
FAILURE_CODE	Code identifying failure. Values TBD	2
TC Source Data Field	This field contains the first 40 bytes from the 'source data' field of the received telecommand packet. If this field is less than 40 bytes in length, all bytes from the 'source data' field will be included, and the rest will be filled with zeros (0x00)	40
CRC	Cyclic Redundancy Check	2

4.1.2 Device Command Distribution

Not Applicable.

4.1.3 Housekeeping and Diagnostic Data Reporting

4.1.3.1 Housekeeping Parameter Report (Service 3,25)

The general packet structure is shown below. The Structure ID identifies the housekeeping packet type. Housekeeping telemetry packets are sent continuously (one packet per second) while the TFTS server is operating.

0 0 0 0 1	APID
1 1	Count
Length = 69	
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1	
0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0	
TIME	
SID	
Parameters	
CRC	

Parameter	Value and Comments	Size (bytes)
TIME	Nominal Housekeeping Report	6
SID	Structure ID (see below)	2
Parameters	(see table on next page)	56
CRC	Cyclic Redundancy Check	2

SID (Structure ID)	Packet type	Default Frequency (msec)
0x0301	Nominal Housekeeping Report	1000

4.1.3.2 Nominal Housekeeping Report (SID=0x0301)

The following table lists the fields that comprise the housekeeping packet's *parameters* block.

Parameter Name	Description	Size (bytes)
OBSID	Observation ID	4
BBID	Building Block ID	4
ITERATIONS	Number of scans to perform in a scan sequence	2
CURR_ITERATION	Current scan iteration being executed	2
CURR_VELOCITY	Requested velocity of current scan iteration	4
CURR_ACCELERATION	Requested acceleration of current scan iteration	4
CURR_SAMP_INTERVAL	Requested sampling interval of current scan iteration	4
CURR_DISTANCE	Requested scan distance of current scan iteration	4
CURR_POSITION	Position of stage in current scan iteration	4
DPU_CNTR_RESET_TIME	Time the DPU counter was last reset (coarse time)	4
NUM_TC	Number of telecommands received by TFTS	4
NUM_TM	Number of telemetry packets sent by TFTS	4
DIRECTION	Stage movement direction UP 0x0000 DOWN 0x0001	2
TASK_STATUS	TFTS software state IDLE 0x0000 SCANNING 0x0001 ABORT 0x0002 ERROR 0x0004	2
U500_HW_STATUS	State of Unidex 500 hardware	4
U500_SW_STATUS	State of Unidex 500 software (device driver)	4

Table 7: Nominal Housekeeping Report Fields

The U500_HW_STATUS word is a 32-bit word of bit flags, representing the internal state of the Unidex 500.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0_{LSB}
31_{MSB}	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Bit	Set (1)	Clear (0)
0	Axis 1 enabled	Axis 1 disabled
1	Axis 1 not in position	Axis 1 in position
2	Command in plane 1 executing [b]	No commands executing in plane 1
3	Plane 1 command queue is not empty [c]	Plane 1 command queue is empty
4	Plane 1 halted	Plane 1 running
5	Global abort active	Global abort not active
6	Feedhold active	Not active
7	PC bus interrupt high	PC bus interrupt not high
8	Not ready for next command, as the command is in the internal receive buffer and has not yet been moved to the appropriate plane. Software should wait for this bit to be cleared when checking for command completion.	Command has been completed (due to no command in internal receive buffer); ready for next command.
9-15	Not Used	
16	Position error	No fault
17	RMS current error	No fault
18	Integral error	No fault
19	+ hardware limit error (bottom of stage)	No fault
20	- hardware limit error (top of stage)	No fault
21	+ software limit error (bottom of stage)	No fault
22	- software limit error (top of stage)	No fault
23	Driver fault	No fault
24	Feedback device error	No fault
25	Global abort active	Global abort inactive
26	Federate > max setting error	No fault
27	Velocity error	No fault
28	Emergency stop	No fault
29	Driver interlock open	No fault
30-31	Not Used	
[a] See U500 Users Manual, chapter 13: Troubleshooting, for descriptions of the causes of these errors.		
[b] A plane is analogous to a thread of program execution. See section 5.4.1 (pp 5-14) of the Unidex 500 Users manual for a full explanation. The TFTS software runs under a single plane of execution.		
[c] An empty queue means that there are no unprocessed commands. If the queue is marked not empty, it is processing commands.		

Table 8: Unidex 500 Hardware Status Word

The following table lists all possible Unidex 500 software errors that can be generated. Only some errors listed below will be generated during operation of the TFTS. This table is provided for reference.

Error Code	Description
0x00000000	Command OK
0xE0021000	(DRV) Function no longer supported
0xE0021001	(DRV) Timeout waiting to read data from U500
0xE0021002	(DRV) Timeout waiting to write data to U500
0xE0021003	(DRV) Timeout waiting for command vector acknowledge
0xE0021004	(DRV) Board Checksum Feedback Error
0xE0021005	(DRV) System download communication error
0xE0021006	(DRV) Command not taken out of buffer (HF2 = 1)
0xE0021007	(DRV) DSP Read Timeout1
0xE0021008	(DRV) DSP Read Timeout2
0xE002100A	(DRV) QuickStat: Timeout waiting for previous command vector to clear
0xE002100B	(DRV) QuickStat: Timeout waiting for this command vector to clear
0xE002100C	(DRV) QuickStat: Timeout waiting for response to this command vector
0xE0021010	(DRV) PSO Initialize Error
0xE0021011	(DRV) PSO Not Initialized
0xE0022001	Out of Memory
0xE0022003	Invalid Firmware file
0xE0022004	Invalid Parameter file
0xE0022005	Invalid Plane
0xE0022006	Invalid Axis
0xE0022007	Invalid Parameter
0xE0022008	Invalid K value
0xE0022009	Invalid Scale value
0xE002200A	Invalid N/D value
0xE002200B	Invalid Notch value
0xE002200C	Invalid Deadband value
0xE002200D	Invalid Clamp value
0xE002200E	Invalid Flag
0xE002200F	Axis not enabled
0xE0022010	Circle Format Error
0xE0022011	Voltage Out of Range
0xE0022012	U500 Plus required
0xE0022014	PSO not initialized
0xE0022015	Axis not defined in this Plane
0xE0022016	CRC radius not defined
0xE0022017	CRC Axes not defined
0xE0022018	CRC Buffer full
0xE0022019	U500 Ultra required
0xE002201B	PSO Mailbox full
0xE002201C	Invalid Calibration file
0xE002201D	Feedrate is ZERO
0xE002201E	Invalid parameter number
0xE0022020	Calibration file format error
0xE0022021	Argument too large
0xE0022022	Incorrect gate array configuration
0xE0022023	PSO command not supported
0xE0022024	Invalid argument
0xE0022028	Invalid axis specified

0xE0022029	Power value less than zero
0xE002202A	Threshold value not found
0xE002202B	Too many low threshold samples
0xE002202C	Peak value not found
0xE002202D	No horizontal edge found
0xE002202E	No vertical edge found
0xE002202F	Maximum allowed iterations exceeded
0xE0022030	Invalid A/D channel specified
0xE0022031	Argument outside allowed range
0xE0022033	Could not open board
0xE0022034	Device Driver not running
0xE0022035	File Error
0xE0022036	Could not calculate Gains
0xE0022037	Could not open registry Key
0xE0022038	Could not create Thread
0xE0022039	Fast Align Positive Limit Axis 1
0xE002203A	Fast Align Negative Limit Axis 1
0xE002203B	Fast Align Positive Limit Axis 2
0xE002203C	Fast Align Negative Limit Axis 2
0xE002203D	Fast Align Positive Limit Axis 3
0xE002203E	Fast Align Negative Limit Axis 3
0xE002203F	Fast Align Positive Limit Axis 4
0xE0022040	Fast Align Negative Limit Axis 4
0xE0022041	Power Reading Saturated
0xE0022042	No Z edge found
0xE0022050	VPP: Duplicated Axis Map
0xE0022051	VPP: Invalid Axis Type
0xE0022052	VPP: Invalid Motion Matrix
0xE0022053	VPP: Invalid Fiber Tip Matrix
0xE0022054	VPP: Invalid Virtual Motion Matrix
0xE0022055	VPP: Invalid Property
0xE0022056	VPP: Invalid Axis
0xE0022057	VPP: Invalid Config File
0xE0022058	VPP: Axis Off Limit
0xE0022059	VPP: Channel Width CW Limit
0xE002205A	VPP: Channel Width CCW Limit
0xE002205B	VPP: Channel Height CW Limit
0xE002205C	VPP: Channel Height CCW Limit
0xE0022100	Obsolete Error Code
0xE0022101	Function no longer supported

Table 9: Unidex 500 Software Errors

4.1.3.3 Exception Report (5,2)

If an error occurs during the execution of a telecommand, the TFTS sends an Exception Report TM(5,2) with its EVENT_ID field set to the kind of error encountered. This is followed by a Telecommand Execution Report – Failure packet. Reasons for the failure can also be derived from fields in the stream of Housekeeping packets.

4.1.3.3.1 DPU Counter Error

This packet is generated in the event of the TFTS control software receiving an error from the DPU counter hardware.

0	0	0	0	1	APID											
1	1	Count														
Length = 37																
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
TIME																
SID																
EVENTID																
OBSID																
BBID																
ITERATIONS																
CURR_ITERATION																
NUM_TC																
NUM_TM																
DPU_COUNTER_ERR																
CRC																

Parameter	Comment	Size (bytes)
TIME	Time of TM packet creation	6
SID	Structure ID (value = 0x301)	2
EVENTID	Type of event = 0x0002	2
OBSID	Observation ID	4
BBID	Building Block ID	4
ITERATIONS	Number of scans to perform in a scan sequence	2
CURR_ITERATION	Current scan iteration being executed	2
NUM_TC	Number of telecommands received	4
NUM_TM	Number of telemetry packets sent	4
DPU_COUNTER_ERR	Identity of DPU counter error: 0x0001 = Counter not incrementing 0x0002 = Counter rollover 0x0003 = Counter glitch	2
CRC	Cyclic Redundancy Check.	2

4.1.3.3.2 Unidex 500 Error: Limit Error and Feedback Error

This packet is generated in the event of the TFTS control software receiving an error from the Unidex 500.
Other Error EVENT_ID = 0x0001
Limit Error EVENT_ID = 0x0004
Feedback Error EVENT_ID = 0x0008

Other Error is any error that's neither a Limit error, Feedback error or DPU error. It could be U500 or Windows operating system related. U500 software errors (due to faulty Unidex function calls) throw this kind of exception.

0 0 0 0 1	APID
1 1	Count
Length = 43	
0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1	
0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0	
TIME	
SID	
EVENTID	
OBSID	
BBID	
ITERATIONS	
CURR_ITERATION	
NUM_TC	
NUM_TM	
U500_HW_STATUS	
U500_SW_STATUS	
CRC	

Parameter	Comment	Size (bytes)
TIME	Time of TM packet creation	6
SID	Structure ID (value = 0x0301)	2
EVENTID	Type of event: Limit Error: 0x0004 Feedback Error: 0x0008	2
OBSID	Observation ID	4
BBID	Building Block ID	4
ITERATIONS	Number of scans to perform in a scan sequence	4
CURR_ITERATION	Current scan iteration being executed	2
NUM_TC	Number of telecommands received	2
NUM_TM	Number of Telemetry packets sent	4
U500_HW_STATUS	State of Unidex 500 hardware	4
U500_SW_STATUS	Reports Unidex 500 device driver error	4
CRC	Cyclic Redundancy Check.	2

4.1.4 Test Service

4.1.4.1 Link Connection Report (Service 17,2)

0	0	0	0	1	APID											
1	1	Count														
Length = 11																
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
TIME																
CRC																

Parameter	Value and Comments	Size (bytes)
TIME	Time of TM packet creation	6
CRC	Cyclic Redundancy Check	2

This function is analogous to a "ping" command used to test TCP/IP connections. When the TFTS receives a Perform Connection Test telecommand, it responds by sending this telemetry packet.

4.1.5 Science Data

4.1.5.1 Nominal Science Report (Service 21, 1)

This telemetry represents the data returned from a scan, and can consist of one or more Nominal Science Report packets.

0	0	0	0	1	APID										
x	x	Count													
Length = variable															
0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
TIME															
SID															
OBSID															
BBID															
ITERATIONS															
CURR_ITERATION															
TOT_PACKETS															
CURR_PACKET															
NUM_DATAPTS															
DPU_COUNTER_TIME (point 1)															
SAMPLE_POS (point 1)															
DPU_COUNTER_TIME (point 2)															
SAMPLE_POS (point 2)															
DPU_COUNTER_TIME (point n)															
SAMPLE_POS (point n)															
CRC															

The data fields DPU_COUNTER_TIME and SAMPLE_POS (in grey) represent a single sample tuple. It repeats the number of times defined in NUM_DATAPTS. In the above example, NUM_DATAPTS = 3.

Parameter	Comment	Size (bytes)
TIME	Time of TM packet creation	6
SID	Structure ID. Value = 0x002A	2
OBSID	Observation ID	4
BBID	Building Block ID	4
ITERATIONS	Number of scans to perform in a scan sequence	2
CURR_ITERATION	Current scan iteration being executed	2
TOT_PACKETS	Number of packets in a scan	2
CURR_PACKET	Current packet number (out of a total of **n** packets)	2
NUM_DATAPTS	Number of data points in this packet	2
DPU_COUNTER_TIME	Time of sample (taken from DPU Counter in 3.17 μs increments)	4
SAMPLE_POS	Table Position (in uu)	4
CRC	Cyclic Redundancy Check.	2

NOTE: This report returns multiple (segmented) variable length data packets to the EGSE, and is the response to the Acquire Single-Sided Interferogram Scan function. The segmentation flag is set to 11. Since telemetry packet cannot be larger than 1024 bytes, and the non-data portion of this packet is 38 bytes large, there are **986** bytes available for data (8 byte time-position pairs). **1** to **123** time-position pairs can be stored. If the data set contains more than 123 data samples, the data set will be spanned across multiple Nominal Science Report packets. Packets with less than the maximum allowable data points are truncated. The length field is adjusted to reflect the size of truncated packets.

4.1.5.2 Diagnostic Science Report (Service 21, 3)

4.1.5.2.1 Diagnostic Science Report – Unidex 500 Parameter Report (SID=0x0002)

This telemetry packet contains a Unidex 500 parameter, as requested by the telecommand Read Unidex 500 Parameter telecommand.

<table>
<tr><td colspan="5">0 0 0 0 1 APID</td></tr>
<tr><td colspan="5">1 1 Count</td></tr>
<tr><td colspan="5">Length = 71</td></tr>
<tr><td colspan="5">0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1
0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0</td></tr>
<tr><td colspan="5">TIME</td></tr>
<tr><td colspan="5">SID</td></tr>
<tr><td colspan="5">OBSID</td></tr>
<tr><td colspan="5">BBID</td></tr>
<tr><td colspan="5">U500_PARAMETER</td></tr>
<tr><td colspan="5">DATATYPE</td></tr>
<tr><td colspan="5">CRC</td></tr>
</table>

Parameter	Comment	Size (bytes)
TIME	Time of TM packet creation	6
SID	Structure ID: Value = 0x0002	2
OBSID	Observation ID	4
BBID	Building Block ID	4
U500_PARAMETER	The returned parameter is represented as an ASCII string, null terminated. As this field is fixed length, unpopulated bytes are filled with zeros.	48
DATATYPE	The datatype of the returned Unidex 500 parameter. 0x0001 Char String 0x0002 32-bit Integer 0x0004 Double Float	2
CRC	Cyclic Redundancy Check.	2

5 PARAMETERS

5.1 TC Parameters

5.1.1 Parameter Definition

Parameter Name	Service Reference	Type	Size (bits)	Conversion Curve	Constraint Table	Comments
ACTIVITYID	(8,4)	UINT	8	None	0 to 2^8-1	Defines activity to perform.
APID	ALL	UINT	11	None	0x7F5	Application ID.
CRC	ALL	UINT	16	None	0 to 2^{16}-1	Cyclic Redundancy Check.
OBSID	(8,4)	UINT	32	None	0 to 2^{32}-1	Observation ID
BBID	(8,4)	UINT	32	None		Building Block ID: Field is split into 3 parts…
BBINTR		constant	2		0 to 3	Location: Bits 0-1 Value:2
BBTYPE		UINT	14		0 to 2^{14}-1	Location: Bits 2-15
BBCOUNT		UINT	16		0 to 2^{16}-1	Location: Bits 16-31
FUNCTIONID	(8,4)	UINT	8	None	0 to 2^8-1	Defines activity to perform.
Length	ALL	UINT	16	None	0 to 2^{16}-1	Number of bytes contained in packet data field.
DISTANCE	(8,4)	UINT	32	10 nm = 1 unidex unit (uu)	0 to 20,000,000	Distance the Aerotech stage travels.
DIRECTION	(8,4)	UINT	16	None	0, 1	Direction that Aerotech stage travels: UP=0, DOWN=1
VELOCITY	(8,4)	UINT	32	uu/s	4 to 32,767,000	Velocity at which Aerotech stage travels.
ACCELERATION	(8,4)	UINT	32	uu/s^2	4000 to 255,000,000	Acceleration at which Aerotech stage performs movement.
ITERATIONS	(8,4)	UINT	16	None	0 to 2^{16}-1	Number of scans to perform in a scan sequence.
SAMPLING_INTERVAL	(8,4)	UINT	32	uu	1 to 8,388,607	Distance interval in which to repeatedly take DPU time samples.
PARAM_NUM	(8,4)	UINT	16	None	1 to 501,	Unidex 500 parameter ID number to read/modify
COMMENTS	(8,4)	char	80*8	None	max 80 ASCII characters	Comments that describe a particular scan – contains ASCII text. Unused space is zero-filled.

DATATYPE	(8,4)	UINT	16	None	1, 2, 4	The datatype that the Unidex 500 expects the parameter (to be written) to be. See Unidex 500 manual for details.
SCRIPT_ID	(8,4)	UINT	16	None	TBD	ID number of script to be executed on the Unidex 500.
Count	ALL	UINT	11	None	0 to 2^{11}-1	Telecommand packet sequence number.
RESET_MODE	(8,4)	UINT	16	None	1, 2, 4	Type of TFTS reset to perform.
PARAM_VALUE	(8,4)	Char	48 * 8	None	Max 48 ASCII chars	The value to populate a Unidex 500 parameter with.

5.2 TM Parameters

5.2.1 Parameter Definition

Name	Length (bits)	Conversion	Limits	Description
NUM_TC	32	None	0 to 2^{32}-1	Number of telecommand packets received by the TFTS.
NUM_TM	32	None	0 to 2^{32}-1	Number of telemetry packets sent by the TFTS.
DIRECTION	16	None	0, 1	Direction of travel of the Aerotech table: UP=0, DOWN=1
TASK_STATUS	16	None	0, 1, 2, 4	State of TFTS software – running a scan / initialization, waiting for commands, or error.
U500_HW_STATUS	32	None	0 to 2^{32}-1	Status word of Unidex 500. This value describes the state of the hardware of the Unidex 500.
U500_SW_STATUS	32	None	0 to 2^{32}-1	Reports device driver errors and state of the Unidex 500 control software.
CURR_VELOCITY	32	uu/s	4 to 32,767,000	Requested velocity of the current scan iteration.
CURR_ACCELERATION	32	uu/s^2	4000 to 255,000,000	Requested acceleration of current scan iteration.
CURR_SAMP_INTERVAL	32	uu	1 to 8,388,607	Requested sampling interval of current scan iteration.
CURR_DISTANCE	32	uu	0 to 20,000,000	Requested scan distance of current scan iteration.
CURR_POSITION	32	uu	0 to 20,000,000	The position of the stage in the current scan iteration.
EVENTID	16	None	0 to 2^{32}-1	Type of exception raised by TFTS.
DPU_COUNTER_TIME	32	Counter	0 to 2^{32}-1	DPU counter value – driven by 315 kHz DPU clock signal

		increments		
U500_PARAMETER	8 * 48	None	Max 48 ASCII characters	Value of requested Unidex 500 parameter – returned as a NULL terminated ASCII string.
DATATYPE	16	None	1, 2, 4	Datatype of requested Unidex parameter – defines how the parameter should be interpreted.
APID	11	None	0x7F5	Application ID.
CRC	16	None	0 to 2^{16}-1	Cyclic Redundancy Check.
Length	16	None	0 to 2^{16}-1	Number of bytes in telemetry packet's data field.
Count	14	None	0 to 2^{14}-1	Telemetry packet sequence number.
TIME	48	Seconds	0 to 2^{32}-1	Time that the telemetry packet was created (elapsed secs since 0:00h Jan 1 1958)
FAILURE_CODE	16	None	TBD	Reasons for failure of acceptance of a telecommand.
TC_PACKET_APID	16	None	0x7F5	A failure code: APID of TM's corresponding TC.
TC_PACKET_LENGTH	16	Number of bytes	5 to 1017 (no packet greater than 1024 bytes)	A failure code: Length data field of TM's corresponding TC.
TC_PACKET_CRC	16	None	0 to 2^{16}-1	A failure code: CRC value of TM's corresponding TC.
TC_PACKET_TYPE	8	None	0 to 2^{8}-1	A failure code: TC packet type of TM's corresponding TC.
TC_PACKET_SUBTYPE	8	None	0 to 2^{8}-1	A failure code: TC packet sub-type of TM's corresponding TC.
TC_Packet_Sequence_ Control	16	None	0 to 2^{16}-1	A copy of the TC packet header sequence control bytes (17^{th} thru 32^{nd} bit) to which this TM replies.
TC_Packet_ID	16	None	0 to 2^{16}-1	Telecommand Packet ID: copy of the corresponding field from the packet header of the TC to which this TM replies.
SID	16	None	0 to 2^{16}-1	Structure ID
OBSID	32	None	0 to 2^{32}-1	Observation ID (facilitates telemetry to be ingested into HCSS database).
BBID	32	None	0 to 2^{32}-1	Building Block ID (facilitates telemetry to be ingested into HCSS database).
ITERATIONS	16	None	0 to 2^{16}-1	Number of scans to perform in a scan sequence.
CURR_ITERATION	16	None	0 to 2^{16}-1	Current iteration in scan being executed.
DPU_COUNTER_ERR	16	None	1,2,4,8	Identity of DPU counter error.
TOT_PACKETS	16	None	0 to 2^{16}-1	Number of packets in a scan.
CURR_PACKET	16	None	0 to 2^{16}-1	Current packet number (out of a total of n packets).
NUM_DATAPOINTS	16	None	0 to 2^{16}-1	Number of data points in the current Nominal Science Report TM packet.
SAMPLE_POS	32	None	0 to 2^{32}-1	Position of the Aerotech stage at a given time.
STEP_NUMBER	16	None	0 to 2^{16}-1	The stage of execution in a currently running scan.
TC Source Data Field	40 * 8	None	Max 40 ASCII chars	The first 40 bytes of the TC's source data field.

DPU_CNTR_RESET_TIME	32	None	0 to 2^{32}-1	Time DPU counter was last reset (in UNIX epoch time)

5.2.2 Conversion Curve

Name	Type	Raw Value	Converted Value	Units	Comments
TBD					

5.2.3 Constraints

TBD