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Herschel-Planck Mission Control System

Interface Control Document
Time Correlator

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Section 4.3.1.4 DCR-1183	2.4
Section 4.2.1.4 DCR-1254	2.5
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1 Introduction

1.1 Purpose

This document describes the External Interfaces to the HPMCS Time Correlator. The intended readers of this document are the elements of the Herschel-Planck Mission Control System development team, Herschel-Planck FCT and Science staff.

1.2 Scope

The document covers the External Interfaces to the HPMCS Time Correlator application as defined in [HPMCS-SAD-TMS]. It covers the layout of Time Couple and Time Correlation Coefficient TM packets as well as the structure of the produced ASCII file.

1.3 Glossary

Refer to the Herschel-Planck Mission Control System Glossary [HPMCS-GLOS] for the definition of the majority of items and abbreviations used within this document. Only terms and abbreviations specific to this document are listed here.

1.3.1 Acronyms

Abbreviations used in this document:

None

1.3.2 Definitions of Terms

Terms and definitions specific for this document:

None

1.4 References

1.4.1 Applicable Documents

The documents, which are applicable for this document, are:

AD-1	HPMCS-GLOS	HPMCS Glossary, Ref: TERMA/SPD/63/HPMCS/TS/GLOS, Issue 2.0, 27 October 2005, TERMA
AD-2 RID-PDR2-32	CCSDS-FORMATS	CCSDS Time Code Formats, CCSDS 301.0-B-3 Blue Book, Issue 3, Jan 2002.
AD-3	HPMCS-SRS	HPMCS Software Requirement Specification, Ref: PT-MCS-SRD-1001-TOS-GDS, Issue 2.5, 7 April 2006
AD-4	HPMCS-ICD-DDS	HPMCS Data Disposition System (DDS), Interface Control Document, Ref: TERMA/SPD/63/HPMCS/TS/ICD/DDS, Issue 1.3, 11 April 2006, TERMA. ESA Ref: PT-CMOC-MDS-3108-OPS-GDS, Issue 1.3, 11 April 2006, TERMA.

1.4.2 Reference Documents

The documents, except for the applicable documents, which are referenced in this document, are:

RD-1	ECSS-E-40	Space Engineering Software, Issue B
RD-2	HPMCS-SAD-TMS	HPMCS SAD Telemetry Monitoring System, Ref: TERMA/SPD/63/HPMCS/DDF/SAD/TMS, Issue 2.1, 30 November 2005, TERMA
RD-3	ESA-ADD-TDEV	SCOS-2000 Packet Management Architectural Design Document, Ref: EGOS-MCS-S2K-ADD-0024, Issue 1.0, 15 February 2006, ESA
RD-4	ESA-ICD-TCO	HERSCHEL/PLANCK Satellite Propagation Delay Data Interface Control Document, Ref: PT-CMOC-FD-ICD-2102-OPS-GFI, Issue 1.0, 20.04.2004, ESA
RD-5	ESA-TN-TCO	H/P OBT-UTC Time Synchronisation TN, Ref: PT-MCS-TN-1001-TOS-OFM, Issue 1.1, Dec 2003
RD-6	ESA-P-GSIRD	Planck Ground Segment Interface Requirement Document Ref: Planck/PSO/2002-003 Issue 3.0b RID-PDR2-150., 27/09/2004
RD-7	ESA-H-GSIRD	Herschel Ground Segment Interface Requirement Document Ref FIRST/HSC/DOC/117 Issue 2.2 04/06/04

1.5 Document Overview

This document is structured according to the standard for Interface Control Documents defined in [ECSS-E-40] and is outlined as described below:

Chapter 1 this chapter, provides an introduction of the document

Chapter 2 provides a brief description of the software system producing the data described within this Interface Control Document. For a detailed description of the software functionality refer to [HPMCS-SAD-TMS].

Chapter 3 this chapter describes the interface requirements applicable for this document

Chapter 4 this chapter provides the detailed information of all identified external interfaces including name, identifier, type, data etc. This information is intended for external parties that need to extract user data from the external interfaces.

2 Software Overview

The Time Correlator component maintains the correlation between the on-board time and the ground. It provides interfaces for correlating OBT to UTC and vice versa. This is mainly used for time stamping of TM packets received from the spacecraft and for uploading Time Tag commands to the spacecraft. Additionally the correlation function is used to correlate Time parameters.

The Time Correlator also handles propagation delays based on inputs from Flight Dynamics and on configurable ground station and on-board processing delays. This information is used for calculating the Adjusted ERT (Earth Reception Time): To obtain a better figure of the exact transmission time, the propagation delay is subtracted from the ERT given by the ground station receiving the TM frames. The calculation of the propagation delay is done by functions provided by the FDS library [ESA-ICD-TCO, Chapter 8]. The Time Correlator provides the library functions with the OWLT filename for a specific ground station and a reference time for which the propagation delay is required. The ground station delays can be defined for each ground station in a dedicated configuration file specified by the environment variable TCO_GSID_FILE. The on-board processing delay is defined by the configuration variable TCO_ONBOARD_PROCESSING_DELAY. The ground station and processing delays are added to the propagation delay provided by Flight Dynamics for calculating the adjusted ERT, i.e. the adjusted ERT equals the ERT minus the sum of the propagation, on-board processing and ground station delays.[RID-PDR2-166, RID-PDR2-169]

The algorithm used for performing the time correlation is specified in appendix A and B of this document together with examples of time couple and resulting time coefficient data.[RID-PDR2-169] For time stamping of real time packets, the most recent time coefficient is always used, whereas for playback packets, the OBT of the received packet is used for finding the time coefficient that was applicable at the time of the packet OBT. [RID-PDR2-169]

Finally the MISC interface provides capabilities to configure the Time Correlator and report status changes. This information is available to any MISC client application and is normally used by the TM SPACON application to allow the Flight Control Team (FCT) to control and monitor the TCO functions.

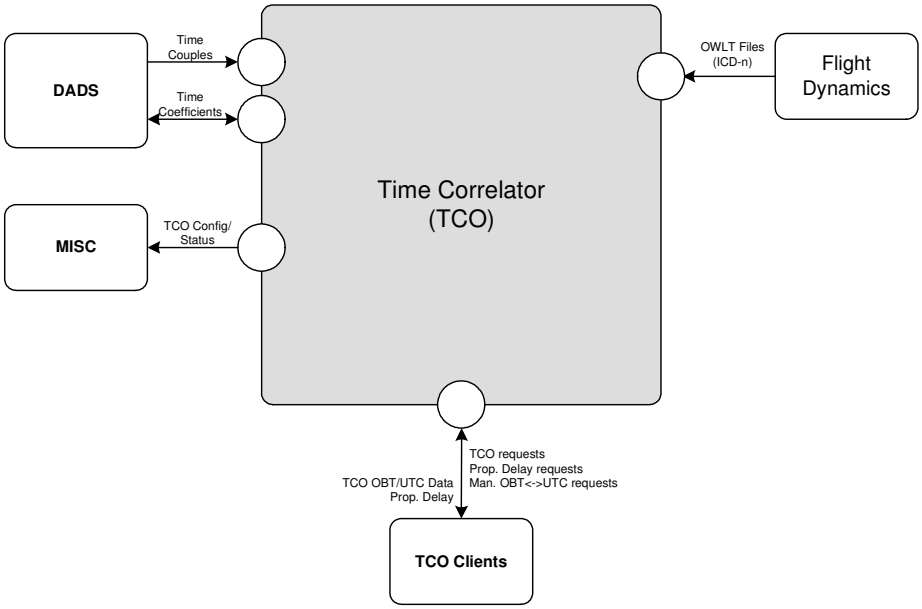

Figure 2-1 : Time Correlator Interfaces

The External Interfaces identified for the Time Correlator component are listed below:

- Time Couple – standard SCOS-2000 TM packet
- Time Correlation Coefficient – standard SCOS-2000 TM packet
- ASCII Log File – standard ASCII file

Each of these interface are described in more detail in chapter 4.

3 Requirements

3.1 Functional Requirements

The general (i.e. mission-independent) functional requirements regarding the Time Correlation are described in [AD-3].

With specific reference to Planck Ground Segment Interface Requirement Document [RD-6] this ICD covers requirements:

PGS-IR-4.1-360

PGS-IR-4.1-370

PGS-IR-4.1-380

PGS-IR-4.1-390

Handling of the requirement PGS-IR-4.1-365 is described in the “Time Correlator” section of [RD-2].[RID-PDR2-211,RID-PDR2-33]

With specific reference to Herschel Segment Interface Requirement Document [RD-7] this ICD covers requirements:

FGS-IR-3.1-420

Handling of the requirement FGS-IR-3.1-430 is described in the “Time Correlator” section of [RD-2].[RID-PDR2-211,RID-PDR2-33]

3.2 On-line Delivery Requirements

N/A

3.3 Off-line Delivery requirements

For both Herschel and Planck, the Mission Operations Centre (MOC) shall make available to the HSC/DPC, the time correlation data for a given operational period at the same time as the spacecraft consolidated housekeeping telemetry for this period, as stated in requirements FGS-IR-3.1-440 and PGS-IR-4.1-390.

4 Interface Design

This section provides detailed information of all External Interfaces for the Time Correlator component.

4.1 Time Couple Interface Description

A Time Couple TM packet is generated each time a Standard Time Source Packet is received from the spacecraft. The packet is defined as a part of the Time Correlator component, but is created and distributed by the packetiser component. The Time Couple TM packet is normally only used by the Time Correlator component but may be retrieved from the archive by external users for validation or later processing.

4.1.1 Data Elements

4.1.1.1 Name and Identification

Name	*Identifier*	*Description*
Time Couple	TCO_TIME_COUPLE	The Time Couple packet contains the Central Time Reference, the Earth Reception Time, the adjusted Earth Reception Time, Validity and Accuracy information.

4.1.1.2 Source and Destination

The Time Couples are created and archived by the packetiser using TCO library functions. The destination is anyone who may be interested in the STSP information such as the Time Correlator component.

4.1.1.3 Frequency/Rate

The frequency of the Time Couples is based on the rate of the STSP packets generate by the spacecraft and downlinked on the VC-0 channel. For Herschel-Planck the downlink rate for VC-0 data is either 500bps or 5kbps depending on the configuration. The STSP packet is downlinked every 64 frames with a frame size of 8920 bits.

According to [HPMCS-SRS] the downlink rate of the VC-0 telemetry can be configured to be either 500bps or 5kbps. In both cases the telemetry is the Essential TM, which will contain the STSP information used by the Time Correlator. The Time Correlator doesn't care about the frequency of the packet because the ERT of the last VC-0 (Frame Count mod 64) [RID-PDR2-168] Frame Count = 0 is used together with the CTR reported in the STSP packet[GSDR-RID-71]. Table 4-1 shows the expected frequency of the Time Couple packets at the example VC-0 bit rates given in [HPMCS-SRS].[RID-PDR2-167]

VC-0 Data Rate	Time Couple Frequency
500bps	One Time Couple every 1142sec (or 19min)
5Kbps	One Time Couple every 114sec (or 1.9min)

Table 4-1 : Time Couple Frequency

4.1.1.4 Data Type and Representation

The Time Couple is stored in a standard SCOS-2000 TM packet, see [ESA-ADD-TDEV]. The SCOS-2000 TM Packet contains 76 [DCR-884] bytes of header data followed by the application data. The following values are used in the header of the Time Couple packets:

- Datastream: Defined by configuration variable DEFAULT_DATA_STREAM (set to 1 for Herschel-Planck)
- Filing Key (SPID): Defined by configuration variable TCO_TIME_COUPLE_PKT_SPID (Default configuration is 240001998)
- PUS APID: 2015
- PUS Type: 0
- PUS Subtype: 0[RID-PDR2-49,RID-PDR2-211]

The application data for a Time Couple packet is defined as:

Parameter	Description	Type	Offset (bits)	Size (bits)
CTR	CTR in CUC format	CUC Format with 4 byte coarse time and 2 byte fine time	0	48
CTRcoarse	CTR, seconds	unsigned integer	48	32
CTRfine	CTR, 1/65536 seconds	unsigned short	80	16
ERTcoarse	ERT, seconds	unsigned integer	96	32
ERTfine	ERT, microseconds	unsigned integer	128	32
ERT ASCII	ERT in ASCII A format YYYY.MM-DDTHH:MM.SS.uuu[RID-PDR2-32,RID-PDR2-33]	23 ASCII characters	160	184[RID-PDR2-32]
ERTadjCoarse	Adjusted ERT (FTT), seconds	unsigned integer	344	32
ERTadjFine	Adjusted ERT (FTT), microseconds	unsigned integer	376	32
ERTadj ASCII	Adjusted ERT in ASCII A format YYYY-MM-DDTHH:MM.SS.uuu[RID-PDR2-32,RID-PDR2-33]	23 ASCII characters	408	184[RID-PDR2-32]
Validity	Validity of the Time Couple	boolean	592	32

Table 4-2 : Time Couple Data Representation

where CTRcoarse and CTRfine are the 6-byte Central Time Reference received in the STSP packet. Both ERT and the adjusted ERT are represented in seconds since EPOCH 1958.001.00.00.00.000. [RID-PDR2-182]

The adjusted ERT is used for packet timestamping in case the time correlation is not valid. [RID-PDR2-169]

The Validity parameter can have the values 0 = INVALID and 1 = VALID.

All application data for a Time Couple packet is stored in network (BIG ENDIAN) format.

Note: Currently the validity of generated Time Couple packets is always VALID, as the Time Couple packet is not generated if the STSP or the TM transfer frame providing the ERT are corrupted in any way. The validity of Time Correlation coefficients generated based on a Time Couple packet is stored in the Time Coefficient packet.

4.1.2 Message Description

The Time Couple Interface, TCO_TIME_COUPLE, is defined in section 4.1.1.4 and is a single message type.

4.1.3 Communication Protocol

The TCO_TIME_COUPLE data is archived in the MOC long-term archive and is made available to any users as part of spacecraft consolidated housekeeping telemetry for a particular period. External users shall retrieve TCO_TIME_COUPLE data using the Herschel-Plank MOC Data Disposition System (DDS), which can be accessed by any external user granted access rights. Refer to [HPMCS-ICD-DDS] for details on how to use the DDS interface.

4.2 Time Correlation Coefficient Interface Description

4.2.1 Data Elements

4.2.1.1 Name and Identification

Name	*Identifier*	*Description*
Time Correlation Coefficient	TCO_COEFFICIENT	The Time Correlation Coefficient packet contains the calculated gradient and offset from the source STSP data and contains validity and accuracy information for the coefficient as well.

4.2.1.2 Source and Destination

The Time Correlation Coefficients are created and archived by the TCO Server process. The coefficients are used by the TCO client application for Time Correlator and is archived both for later use in time-stamping and for distribution to external users.

4.2.1.3 Frequency/Rate

The frequency of the Time Correlation Coefficients is, as for the Time Couples, based on the rate of the STSP packets generate by the spacecraft and downlinked on the VC-0 channel. For Herschel-Planck the downlink rate for VC-0 data is either 500bps or 5kbps depending on the configuration. The STSP packet is downlinked every 64 frames with a frame size of 8920 bits.

VC-0 Data Rate	Time Couple Frequency
500bps	One Time Correlation Coefficient every 1142sec (or 19min)
5Kbps	One Time Correlation Coefficient every 114sec (or 1.9min)

Table 4-3 : Time Correlation Coefficient Frequency

4.2.1.4 Data Type and Representation

The Time Correlation Coefficient is stored in a standard SCOS-2000 TM packet (see [ESA-ADD-TDEV]). The SCOS-2000 TM Packet contains 76 bytes of header data followed by the application data.

The following values are used in the header of the Time Coefficient packets:

- Datastream: Defined by configuration variable DEFAULT_DATA_STREAM (set to 1 for Herschel-Planck)
- Filing Key (SPID): Defined by configuration variable TCO_MCS_COEF_PKT_SPID (default 240007998[DCR-1471]) for MCS (housekeeping) coefficient packets, and defined by configuration variable TCO_SCIENCE_COEF_PKT_SPID (default 240006998) for science coefficient packets.
- PUS APID: 2015
- PUS Type: 0
- PUS Subtype: 0[RID-PDR2-49,RID-PDR2-211]

The application data for a Time Correlator Coefficient packet is defined as:

Parameter	Description	Type	Offset (bits)	Size (bits)
CTR	CTR in CUC format	CUC Format with 4 byte coarse time and 2 byte fine time	0	48
CTRcoarse	CTR, seconds	unsigned integer	48	32
CTRfine	CTR, 1/65536 seconds	unsigned short	80	16
UTCvalSec	UTC validity time of coefficient (Adjusted ERT of Time Couple generating Coefficient), seconds	unsigned integer	96	32
UTCvalMicro	UTC validity time of coefficient (Adjusted ERT of Time Couple generating Coefficient), microseconds	unsigned integer	128	32
UTCvalASCII	UTC validity time of coefficient in ASCII A format: YYYY-MM-DDTHH:MM.SS.uuu[RID-PDR2-32,RID-PDR2-33]	23 ASCII characters	160	184
UTCcorSec	UTC time correlated from the OBT of the generating Time Couple using the last valid coefficient set, seconds	unsigned integer	344	32

Parameter	Description	Type	Offset (bits)	Size (bits)
UTCcorMicro	UTC time correlated from the OBT of the generating Time Couple using the last valid coefficient set, microseconds	unsigned integer	376	32
UTCcorASCII	UTC time correlated from the OBT of the generating Time Couple using the last valid coefficient set in ASCII A format : YYYY-MM-DDTHH:MM.SS.uuu	23 ASCII characters	408	184
Gradient	Gradient (Slope) of the coefficient	double	592	64
Offset	Offset of the coefficient	double	656	64
Accuracy	Accuracy and validity[RID-PDR2-78] of the Time Coefficient	unsigned integer	720	32
LSQtcoNumber	Number of Time Couples used in Least Square Fit to calculate this coefficient set	unsigned short	752	16
TcoMode	Time correlation Mode at Coefficient generation	unsigned char	768	8
ResetChkStatus	Status of OBT Reset checking at Coefficient generation	unsigned char	776	8
MsbMaskStatus	Status of OBT MSB masking during OBT Reset checking at Coefficient generation	unsigned char	784	8
ResetChkSpid	SPID of TM packet used for OBT Reset Checking	unsigned integer	792	32
FixedGradientUsed	If the fixed gradient is used for TC at coefficient generation	boolean	824	8
FixedCTRcoarse DCR-1425	CTR of the last coefficient before the Fixed Gradient was set, seconds	unsigned integer	832	32
FixedCTRfine DCR-1425	CTR of the last coefficient before the Fixed Gradient was set, 1/65536 seconds	unsigned short	864	16
FixedUTCvalSec DCR-1425	UTC validity time of the last coefficient before the Fixed Gradient was set (Adjusted ERT of Time Couple generating Coefficient), seconds	unsigned integer	880	32
FixedUTCvalMicro DCR-1425	UTC validity time of the last coefficient before the Fixed Gradient was set (Adjusted ERT of Time Couple generating Coefficient), microseconds	unsigned integer	912	32

Table 4-4 : Time Correlation Coefficient Data Representation

where CTRcoarse and CTRfine are the 6-byte Central Time Reference received in the STSP packet. The UTC time represents the adjusted ERT time in seconds since EPOCH 1958.001.00.00.00.000.[RID-PDR2-182] . Note that the last 5 fields containing information needed for fixed gradient correlation is ONLY related to correlation of telecommand execution time and telecommand parameters. [DCR-1425]

Gradient and offset are defined as Double precision value (IEEE standard) of 64-bit width.

The Accuracy parameter can have the values '1 = INVALID', '2 = VALID and ACCURATE' and '3 = VALID and[RID-PDR2-78] INACCURATE'.

The accuracy depends on the value of the gradient compared to 1. [SPR-1451] Depending on the outcome of the comparison on of the following rules will be applied:

- In case the difference is larger than a configurable validity limit, the coefficient is declared INVALID.
- If the difference is within the validity limit but outside the accuracy limit, the coefficient will be marked as INACCURATE.
- If the result is within both limits, the coefficient is declared ACCURATE.

The validity limit is a MCS dynamic configuration parameter.

The TcoMode parameter can have the values '0 = Time Correlation is based on use of STSP' and '1 = Time Correlation is based on use of TM frame adjusted ERT'.

The ResetChkStatus parameter can have the values '0 = On-Board Time Reset Checking is DISABLED' and '1 = On-Board Time Reset Checking is ENABLED'.

The MsbMaskStatus parameter can have the values '0 = OBT MSB is not used in OBT Reset checking (i.e. masked out before check for OBT Reset)' and '1 = OBT MSB is used in OBT Reset checking (i.e. not masked out before check for OBT Reset) '.

The ResetChkSpid parameter can have the value of any SCOS-2000 TM Packet IDentifier (SPID) defined in the mission database.

The FixedGradientUsed parameter indicates if the fixed gradient is used for TC uplink at coefficient generation. It can have the value 1=used and 0[DCR-1484]=not used.

The FixedCTRcoarse and FixedCTRfine parameters store the CTR coarse and CTR fine of the last coefficient before the Fixed Gradient was set. In case of the first coefficient or the Fixed Gradient is not set, these parameters store the same value as the CTRcoarse and CTRfine parameters. [DCR-1425]

The FixedUTCvalSec and FixedUTCvalMicro parameters store the UTC validity time of the last coefficient before the Fixed Gradient was set. In case of the first coefficient or the Fixed Gradient is not set, these parameters store the same value as the UTCvalSec and UTCvalMicro parameters.[DCR-1425]

All application data for a Time Coefficient packet is stored in network (BIG ENDIAN) format.

4.2.2 Message Description

The Time Correlation Coefficient Interface, TCO_COEFFICIENT, is defined in section 0 and is a single message type.

4.2.3 Communication Protocol

The TCO_COEFFICIENT data is archived in the MOC long-term archive and is made available to any users as part of spacecraft consolidated housekeeping telemetry for a particular period. External users shall retrieve TCO_COEFFICIENT data using the Herschel-Plank MOC Data Disposition System (DDS), which can be accessed by any external user granted access rights. Refer to [HPMCS-ICD-DDS] for details on how to use the DDS interface.

4.3 ASCII Log File Interface Description

The HPMCS Time Correlator will as required by requirement TMS-FU-C-4.2-270, see [HPMCS-SRS], produce an ASCII log containing an ASCII representation of the Time Correlation parameter data. This log file is made available to internal HPMCS users.

4.3.1 Data Elements

4.3.1.1 Name and Identification

Name	*Identifier*	*Description*
Time Correlation Log File	TCO_LOG_FILE	The Time Correlation Log File contains information from each time coefficient packet in ASCII format

4.3.1.2 Source and Destination

The Time Correlation Log File is created and updated by the TCO Server process. The file is stored in a configurable directory on the HPMCS server.

4.3.1.3 Frequency/Rate

A new log file is generated when the TCO Server starts up, and when the file reaches a configurable size. A new line is added to the currently open log file each time a Time Correlation Coefficient is produced. The frequency of the Time Correlation Coefficients is based on the rate of the STSP packets generated by the spacecraft and downlinked on the VC-0 channel. For Herschel-Planck the downlink rate for VC-0 data is either 500bps or 5kbps depending on the configuration. The STSP packet is downlinked every 64 frames.

VC-0 Data Rate	Time Correlation Log File Update Frequency
500bps	One update every 1142sec (or 19min)
5Kbps	One update every 114sec (or 1.9min)

Table 4-5 : Time Correlation Log File Update Frequency

4.3.1.4 Data Type and Representation

The Time Correlation Log file is a text file containing one line for each time coefficient packet generated by the TCO server. The format of the file name is:

TCOmain_<time_of_file_creation>.log.nnnnn

where time of file creation has the format YYYY_MM_DD_HH_MM_SS and nnnnn is the split number. An example of a valid file name would be \"TCOmain_2005_09_07_11_38_03.log.00001\". DCR-1568

Each line of the TCO log file contains the data applicable for one time coefficient in tab separated fields. Each field consists of a caption and a value (for example “Validity: INVALID”). The table below lists the fields that are present in each line.

Caption	Description	Value Type

Caption	Description	Value Type
Time:	Time of update (filing time of time coefficient packet)	Time in ASCII A format YYYY-MM-DDTHH:MM.SS.uuuuuu RID-PDR2-32,RID-PDR2-33 DCR-1183
OBT:	On-Board Time from the Time Coefficient Packet (CTRcoarse and CTRfine parameters)	Time in ASCII A format YYYY-MM-DDTHH:MM.SS.uuuuuu RID-PDR2-32, RID-PDR2-33 DCR-1183
ERT:	ERT of Time Couple generating Coefficient	Time in ASCII A format YYYY-MM-DDTHH:MM.SS.uuuuuu RID-PDR2-32, RID-PDR2-33 DCR-1183
Adjusted ERT:	Adjusted ERT of Time Couple generating Coefficient (UTC validity time of coefficient)	Time in ASCII A format YYYY-MM-DDTHH:MM.SS.uuuuuu RID-PDR2-32, RID-PDR2-33 DCR-1183
Correlated UTC:	UTC time correlated from the OBT of the generating Time Couple using the last valid coefficient set	Time in ASCII A format YYYY-MM-DDTHH:MM.SS.uuuuuu DCR-1183
Delay:	Propagation (OWLT, G/S and on-board processing) delay	double
Gradient:	Gradient from the Time Coefficient Packet	double
Offset:	Offset from the Time Coefficient Packet	double
Validity:	Time Correlation Status from the Time Coefficient Packet (Accuracy parameter)	One of the strings “INVALID”, “VALID and ACCURATE” or “VALID and INACCURATE”.
No. Time Couples (N):	Number of Time Couples used in Least Square Fit to calculate this coefficient set	unsigned integer
TCO Mode:	Time correlation Mode at Coefficient generation	unsigned integer
Reset Check Status:	Status of OBT Reset checking at Coefficient generation	unsigned integer
OBT MSB Mask Status:	Status of OBT MSB masking during OBT Reset checking at Coefficient generation	unsigned integer
Reset Check SPID:	SPID of TM packet used for OBT Reset Checking	unsigned integer
Fixed gradient used	If the fixed gradient is used for TC uplink at coefficient generation	unsigned integer

Caption	Description	Value Type
Fixed OBT: DCR-1425	On-Board Time from the Time Coefficient Packet if the fixed gradient is not used or On-Board Time from the last Time Coefficient before the fixed gradient was set	Time in ASCII A format YYYY-MM-DDTHH:MM.SS.uuuuuu
Fixed Adjusted ERT: DCR-1425	Adjusted ERT of Time Couple generating Coefficient if the fixed gradient is not used or Adjusted ERT of Time Couple generating Coefficient before the fixed gradient was set	Time in ASCII A format YYYY-MM-DDTHH:MM.SS.uuuuuu

Table 4-6 : Time Correlation Coefficient Data Representation

4.3.2 Message Description

The Time Correlation Log File Interface, TCO_LOG_FILE, is defined in section 4.3.1.4 and is a single message type.

4.3.3 Communication Protocol

Communication protocol not applicable, the Time Correlation Log files are stored in a configurable directory on the HPMCS server and is only available to HPMCS users.

Appendix A Correlation Algorithm

Time correlation is performed using the following 1st order linear expression:

$$UTC = (OBT - OBT_{REF}) \cdot m + c + UTC_{REF}$$

where ***m*** and ***c*** are calculated from a least square fit over the last n received time couples using a delta approach by subtracting the previous received time couple. The reference OBT_{REF} and UTC_{REF} are the Central Time Reference (CTR) and adjusted ERT from the corresponding time couple used for computing ***m*** and ***c***, where ***m*** is the slope and ***c*** is an expression for the adjusted offset since the last computation. The adjusted ERT is the ERT time from the Transfer Frame associated to a time couple taking into account propagation delay and other processing delay information.

The least square algorithm used for calculating the gradient ***m*** and offset ***c*** is the following:

$$m = [N*(\sum((UTC-UTC_{ref})*(OBT-OBT_{ref}))) - \sum(OBT-OBT_{ref}) * \sum(UTC-UTC_{ref})] \; / \; [N*\sum(OBT-OBT_{ref})^2 - \sum(OBT-OBT_{ref})* \sum(OBT-OBT_{ref})]$$

$$c = [\sum(OBT-OBT_{ref})^2 * \sum(UTC-UTC_{ref}) - \sum((UTC-UTC_{ref})*(OBT-OBT_{ref})) * \sum(OBT-OBT_{ref})] \; / \; [N*\sum(OBT-OBT_{ref})^2 - \sum(OBT-OBT_{ref})* \sum(OBT-OBT_{ref})]$$

where N is the number of Time Couples performing the least square fit over, (OBT_{ref}, UTC_{ref}) is the first (earliest) Time Couple in the set of N Time Couples and (OBT, UTC) are the N Time Couples used to calculate the new coefficient set (m, c).

Appendix B Correlation Calculation Example

The given example shows the time correlation calculations for a sequence of time couples. The time couples have been generated with the *TCOhpTimeCoupleMain* test tool. The tool was started with the options "-r 10 –e 200", generating time couple packets every 10 seconds and inserting an error of 200 ms to the OBT value of every 10th packet. The number of valid couples used in the Least Square calculation of coefficients was set to 3 (MISCconfig static variable (TCO_MCS_TIMECOUPLES_BUFFER), i.e. the latest 3 Time Couples is used in the Least Square calculation of coefficients. In the displayed time couple sequence the 'OBT' field of the time couple which contains the introduced error (Time Couple 4) is indicated in red.

Note: The displayed couples below is not the start of the time couple injection and the below data has been extracted from a point where time correlation was already VALID and ACCURATE.

Description	Time Couple 0	Time Couple 1	Time Couple 2	Time Couple 3	Time Couple 4
RAW OBT (coarse time)	1523292952	1523292962	1523292972	1523292982	1523292992
RAW OBT (fine time)	29705	29705	29705	29705	42813
ADJ. ERT SECONDS	1523292952	1523292962	1523292972	1523292982	1523292992
ADJ. ERT SUBSECS	453267	453267	453267	453267	453267
ADJ. ERT ASCII	2006-04-09T16:55:52.453	2006-04-09T16:56:02.453	2006-04-09T16:56:12.453	2006-04-09T16:56:22.453	2006-04-09T16:56:32.453
GRADIENT	1.000000	1.000000	1.000000	1.000000	0.990066
OFFSET	0.000000	0.000000	0.000000	0.000000	0.033331

Description	Time Couple 5	Time Couple 6	Time Couple 7	Time Couple 8	Time Couple 9
RAW OBT (coarse time)	1523293002	1523293012	1523293022	1523293032	1523293042
RAW OBT (fine time)	29705	29705	29705	29705	29705
ADJ. ERT SECONDS	1523293002	1523293012	1523293022	1523293032	1523293042
ADJ. ERT SUBSECS	453267	453267	453267	453267	453267
ADJ. ERT ASCII	2006-04-09T16:56:42.453	2006-04-09T16:56:52.453	2006-04-09T16:57:02.453	2006-04-09T16:57:12.453	2006-04-09T16:57:22.453
GRADIENT	0.999867	1.010067	1.000000	1.000000	1.000000
OFFSET	-0.065329	0.034011	0.000000	0.000000	0.000000

Note: Due to the fact that example time couples have been generated with the TCOhpTimeCoupleMain test tool, which is bypassing the MCS Packetiser, the adjusted ERT is equal to the ERT i.e. the propagation delay is not taken into account.

The table provides the following Information:

Retrieved from an Alpha Numeric Display of the *MONtelemetryDesktop* displaying content of generated TCO Time Couple and Time Coefficient packets:

- RAW OBT (coarse time)
- RAW OBT (fine time)
- ADJ. ERT SECONDS
- ADJ. ERT SUBSECS
- ADJ. ERT ASCII
- GRADIENT
- OFFSET