

Annex C (normative)

Spacecraft time protocols

C.1 Introduction

The text in this annex has been transcribed from ESA PSS-04-106 Packet Telemetry Standard, Issue 1, January 1998.

All spacecraft shall maintain a spacecraft reference time, called “Spacecraft Elapsed Time”, for the purpose of time-tagging telemetered events. The spacecraft clock is a free-running counter from an arbitrary starting point (epoch). The corresponding absolute time in the UTC (Universal Time Coordinated) reference frame is derived by ground correlation of the spacecraft clock. This correlation information is normally distributed, on the ground, together with the source packets. It can also be re-transmitted to the spacecraft, if UTC is used by the spaceborne data systems as an additional service.

The three subsections which follow cover the following fields:

- Presentation of spacecraft elapsed time.
- Format of standard spacecraft time source packet.
- Spacecraft time-correlation procedures.

C.2 Presentation of spacecraft elapsed time

The spacecraft elapsed time is maintained by the central clock on board the spacecraft and made available to all users. The time code format used is the CCSDS Unsegmented Time Code (CUC) format, which is represented as a combination of a preamble field (P-field) and a time specification field (T-field). The P-field may be either explicitly or implicitly conveyed with the spacecraft time code. If it is explicitly conveyed, it shall immediately precede the T-field.

The general format of both fields is as follows:

- P-field (1 octet): spacecraft time format specification.
- T-field (1 to 7 octets): spacecraft time specification.

The spacecraft elapsed time shall be represented as an unsegmented binary count of seconds and binary powers of subseconds, counting from an arbitrary epoch. The

resolution can be 2^0 , 2^{-8} , 2^{-16} or 2^{-24} seconds. The time shall be formatted as follows:

- a. P-Field:
 - bits 0 – 3 = 0010
 - bits 4 – 5 = no. of octets of coarse time, minus one, i.e. 1 to 4 octets.
 - bits 6 – 7 = no. of octets of fine time, i.e. 0 to 3 octets.
- b. Complete spacecraft time:

P-Field	T-Field							
00100000								
00100001								
00100010								
00100011								
00100100								
00100101								
00100111								
00100111								
00101000								
00101001								
00101010								
00101011								
00101100								
00101101								
00101110								
00101111								
	2^{32}	2^{24}	2^{16}	2^8	2^0	2^{-8}	2^{-16}	2^{-24}

- c. Unit of time: TAI (Temps Atomique International) second.
- d. Epoch: arbitrary, i.e. the epoch is of no importance, since elapsed time samples are UTC correlated on ground (see following sections).

If spacecraft time information is used as ancillary data for the interpretation of the source packet data, then time shall be inserted in the data field header of the source packet data field.

The presence of time in a data field header shall be application dependent. The time code format used can be either that of the spacecraft elapsed time (CUC) or that of the spacecraft UTC (CCSDS Day Segmented time code (CDS)) when this additional service is provided on board the spacecraft.

The P-field shall be included if application-specific interpretation of the T-field is mandated, otherwise it is optional.

The length of the T-field is application dependent, as defined by the user. It can be smaller than the distributed central spacecraft time. If it is longer, the additional clock octets shall be generated by the on-board user. In all cases, the length of the T-field shall be sufficient to avoid ambiguity during the mission, and the resolution shall be sufficient to meet the requirements of interpreting the data without additional processing of the time information.

C.3 Standard spacecraft time source packet

The standard source packet used to transport the regular spacecraft elapsed time samples to ground for time correlation with UTC is formatted as follows:

- Application process identifier: “all zeros” (reserved APID).
- Data field header flag: set to “0”.
- Packet data field: the data field of the standard source packet only contains spacecraft time system information formatted as follows:
 1. The first octet in the data field shall specify the sampling rate of the spacecraft clock contents as explained further in subclause C.4. The format and specification of this octet is as follows:

Bits 0, 1, 2, 3: Not specified in this Standard (to be obtained from the supporting infrastructure or to be set to ‘all zeros’ if not used).

Bits 4, 5, 6, 7: Specify the sampling rate of the spacecraft clock contents as described in subclause C.4. The code allocation is as follows:

Bit 4	Bit 5	Bit 6	Bit 7	Rate (in Frames)
0	0	0	0	1
0	0	0	1	2
0	0	1	0	4
0	0	1	1	8
0	1	0	0	16
0	1	0	1	32
0	1	1	0	64
0	1	1	1	128
1	0	0	0	256

2. The next octets contain spacecraft time information in the form of a P-field and a T-field, with length and contents as described in subclause C.2.
3. The last octets contain any relevant spacecraft time-system parameters. This includes the provision of system configuration flags for the identification of the various fixed, on-board delays. The format for this part of the packet data field shall be obtained from the supporting infrastructure.

C.4 Spacecraft time correlation procedures

On board the spacecraft, the contents of the spacecraft elapsed time clock are sampled at the instant of occurrence of the leading edge of the first bit of the attached synchronisation marker of that telemetry transfer frame of virtual channel “0” with a virtual channel frame count “0”. This time sample shall then be placed into the standard spacecraft time source packet and telemetered to ground before the frame counter of virtual channel “0” has counted 255 more frames, so as to avoid ambiguity.

Should this sampling rate (intervals of 256 frames of virtual channel “0”) prove too low for the mission requirements, it is permissible to sample the spacecraft clock contents at intervals of 128, 64, 32, 16, 8, 4, 2 or 1 frame(s) of virtual channel “0”, by choice. Consequently, the time sample shall be telemetered to ground before the selected number of frames of virtual channel “0” have elapsed (128, 64, 32, 16, 8, 4, 2 or 1, all counts starting from virtual channel frame count “0”).

The ground data capture system shall:

- a. accurately time-tag the instant of reception of the same first bit of the attached synchronisation marker of the virtual channel “0” transfer frame

with a virtual channel frame count “0”. The time standard used is CDS-coded UTC;

- b. extract the standard spacecraft time source packet and collect the CUC-coded time sample.

Thus, a correlation between the spacecraft elapsed time and the UTC reference on ground shall be established, which can be used:

- on ground, to transform the spacecraft elapsed time information contained in the source packets into UTC information;
- on board the spacecraft, to achieve directly the same service as on the ground.