Preparation and validation of WEC time corrections 2007--11-24 to 2007-12-31

Keith Yearby, 23 July 2008

Contents

1 Introduction

For precise time stamping of Cluster science data it is necessary to accurately determine the UT time at which each VC0 reset pulse occurs onboard. This pulse is time correlated with the transmission of the first bit of the housekeeping virtual channel (VC0) and the contents of the onboard time counter at this time is recorded in the On-board Time (OBT) field of the VC0 transfer frame (EID-A section 3.3.1.3.1 and 3.3.7.2.2). The time of the pulse is called the Spacecraft Event Time or SCET, and is given to a standard accuracy of +/- 2ms.

However for inter-spacecraft comparisons of EFW and STAFF waveform data a much higher accuracy is needed. This is achieved by preparing time correction (TCOR) files. The process is described in general in the document 'Precise reconstitution of the Spacecraft Event Time (SCET)'.

The purpose of the present document is to describe the precise procedure used from 2007-11-24 to the end of the year. During this period a new operational procedure was used at ESOC, where time correlations were performed during each nominal pass. This in turn required a new procedure to prepare the time corrections.

2 Data and references

Source data:

WBD data DVDs for 2007.
Cluster RDM for 2007.

Documents:

Precise reconstitution of the Spacecraft Event Time (SCET), Keith Yearby, 2004 July 7

Software:

wbddiff, version 1.0, 2004-06-11
maketcor3, version 3.9, 2008-03-20
veritcor, version 1.3, 2005-07-19
tcor2cef, version 1.6, 2006-03-02

3 Preparation of the Point Valid DIFF measurements

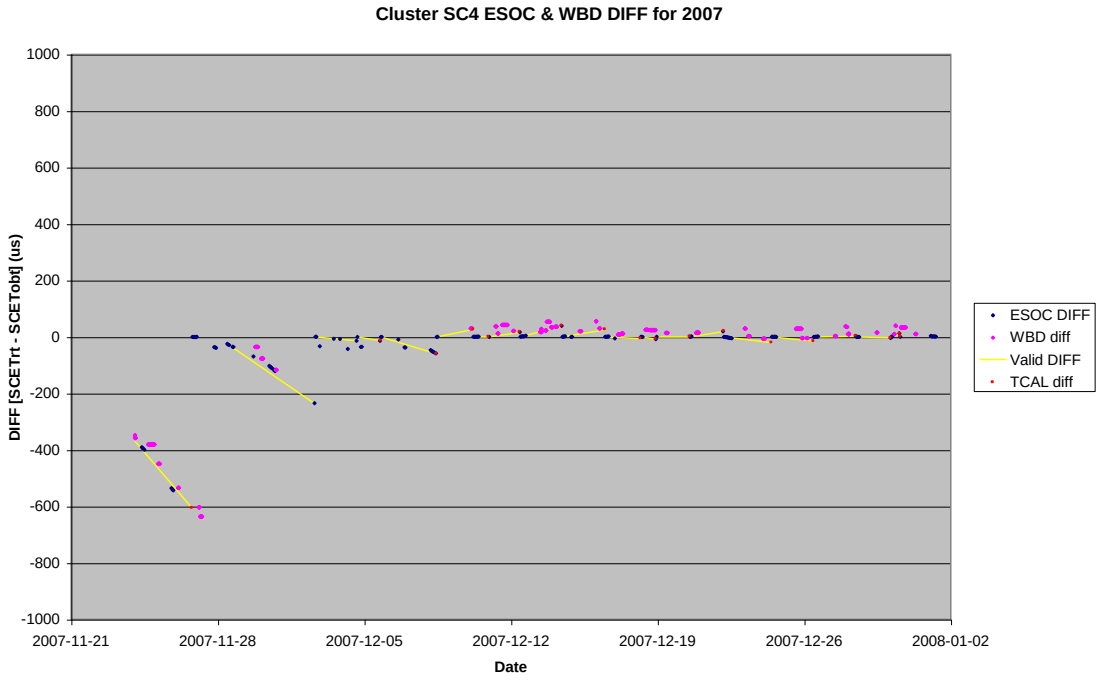
From 2007-11-24 onwards ESOC perform time correlations during every nominal pass. Then the DIFF usually remains small, typically less than 20 μs. A linear interpolation between one time correlation and the next is normally quite sufficient to obtain DIFF to an acceptable accuracy. The DIFF value just after each time correlation can be assumed to be zero - this is what the time correlation achieves. The DIFF just before the same time correlation can be calculated using coefficients of the previous time correlation.

The DIFF values can be extracted from the TCAL files on the RDM. This is done automatically using the software tool 'readtcal' (version 2.0, 2008-07-21). This requires as input a list of the full path names of the TCAL files. The standard HK+TCAL list used by 'maketcor' is suitable, and in this case the files already prepared for the earlier 2007 data were used. The following commands were used:

```
../readtcal -f 07_1_hkla_files.txt -o 07_1_tcaldiff.txt
../readtcal -f 07_2_hkla_files.txt -o 07_2_tcaldiff.txt
../readtcal -f 07_3_hkla_files.txt -o 07_3_tcaldiff.txt
../readtcal -f 07_4_hkla_files.txt -o 07_4_tcaldiff.txt
```

As before, the accuracy of the DIFFs are checked by comparing each WBD measurement with a linear interpolation between the nearest validated ESOC (TCAL) measurements before and after. The average and standard deviation of all measurements were calculated. These figures exclude WBD measurements from DSN antennae 80 and 81 for all S/C, and additionally antenna 67 for S/C 3. These antennae show unusually high offsets which do not appear to be due to any error in the ESOC measurements.

There were also some difficulties at the start of the period on SC4 due to long intervals between time correlations. These data were loaded into a spreadsheet together with the ESOC and WBD data, in a similar way to earlier periods, and manually adjusted to obtain a good fit.



The final 'point valid diff' files were:

```
07_1_tcaldiff.txt
07_2_tcaldiff.txt
07_3_tcaldiff.txt
0711_4_diff.prn
```

The final average and standard deviation of the WBD-ESOC comparison were:

SC	Average wbd-esoc (micro-sec)	St Dev wbd-esoc (micro-sec)
1	14.8	4.1
2	13.9	4.6
3	8.3	6.4
4	9.1	6.7

4 Generation of the ASCII TCOR files

The generation of the ASCII TCOR files is performed on the Sun network where direct access to the Cluster RDM is available.

Then 'maketcor' is used to generate the ASCII TCOR files. For this period it was updated to version 3.9. This starts new segment after any gap in the telemetruy. VC0 phase tracking also improved - earlier versions occasionally spuriously re-initialised due to use of zero to indicate un-initialised. This value occasionally occurred in the data.

```
../maketcor3.9 -d 07_1_tcaldiff.txt -f 07_1_hkla_files.txt \
    -s 071124 -e 071231 -w ../wbddiff/wbd_all_c1_ncd.txt \
    > 0711_1_tcor.txt
../maketcor3.9 -d 07_2_tcaldiff.txt -f 07_2_hkla_files.txt \
    -s 071124 -e 071231 -w ../wbddiff/wbd_all_c2_ncd.txt \
    > 0711_2_tcor.txt
../maketcor3.9 -d 07_3_tcaldiff.txt -f 07_3_hkla_files.txt \
    -s 071124 -e 071231 -w ../wbddiff/wbd_all_c3_ncd.txt \
    > 0711_3_tcor.txt
../maketcor3.9 -d 0711_4_diff.prn -f 07_4_hkla_files.txt \
    -s 071124 -e 071231 -w ../wbddiff/wbd_all_c4_ncd.txt \
    > 0711_4_tcor.txt
```

5 Validation of the TCOR files

The software tool ‘maketcor3’ performs some automatic validation as the files are produced. Data that fails automatic validation are not included in the output files.

Further validation of the TCOR files is performed by generating version 0 CEF files, using these to apply time corrections, then analysing the time tags of the corrected data. Anomalies identified in the corrected data may then be related to errors noted in the TCOR file comments, and the TCOR records deleted or corrected. The process is then repeated until no anomalies are found. Comments in the ASCII TCOR files indicate where such corrections have been made. For the period of this report, manual correction was only needed on S/C 1.

The time tags are analysed using ‘veritcor’. This takes the time increment between each pair of records in the file, subtracts the nominal value of 5.15222168 seconds, and accumulates the minimum, maximum, mean and standard deviation over each 24 hour period. On SC1 and SC3 it is known that time jumps of -125.9 us occur occasionally. These are counted and removed before further analysis. Gaps in the file are allowed for, and by default ‘veritcor’ only processes records that are time corrected.

It uses the same HK+TCAL file list file as 'maketcor3', although only the HK files are used. 'veritcor' includes the same code module used by TED to apply the TCOR corrections, and requires CEF TCOR files to be installed with the same index files. The '-T .' option specifies that the TCOR files (and the index files) are located in the default directory.

```
../tcor2cef -t 0711_1_tcor.txt
../tcor2cef -t 0711_2_tcor.txt
../tcor2cef -t 0711_3_tcor.txt
../tcor2cef -t 0711_4_tcor.txt
../veritcor -f 07_1_hkla_files.txt -T . -v 4 > 0711_1_veritcor.txt
../veritcor -f 07_2_hkla_files.txt -T . -v 4 > 0711_2_veritcor.txt
../veritcor -f 07_3_hkla_files.txt -T . -v 4 > 0711_3_veritcor.txt
../veritcor -f 07_4_hkla_files.txt -T . -v 4 > 0711_4_veritcor.txt
```

6 Production of the CEF files

The final CEF files were produced by running TCOR2CEF on the validated ASCII format TCOR files, with version number 1 specified. The file comparison utility (diff) was used to check that the only changes between the version 0 files used for validation, and the final version, are in the filenames, version numbers, and generation date.

The CEF file name is generated automatically using information contained in the file (except for the version number which is specified). Note that the date included in the name is the date of the first data actually present in the file, which may not be the same as the start of the nominal period covered by the file.

```
hoodie% ../tcor2cef -t 0711_1_tcor.txt -v 2
TCOR2CEF, version 1.6

TCOR file:          0711_1_tcor.txt, s/c: 1, records: 346
Generated CEF name: C1_CP_DWP_TCOR__20071124_V02
Time range:         2007-11-24T00:00:00Z/2007-12-31T18:47:23Z
Finished, CEF size: 38629 bytes
Total duration:     3264443 seconds
Corrected:          3215281 seconds (98.5 %)
hoodie% ../tcor2cef -t 0711_2_tcor.txt -v 2
TCOR2CEF, version 1.6

TCOR file:          0711_2_tcor.txt, s/c: 2, records: 338
Generated CEF name: C2_CP_DWP_TCOR__20071124_V02
Time range:         2007-11-24T00:00:00Z/2007-12-31T15:35:57Z
Finished, CEF size: 37471 bytes
Total duration:     3252957 seconds
Corrected:          3170931 seconds (97.5 %)
hoodie% ../tcor2cef -t 0711_3_tcor.txt -v 2
TCOR2CEF, version 1.6

TCOR file:          0711_3_tcor.txt, s/c: 3, records: 306
Generated CEF name: C3_CP_DWP_TCOR__20071124_V02
Time range:         2007-11-24T00:00:00Z/2007-12-30T10:52:34Z
Finished, CEF size: 34370 bytes
Total duration:     3149554 seconds
Corrected:          3031754 seconds (96.3 %)
hoodie% ../tcor2cef -t 0711_4_tcor.txt -v 2
TCOR2CEF, version 1.6

TCOR file:          0711_4_tcor.txt, s/c: 4, records: 417
Generated CEF name: C4_CP_DWP_TCOR__20071124_V02
Time range:         2007-11-24T01:19:55Z/2007-12-30T14:19:12Z
Finished, CEF size: 46995 bytes
Total duration:     3157157 seconds
Corrected:          2815010 seconds (89.2 %)
```

Finally, the CEF files are checked using CEFpass.

```
setenv CEFPATH ~/CAA/headers
~/CAAtools/CEFpass C1_CP_DWP_TCOR__20071124_V02.cef
~/CAAtools/CEFpass C2_CP_DWP_TCOR__20071124_V02.cef
~/CAAtools/CEFpass C4_CP_DWP_TCOR__20071124_V02.cef
~/CAAtools/CEFpass C3_CP_DWP_TCOR__20071124_V02.cef
```

7 Caveats

The following general caveats apply to TCOR data 2007-11-24 - 2007-12-31:

Use with caution. If published results depend critically on timing accuracy it is recommended that the DWP team should re-verify the TCOR data in question.

TCOR data is not available at all times. In this first release, data that fails validation is simply deleted from the files. For this period, TCOR coverage is typically around 90 to 99%.

Interpolation between TCOR records in CEF files is only permitted in limited circumstances. The time corrections are provided at the start and end times of each period of the same telemetry mode. The OFFSET is constant throughout each period, and the same value will be written in the records at the start and end of the period. If the OFFSET values before and after the required time are different, or either has the fill value of -1e31, then OFFSET is not available for that period. No interpolation between different OFFSET values is allowed. The DIFF may be obtained by linear interpolation of the DIFF values immediately before and after the required time. However, if either DIFF has the fill value of -1e31, then DIFF is not available for that period. It is not allowed to interpolate over a fill value.

8 Delivery

The files are delivered to the CAA using SCP.

```
hoodie% scp *V02.cef \
    dwp@caa-delivery.estec.esa.int:/c/data-51/DWP/TCOR
C1_CP_DWP_TCOR__20071124_V02.cef        100%   38KB   0.0KB/s   00:00
C2_CP_DWP_TCOR__20071124_V02.cef        100%   37KB   0.0KB/s   00:00
C3_CP_DWP_TCOR__20071124_V02.cef        100%   34KB   0.0KB/s   00:00
C4_CP_DWP_TCOR__20071124_V02.cef        100%   46KB   0.0KB/s   00:00
```