DIGITAL WAVE PROCESSOR DATA IN THE CLUSTER ACTIVE ARCHIVE

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ABSTRACT

The Digital Wave Processor (DWP) is the central control and data processing unit for the Cluster Wave Experiment Consortium (WEC) which comprises the EFW, STAFF, WHISPER and WIDEBAND instruments. All commanding and telemetry acquisition for the WEC is routed via DWP, except for WIDEBAND telemetry to the Deep Space Network.

DWP performs on board science data processing for WHISPER and STAFF and also contains a particle correlator experiment which computes the auto-correlation (ACF) of electron counts received by the PEACE HEEA sensor. The correlator detects modulations and short time bursts in the electron population as an indicator of wave-particle interactions.

Time synchronisation of WEC modes is controlled by DWP, and one of the functions of DWP is determination of the precise time at which the WEC data was acquired on board. For burst mode EFW and STAFF waveform data the timing accuracy required exceeds the standard 2 ms accuracy provided by the spacecraft ground segment, so the DWP team have developed a method of enhancing the timing accuracy.

DWP data products in the Cluster Active Archive include high resolution correlator data, time correction data, an overall WEC status log and documentation.

1. INTRODUCTION

The Digital Wave Processor (DWP) (Fig. 1) is the central control and data processing unit for the Wave Experiment Consortium (WEC) (Fig. 2).

1.1. DWP as an experiment controller

The Wave Experiment Consortium comprises the EFW, STAFF, WHISPER and WIDEBAND instruments. The

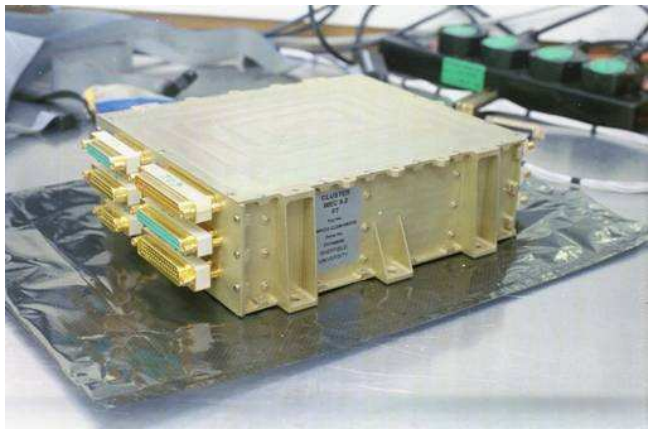

Figure 1. The Digital Wave Processor (DWP).

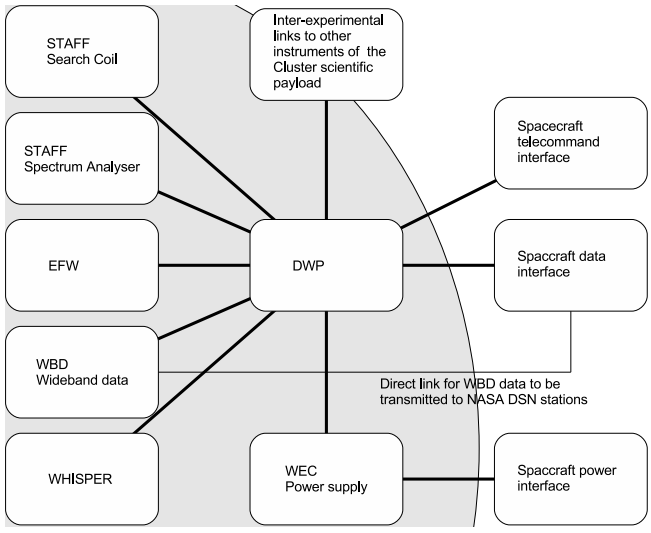

Figure 2. DWP in relation to the WEC instruments and other spacecraft interfaces.

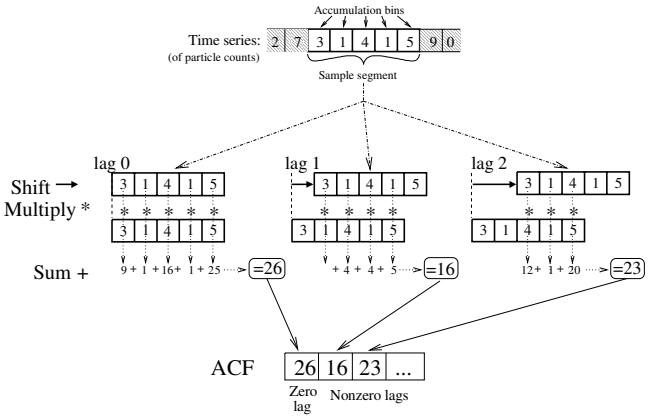

Figure 3. Autocorrelation function (ACF) computation. This diagram shows how the ACF is calculated from the particle count time series.

relation betweeen these instruments as DWP is shown schematically in Fig. 2.

All commanding and all telemetry acquisition for the WEC is routed via DWP, except for WIDEBAND telemetry to DSN.

Time synchronisation of WEC modes is controlled by DWP.

Science telemetry is dynamically allocated between the WEC instruments, according to the requirements of each mode.

DWP performs on board science data processing for Whisper and STAFF (and WIDEBAND if DSN not used).

1.2. DWP as a particle correlator

DWP contains a particle correlator experiment which computes the auto-correlation (ACF) of electron counts received by the PEACE HEEA sensor.

The correlator detects modulations and short time particle bursts in the electron population as an indicator of wave-particle interactions.

An illustration of the ACF computation algorithm is shown in Fig. 3. An example of a computed ACF is shown in Fig. 4.

Frequency range: 1.4 kHz to 41.6 kHz in 32 frequency bands and DC to 4 Hz based on successive ACF outputs.

Energy range: 0.6 eV to 26 keV in 15 energy bands (PEACE mode dependent).

Time resolution: 1 ACF/spin in normal mode, to 16 ACF/spin in burst mode.

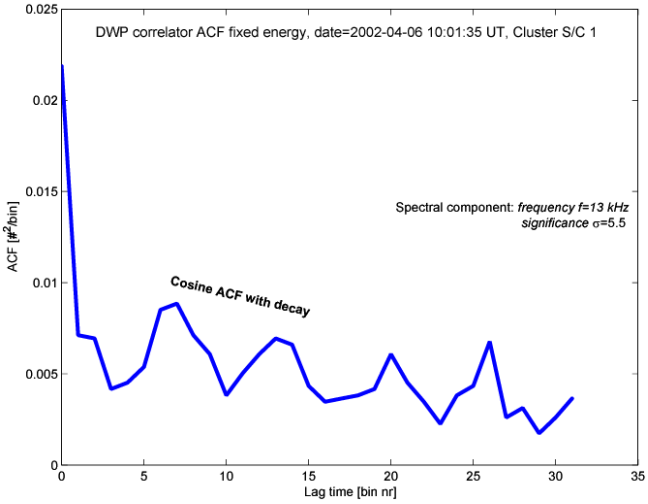

Figure 4. Autocorrelation example. This ACF is taken from Cluster spacecraft 1 on 2004/04/06 10:01:35 UT. It is described as a cosine ACF, with decay. The spectral component is 13kHz and σ=5.5.

1.3. DWP support tasks

The DWP team co-ordinates the preparation of the WEC command schedule and prepares an overall WEC PIOR each week.

DWP provides a software package (TED) to decommutate and extract the telemetry data for each WEC instrument.

This process includes determination of the precise time at which the data was acquired on board by DWP.

For burst mode waveform data the timing accuracy required exceeds the standard 2 ms accuracy provided by ESOC, so the DWP team have developed a method of enhancing the timing accuracy using time difference measurements provided by ESOC and WIDEBAND.

2. DATA PRODUCTS

The DWP data products that are to be included in the CAA are the time correction, autocorrelation functions, WEC status log, PIORs and related documentation.

2.1. Time correction

Dataset name: `C1_CP_DWP_TCOR`.

Each file contains the following parameters:

`Time_C1_CP_DWP_TCOR`

`Offset_C1_CP_DWP_TCOR`

Diff__C1_CP_DWP_TCOR

Offset is the difference in microseconds between the reference time for the packet (VC0 reset pulse) and the onboard time stamp for that packet. It is only applicable to data recorded on the onboard solid state recorder, and not to WIDEBAND data acquired via DSN.

Diff is the difference in microseconds between the onboard time and UTC, and is determined independently by ESOC and WIDEBAND.

Offset and Diff should be added to the UTC packet times (SCET) to get the accurate reference time of the packet.

For WIDEBAND DSN data only the Diff should be used.

Diff originates in the drift of the onboard time relative to UTC, and is slowly varying.

The Diff values are prepared from measurements provided by ESOC and WIDEBAND, but this process is not straight forward as the raw measurements sometimes have large errors.

Offset changes each time the telemetry mode changes, but is constant during each period of the same mode.

The TCOR files specify the Offset and Diff values at the start and end of each period of the same TM mode.

Each file will cover the period of validity of one time correlation - typically a few months.

The TCOR CEF files will be less than 1M bytes/year for all spacecraft.

The variation of Offset and Diff in the test file can be seen in Fig. 5.

2.2. Auto correlation functions

2.2.1. High resolution science data

There are two similar data sets:

C1_CP_DWP_COR_FX for the fixed (pre-selected) energy band.

C1_CP_DWP_COR_SP for the stepped energy which steps through the remaining 14 bands, at one step per spin.

Each contain the parameters indicated in Table 1.

The COR_FX and COR_SP datasets will be provided as CEF files, one file per day for each dataset. Estimated quantity of data between 20 and 50 M byte/day, depending on how much burst mode is used.

2.2.2. Calibration dataset

Specification to be defined.

May include energy level table, geometric factor, dead times, etc.

2.3. PIORs

UT time tagged PIOR files (CL_CD_DWP_UT_PIOR)

These files exist already in our planning system and just need to be renamed for input to the archive.

These files provide a record of what commands were uplinked to WEC and are complementary to the WEC status log in that they indicate what was intended rather than what actually happened.

They also contain associated information on the PEACE mode (to support the particle correlator operations), and selected scientific events (predicted boundary crossings etc.).

Each file covers one planning period - about one week.

They will be archived as documents, indexed by the start and end times of the planning period.

ASCII file size about 100 K bytes/week, or 5 M bytes / year.

2.4. WEC status log

Dataset name: C1_CP_DWP_LOG

A log of the overall status of the WEC instruments

One record for each interval that the WEC operates in the same mode.

A total of 64 parameters including:

Time interval, Instrument modes, Telemetry use statistics, Errors and anomalies and Summary of voltage and temperature housekeeping.

Produced by automatic analysis of WEC telemetry with caveats added manually.

Test files containing one day's data are about 60k bytes, but 90% of this is metadata. Production files containing one months data should be about 250K bytes, so about 12 M bytes/year for all SC overall.

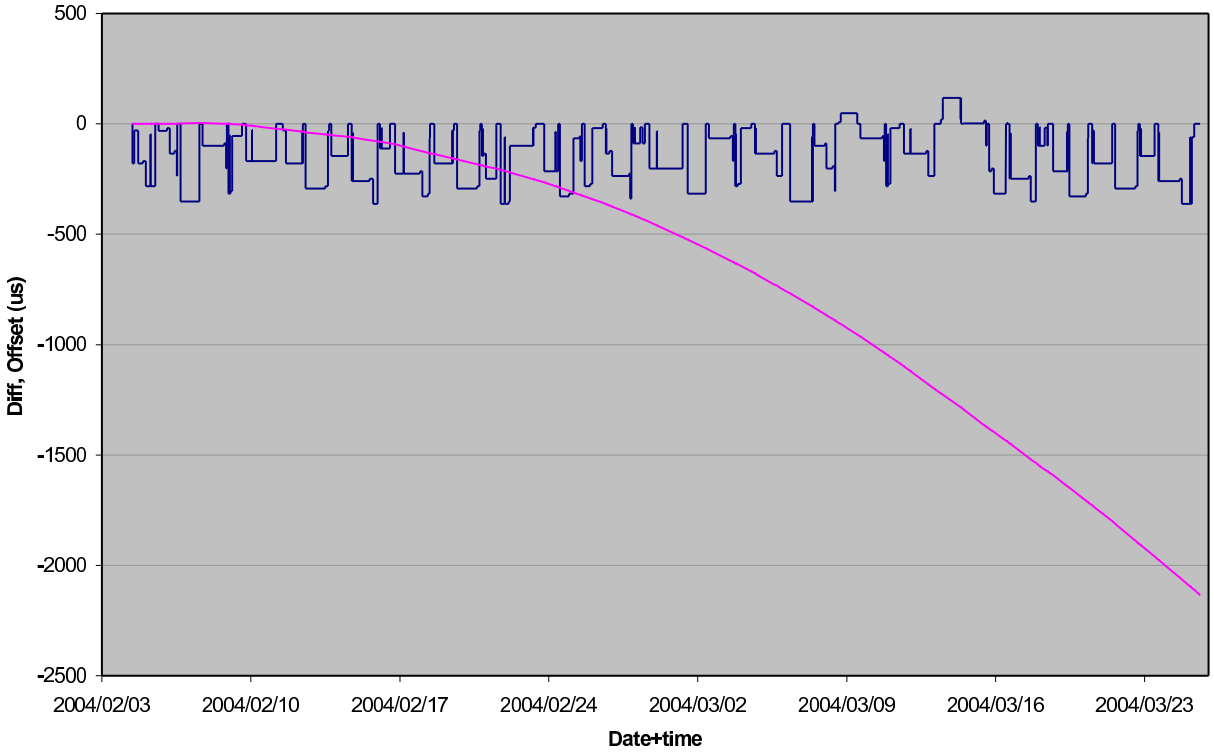

Figure 5. Time correction. Shown here are the DIFF and OFFSET components of the time correction for Spacecraft 1 for the period beginning February 2004 ending March 2004. The DIFF component can be seen to be slowly time varying. The OFFSET component changes with telemetry mode changes yet remains constant throughout those modes. The total time correction to apply to the ESOC timestamps is the sum of these two components.

Time	**Interval centered time tag**
Half_Interval	Half interval for data accumulation
Look_Angle_Azimuth	PEACE azimuthal look direction for which ACF has been calculated
Half_Azimuth	Half azimuth angle over which ACF accumulated
Look_Angle_Polar	PEACE polar look direction for which ACF has been calculated
Field_Angle_Azimuth	Azimuthal angle of the magnetic field direction
Field_Angle_Polar	Polar angle of the magnetic field direction
Energy	PEACE energy at which ACF has been calculated
Half_Energy	Half energy range over which ACF accumulated
ACF_Count	Number of Auto Correlation Functions summed in this accumulation
PEACE_sweeps	Number of PEACE sweeps summed in this accumulation
Count_rate	Estimated count rate
ACF_Zero_Lag	Zero lag electron auto correlation
ACF_non_zero_lags	Normalised electron Auto Correlation Function (31 lags)
Lag_Time	The time offsets for each lag in the ACF.

Table 1. Particle correlator parameters in the CAA.

2.5. Documentation

2.5.1. WEC telemetry and extraction decommutation software

Dataset name: CL_CD_DWP_TED.

This software is archived for reference purposes only, as C source code. No DWP software will run in the archive.

The software and its associated documentation will be provided as a TAR archive.

There may be several versions, which should be available to users simultaneously.

2.5.2. WEC User Manual

Dataset name: CL_CD_DWP_WEC_UM.

A comprehensive description of the WEC experiments, telemetry and command formats.

The User Manual will be provided as a set of 8 PDF files, one for each chapter. About 4.5 Mbytes total.

3. PRODUCTION, QUALITY CONTROL AND DELIVERY PROCEDURES

All DWP data products will be produced by the DWP team and delivered to the archive as CEF, ASCII, PDF, or TAR files.

Data products will be validated by the DWP team prior to delivery.

File transfers will be initiated by the DWP team and performed using SCP (the secure copy client of SSH2).

3.1. Production Status as of September 2005

3.1.1. Correlator

Procedure is defined and main software tools written.

Production of test data set is commencing, with 'Assembly line' production to start soon after.

3.1.2. Time Correction files

Procedure defined and main software tools written.

Routine production is waiting for appointment of DWP archive developer, and UK distribution of WBD data DVDs.

3.1.3. WEC status log

Preliminary version of software available.

54 out of the 64 parameters are implemented.

3.1.4. PIORs

Datasets already exist.

Simple software tool to be developed to handle naming and delivery of files. Documentation

Datasets already exist. User manual may be updated.

3.2. Data delivered as of September 2005

These test data files have been delivered:

C1_CP_DWP_TCOR__20040204_V01.cef

CL_CD_DWP_UT_PIOR__ (cont)
200504012043_200504090001_V01.txt

C1_CP_DWP_LOG__20050321_V01.cef

Example correlator file is available (metadata definitions only):

C1_CP_DWP_COR_FX__20010101_V02.cef

Further test data files and header files are now available in /home/dwp/incoming on caa1.estec.esa.int