WEC Detailed Data Analysis Software
User Requirements

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December 15, 1999

Document Status Sheet			
1. Document Title: **WEC/ISDAT User Requirements**			
2. Document Reference Number: **CWD-URD-001**			
3. Issue	4. Revision	5. Date	6. Reason for Change
Draft	0	93 Sep 14	New document. Only EFW included
Draft	1	93 Oct 12	WECdata report UR included
Draft	2	93 Oct 15	Chris' comments included
1	0	94 Jan 20	After WEC discussion. Simon Walkers comments included. Changed to esadoc format. Removed ISDAT or user supplied labels on detailed requirements.
1	1	94 Feb 08	Data distribution section completely re-written to accout for the choice of CD-ROM as RDM and to put it in a WEC perspective rather than an EFW perspective. Included DWP requirements (E-mail from S Walker 3 Feb 1994 Re. WEC data task 3.1. Included Ephemeris requirements (E-mail from S Walker 3 Feb 1994 re. WECdata task 4.10).
1	2	94 Feb 14	Changed labels UR-WEC-109 - UR-EFW-101, ur-WEC-120 - UR-EFW-102, UR-WEC-123 - UR-EFW-103, UR-WEC-128 - UR-EFW-104
2	0	94 Jun 22	Numerous changes introduced at the WEC data meeting in Uppsala 31 May to 2 June 1994. All priorities were set and defined.

Contents

1 Introduction

1.1 Purpose of the document

This document describes *what* the ISDAT is required to do from the users point of view. and *how well* it is to be done. It does not contain any description on *how* the functions are performed.

This document supersedes the "CEDAS 2.1 Product Requirements" [Ref. 3] (last revision 1.12 dated 12 March 1990)

The document originates in the EFW user requirements document, and may therefore seem to refer EFW in a high proportion.

1.2 Scope of the software

The scope of the software is to provide tools for detailed scientific analysis of all the WEC instriments.

1.3 Definitions, acronyms, and abbreviations

A complete list of acronyms is given in an appendix.

1.4 Overview

Chapter 2 of this document contains a summary of the scientific goals of the EFW experiment. The goals are organised after scale lengths. After each paragraph, the analysis implications are summarised. Chapter 2 also contains a short overview of the measured parameters and the amount of data involved.

Chapter 3 lists the detailed user requirements deduced from WEC users. The requirements are divided into capability requirements and constraint requirements. Each requirement is labelled, and for each requirement the origin of the requirement is given. Each requirement is also classified as essential or having priority 1-3.

The document organisation follows the ESA software engineering standards [Ref. 4] recommendations for a user requirements document.

2 General Description

2.1 Scientific Background

2.1.1 Introduction

A summary of the Cluster EFW scientific goals is found in [Ref. 5] upon which this background information is largely based.

The CLUSTER spacecraft will pass through numerous plasma regimes separated by a variety of boundaries and discontinuities. From the view point of an electric field and plasma fluctuation experiment, this means that a large variety of wave-wave, wave particle and nonlinear plasma interactions as well as time and space variations of macroscopic and quasi-static electric fields will be found along the trajectory of the space craft. These phenomena will occur over widely differing temporal, spatial, and amplitude ranges. To provide an adequate understanding of the phenomena, an electric field and plasma fluctuation experiment must be able to measure, in two dimensions, over frequencies ranging from DC to 10 kHz with a time resolution of 100 microseconds. This will cover waves up to lower hybrid modes, and the time resolution will resolve time domain structures. Amplitudes of a few μ V/m to 700 mV/m has to be covered and plasma density fluctuations from about 1 to 50 % relative variation. It should be able to measure phase velocities of electrostatic structures over time scales of milliseconds by interferometric timing between opposing boom pairs. In order to measure the polarisation of electrostatic waves and resolve the k vectors of waves propagating perpendicular and parallel to the magnetic field with frequencies faster than the spin rate of the spacecraft, has have two pairs of electric field sensors which can be sampled to produce an instantaneous two dimensional electric field vector. The operation mode with all four probes measuring density fluctuations, will allow two dimensional plasma wave interferometer measurements to determine wavelength, phase velocities and time of flight of plasma phenomena. Finally, it has an internal burst memory in order to record high time resolution data at rates higher than the telemetry stream. This burst memory will is enough to sample over the spatial distances associated with the bow shock, auroral structures, the plasma sheet boundary, and the magnetopause.

The experiment has four spherical sensors located at the end of 50 m long booms in the spin plane of the satellite. It covers four basic frequency ranges with two analogue-to-digital converters that can sample up to 40 ksamples/s and it has an internal memory of one megabyte.

The experiment thus covers a wide range of time and frequency scales with corresponding demands on computation and display capabilities. We will also cover a wide range of spatial scale sizes. The more detailed scientific background following below is ordered after the scale sizes.

2.1.2 Electric Fields at Small Scales

Scientific Questions Some of the most interesting magnetospheric physics is associated with nonlinear processes that result in the acceleration of plasma. S3-3, Viking and ISEE electric field measurements have shown that particle acceleration is associated with large amplitude, short duration electric field signatures. Small spatial and temporal scale structures are important because they provide the necessary dissipation in the various magnetospheric boundary regions. They are equally important, from the view of basic plasma physics. They represent the nonlinear state of the plasma under various conditions and as such are at the forefront of basic plasma physics.

Since such structures are inherently nonlinear, it is desirable to study them in the time domain. The use of time domain information nicely complements the spectral information that is important in the study of linearly propagating waves. The investigation of nonlinear structures in the time domain provides the best opportunity to make new discoveries by exploiting the capabilities allowed by recent advances in technology.

ISEE observations in the bow shock reveal intense electric field spikes with amplitudes of 100 mV/m and durations of .05 second. The spikes are often bipolar. Almost none of the properties of these waves can be determined by the ISEE experiment but can be determined by the Cluster quasi-static experiment. The phase velocity, scale size, polarisation relative to the ambient magnetic field, three-dimensional structure, coherence length, relation to comparable temporal scale density and magnetic field fluctuations can be determined with the Cluster electric field instrument in four satellites. These quantities are needed to evaluate the role of the spikes in providing anomalous resistivity, thermalising ion and electron distributions, and in the production of high energy electron beams commonly seen at the bow shock.

High time resolution data must be obtained using the internal burst memory in various different sampling schemes based on the region of space being sampled. Whenever higher-time resolution data have become available, new phenomena have been discovered, e.g. recent rocket observations of Langmuir solitons. One anticipates the discovery of many interesting important new structures in the high-frequency time domain data to be obtained by the Cluster satellites.

Data Analysis Implications This is a most demanding regime from the data analysis point of view. For example:

Short duration of spiky pulses prohibits ordinary FFT analysis. Normally these events have to be studied and displayed in the time domain.

Time domain display of short events with unpredictable occurrence requires stepping through huge amounts of data in small steps. Therefore it is necessary to be able to search through data fast. At a later stage it might also be desirable to be able to implement automatic search algorithms of AI type to automatically scan through the data in search for these spiky events.

Various conditions We are interested to find out under which conditions the small scale fields occur. It is therefore necessary to have access to other parameters as well as the E-field. Such parameters are:

- Plasma density and temperatures
- Bulk plasma motion
- Electron distributions

Phase velocity determination requires interferometer analysis tools like:

- Cross correlation
- Cross spectral analysis
- Satellite velocity determination
- satellite aspect determination

Scale size and 3D structure determination requires correlation analys tools for data from different probes.

Coherence length determination requires simultaneous data from all four satellites.

Polarisation determination requires knowledge of the satellite orientation with respect to the ambient magnetic field.

B-field correlations requires access to B-field data.

Unknown phenomena Requires high time resolution unprocessed raw data.

Plot formats:

- Time series, mixed data, correlations
- Frequency spectra, line plots and gray (colour) scales
- Hodograms
- Fast interactive time plots
- Satellite differences in various coordinate systems

- Frequency of occurrences in various coordinate systems

2.1.3 Electric Fields at Intermediate Scales

Scientific questions Many of the central scientific goals of the Cluster mission relate to electric fields at intermediate scales (100's of km to a few R_E). These include MHD turbulence in the solar wind, magnetosheath and cusp, instabilities driven by velocity shears, waves associated with quasi-parallel shocks, transfer events, impulsive penetration of plasma into the magnetosphere, and slow mode shocks in the near tail in association with reconnection. Electric field data will provide information which is vital for determining wave modes, wave vectors, phase velocities and energy flow. The spatial and temporal variation in the auroral zone electric field is another interesting topic addressed by measurements on these spatial scales.

The average behaviour of the auroral zone electric field and related electrodynamical parameters for various geophysical conditions is relatively well documented. This is, however, not the case for the "instantaneous" auroral electrodynamics on which very few studies have been conducted. A new technique to obtain global realistic and self-consistent distributions of auroral electrodynamical parameters has been recently developed. Simultaneous observations on the different spacecraft involved are used both for calibration of the model input data (field-aligned currents and conductivities) and for tests of the results (equipotential pattern). For these kinds of studies the Cluster mission with simultaneous four-point measurements will be ideally suited.

The electric field is an important parameter in the measurement of MHD turbulence. MHD turbulence is expected in all the important regions to be investigated by Cluster. The electric field, together with the magnetic field, determines the Poynting flux and the propagation direction of the waves and plasma flows in these regions. The scale size and the magnitude of the electric fields involved have a wide range of values in these various regions. In the solar wind, scale sizes are several hundred kilometers to many thousands of kilometers and electric field magnitudes are the order of 1 mV/m. On auroral field lines, the electric field is typically much larger. Magnitudes of over 100 mV/m are common on scale sizes from less than a kilometer to tens of kilometers. The quasi-parallel shock structure provides a strong challenge to space physicists attempting to understand the role of different wave modes and scale sizes in the deceleration and thermalisation of upstream plasma. The four Cluster spacecraft can determine the phase velocity and Poynting flux waves and "shocklets" upstream and downstream of the shock. In the absence of such measurements it would be difficult to distinguish between waves standing in the shock frame, those waves created in the upstream region and convected and amplified across the shock transition region, and those waves created in the transition region.

Data Analysis Implications

Pointing flux determination requires simultaneous access to electric and magnetic wave components with good control over phase relationships. Frequency analysis methods will also be required.

Instantaneous auroral electrodynamics requires access to several parameters in addition to Cluster data. For example incoherent radars and other radars, optical data, IMF etc.

Velocity shears can be derived from E-field and δn interferometer analysis.

Quasi parallel shocks detection requires high time resolution data, integration along orbit, interferometer analysis, interspacecraft comparison etc.

Transfer events requires E- and B-field analysis as well as comparison with particle data.

Impulsive penetration of plasma might be detected with the δn interferometer analysis.

Plot formats:

- Time series; mixed data; correlations and four spacecraft representation.
- Frequency spectra, line plots and gray (colour) scales
- Fast interactive time plots

- Satellite differences in various coordinate systems

2.1.4 Electric Fields at Large Scales

Scientific questions At the longest scale lengths of interest for the Cluster study are the electric fields associated with processes such as steady-state reconnection at the magnetopause, convection in the "quiet" magnetotail, and the formation of a near-earth neutral line.

Steady-state convection in the magnetotail has been examined using analytic and numerical methods as well as simulations. Their models will be testable for the first time using the Cluster electric field data. ISEE-1 electric field data have suggested that the electric fields associated with the hypotesised near-earth neutral line are confined to $\approx 10 - 15R_E$ in the dawn-dusk direction. Comparisons of observed electric fields in the tail (20-40 mV/m during candidate neutral line events) with cross-polar-cap potentials imply that the field is primarily inductive. The Cluster satellite electric and magnetic field data will allow direct determination of associated electric fields, the relative importance of inductive and potential fields, as well as the relationship of the neutral line propagation speed to the electric field and where reconnection is initiated in the plasma sheet. The four satellites will also be able to determine the extent of substorm electric fields which may not be directly related to the neutral line, in particular how these fields are related to substorm injection. Comparisons of the E x B velocity to plasma sheet boundary motions have shown that the two agree during plasma sheet contraction, but not during expansion. Cluster electric field data can provide additional, more detailed information for understanding plasma sheet-motion, in particular, variations in the dawn-dusk and earthward-tailward directions.

Data Analysis Implications In this regime the dc electric field measurements are the most relevant. From the data analysis and presentation viewpoint it is important to note that comparison with models is important and has to be accommodated by the data analysis software.

2.1.5 Waves

In most of the studies involving EFW data, wave-wave and wave-particle interactions are of vital scientific interest. It is therefore important that the s/w accommodates a comprehensive frequency analysis and correlation analysis toolbox.

2.1.6 Cold Plasma Characteristics

The cold plasma features are of utmost importance in connection with determination of wave modes as well as in the study of weak double layers and boundary regions. The cold plasma density and temperatures can be estimated from the EFW Langmuir probe sweeps. The relative (and fast) density variations can be deduced from the fixed bias Langmuir probe currents and the E-field floating ground signal under certain assumptions. The automatic evaluation of probe sweeps is a challenging data analysis task and has to be accompanied with manual interactive analysis tools for verification of results. It might be practical to successively build up a data base of analysed probe sweeps. The plasma parameters are also derived by WHISPER, so WHISPER data and analysis tools should also be available.

Identification and characterisation of boundaries are prime goals of the Cluster mission. Both magnetopause crossings and bow-shock crossings will be associated with gradients in plasma density measurable over a few seconds. Hence, good time resolution measurements of relative density variations are crucial. The Whisper experiment will measure absolute densities with a time resolution of 2.7 seconds. EFW will in Langmuir mode, measure relative density variations with at least 0.1 seconds time resolution and is therefore capable to resolve structures inside the transition regions.

Level	Share of 16.8 kb/s	Bytes at 50% data taking		
		per day	per week	2 Years
Cluster	100%	362.88 MB	2.540 GB	264.902 GB
WEC	30%	108.86 MB	762.048 MB	79.471 GB
EFW	10%	36.29 MB	254.016 MB	26.490 GB

Table 1: Approximate data amounts for all four satellites

2.1.7 Spacecraft Potential

A stable spacecraft potential is of great importance for most of the scientific measurements on board. On Cluster, the spacecraft potential will be actively stabilised by the ASPOC ion emitter partly based on the EFW floating ground signal. The spacecraft potential can also be derived from the EFW Langmuir probe sweeps. From the data processing viewpoint we thus have the same requirements as in the case of plasma parameter deduction from the Langmuir probe sweeps. In addition we will need information from ASPOC to determine if ASPOC is on or off. We might also be interested to use information of ion currents.

2.2 Data Distribution

According to the AO [Ref. 1], the complete data set from all four Cluster spacecraft will be distributed to all PI's on optical disks. It has recently (autumn 1993) been decided to distribute data on CD-ROMs to all Cluster CoI's [Ref. 8].

The orbital period of the Cluster spacecraft is 65 hours, the spin period 15 rpm, and the operational lifetime 2 years. The telemetry rate is approximately 16.8 kbits/s. Data at that rate will be taken approximately 50 % of the time above 35000 km altitude. Science data acquisition below 35000 km is not baselined, but there is a strong interest from the experimenters to take data down to 20000 km. The total scientific data amount is thus about 265 Gbits for a two year period. Table 2.2 summarises the estimation of data amounts.

In addition to data discussed above, wide band data (WBD) from the WBD instrument will be collected. As the telemetry from the Wide Band Data (WBD) experiment will only be collected by the NASA/DSN, the related acquisition, processing and distribution activities will be the responsibility of NASA and the WBD PI. NASA will send a raw data set to ESOC/OCC for long term archiving purposes, with exact format (SEDU/ etc) still to be negotiated. The WBD PI will distribute the experiment data to the Cluster European data centres for access by the European Cluster PIs. At the request of the European PIs, the distributed WBD data will be the original waveforms, not Fourier transforms.

2.3 STAFF

TBW

2.4 EFW

2.4.1 EFW Measuring modes

To meet the scientific objectives the electric field instrument will be capable of measuring, in various modes;

- Instantaneous spin plane components of the electric field vector, over a dynamic range of 0.1 to 700 mV/m, and with variable time resolution down to 0.1 millisecond.
- The low energy plasma density, over a dynamic range at least 1 to 100 cm^{-3};

- Electric fields and density fluctuations in double layers of small amplitude, over dynamic ranges of 0.1 to 50 mV/m for the fields and 1 to 50 percent for the relative density fluctuations, and with a time resolution of 0.1 milli-seconds on some occasions;
- Electric fields and density fluctuations in electrostatic shocks or double layers of large amplitude, over dynamic ranges of 0.1 to 700 mV/m for the fields and 1 to 50 percent for the relative density fluctuations, and with a time resolution of 0.1 milli-seconds on some occasions;
- Waves, ranging from electrostatic ion cyclotron emissions having amplitudes as large as 60 mV/m at frequencies as low as 50 millihertz, to lower hybrid emissions at several hundred Hertz and with amplitudes as small as a few μ V/m;
- Time delays between signals from up to four different antenna elements on the same spacecraft, with a time resolution of 25 microseconds on some occasions.
- The spacecraft potential.

The main characteristics of the instrument are the capability of high sampling rate, two-dimensional electric field measurements and two dimensional plasma interferometer measurements with four Langmuir probes.

2.4.2 Measured quantities

Three main parameters will be measured.

i) The quasi static Electric Field.

ii) The Wave Electric Fields

iii) The plasma Density and the relative Density Fluctuations

The measured quantities are specified in Table 2.

Measured quantity	Frequency range	Dynamic range	Sampling rate
DC Electric Field (2 components)	0 - 10 Hz	700 mV/m - 0.1 mV/m	25/s
	0 - 180 Hz	700 mV/m - 0.1 mV/m	450/s
	0 - 4000 Hz	700 mV/m - 0.1 mV/m	9000/s
	0 - 32000 Hz	700 mV/m - 0.1 mV/m	36000/s
AC Electric Field (2 components)	10 - 8000 Hz	10 mV/m - $\approx$ 1 μV/m See note.	18000/s
Plasma density i fluctuations	0 - 10 Hz	1 - 100 cm^{-1}	25/s
	0 - 180 Hz	1 - 100 cm^{-1}	450/s
	0 - 4000 Hz	1 - 100 cm^{-1}	9000/s
Density and Temperature (Langmuir sweeps)		1 - 100 cm^{-1} eV range	

Note: For gain = 10.

Table 2: Measured quantities

The EFW instrument can be operated in three different data rates as specified in Table 3.

2.5 WHISPER

TBW

Nominal telemetry rate	1440 bits/sec
Tape Loading Mode Data Rate	$\leq$ 29.5 kbits/sec
Burst Memory Loading Mode Data Rate	$\leq$ 1280 kbits/sec

Table 3: EFW Data rates

2.6 WBD

TBW

2.7 DWP

2.7.1 DWP Tasks

The main tasks of the DWP instrument are:

- WEC instrument coordination
- Run processing applications on output data from the various WEC experiments
- Carry out auto/cross correlations of particle and field data
- Compression of data
- Packing of house keeping and compressed experiment data into telemetry stream

2.7.2 DWP data types

The user will want to access:

- Housekeeping data
- WEC PI data sets
- Particle correlator data

The first two items are tasks for the DWP^{-1} process that is required to extract any PI data set from the telemetry scheme. The latter is PI data that should be extracted, displayed and analysed using the tools provided by ISDAT.

2.7.3 Telemetry stream

The telemetry stream consists of WEC house keeping data together with data from all WEC instruments (depending upon the mode of operation). The PI data sets themselves will have been compressed using specific algorithms within the DWP.

2.7.4 Access to data

All instrument house keeping is coded and placed in the telemetry stream by DWP. Therefore if data is going to be read and delt with in the correct manner it is necessary to extract the relevant house keeping data.

Once the house keeping data has been processed, it is then possible to extract the PI data sets from the individual frames of telemetry.

The raw telemetry data will require decompressing in order to recreate the original measurements produced by the instrument in question.

Specific requirements related to the data access are listed under section 3 labelled UR-DWP-***.

2.7.5 Particle correlator processing

This data set can be either the autocorrelation of particle data set or a cross correlation between particle and electric field data. It is created within the DWP.

Specific requirements related to this are listed under section 3 labelled UR-DWP-***.

2.8 Platform ephemeris requirements

Specific requirements are listed in section 3 under labels UR-EPH-***-***.

2.8.1 Position

The user will want to determine the position of S/C #n either in a time interval $t_1 - t_2$ or at a specified time t. The formaer requires a quicksummary type answer to help the user pinpoint more precisely a time period whilst the latter may produce a more accurate value.

Th eoutput from the calculations can be displayed in a textual format for high accuracy calculations or graphically for summary plots. Summary plots could also show the result of and model output if requested by the user.

How accurate should the calculations be? For summary plots, the accuracy need only to be of the order of $R_E/100$ (i.e. around 50 - 100 km) but for more exact work, an accuracy of the order of 0.5 - 1 km may be required.

2.8.2 A possible user scenario

Where did CLUSTER #1 cross the magnetopause 1st June 1997?

A plot of the summary parameter ephemeris positions could be used in conjunction with models of boundaries to determine the most probable crossing times. The user could then request a data set for this period and determine the crossing more precisely. Once the exact time has been determined, the exact position can be calculated.

2.8.3 Methods of calculation

There are two possible methods by which ephemeris data may be extracted:

1. Interpolation of summary parameters.
2. Calculation directly from data on the RDM.

The former method should provide a quick method by which to obtaining the basic position of the S/C but for more accurate work such as determiningseparations the latter method is probably better.

2.8.4 Spacecraft separations

Much of the new science from the Cluster mission will make use of measurements taken at four spatially separated points. Processes will be observable in three spatial dimensions, allowing gradients to be calculated. The separation is also important for determining the base line for interferometry.

2.8.5 Spacecraft phase angle

The phase angle of the spacecraft is required to determine the polarisation of the waves with respect to the local magnetic field direction. The phase angle can be computed using the times of the sun reference pulses and that on the measurement. This results in the measurement being described in terms of the S/C coordinate frame. This requires transforming into components parallel and perpendicular to the local magnetic field.

2.9 User characteristics

The detailed data analysis should be made possible to do directly by scientists at all the WEC CoI institutions. Characteristics of these users can be summarised:

- Variable degree of computer experience, from experts to beginners.
- Multilingual, but with English as common language
- A high probability of requiring software features that are not foreseen before real data analysis has begun.
- A geographically widespread community
- Are beforehand used to many different ways of analysing data.

2.10 General constraints

The detailed analysis shall run on UNIX workstations. Programming languages shall be C and Fortran. It is also desirable that ISDAT runs in the POSIX environment on VAX and Alpha APX platforms from Digital Equipment Corporation. The latter will be included in the formal requirements as soon as it has been demonstrated that it is a realistic requirement.

2.11 Assumptions and dependencies

It is assumed that manpower and other resources is supplied by the WEC Co:I institutions.

2.12 Operational environment

The operational environment will be very heterogeneous, from the single scientist to big data centres.

3 Specific Requirements

The priorities are given on a scale from 0 to 3 with the following meaning:

0 Essential for a minimum system

1 Needed for a meaningful scientific analysis of data at WEC level. To be implemented and tested before launch.

2 Required, but can be implemented after launch.

3 Valuable, but firm commitment not required before launch. Should be considered for the design of the basic system.

The specific requirements are labelled UR-WEC-*** for WEC related requirements and UR-DWP-***, UR-STA-***, etc. for instrument related requirements.

3.1 General requirements

UR-WEC-001 A software package for detailed analysis of WEC data (ISDAT) shall be available for WEC CoI institutions.
Origin: The EFW meeting at KTH in March 1987 see [Ref. 2] for EFW. UK-4 in [Ref. 7] for UK PI groups. F-1 in [Ref. 7] for French CoI's.
Priority: 0

UR-WEC-002 to 100 Not used.

3.2 Function requirements

UR-WEC-101 Besides standard analysis and display features, described in separate requirements, the WEC data system shall contain a mechanism to add personal [1] analysis and display software.
Origin: The scientific need of unforeseen types of analyses. (see 2.1.7 page 3).
Priority: 0

UR-WEC-102 The WEC data system shall have an interface to IDL.
Origin: A desire to use familiar analysis techniques. WECdata report [Ref. 7] Ch 6 p 17.
Priority: 1

UR-WEC-102a The WEC data system shall have an interface to MATLAB.
Origin: A desire to use familiar analysis techniques. WECdata report [Ref. 7] Ch 6 p 17.
Priority: 3

UR-WEC-103 The WEC data system shall have a capability to read input data over local or wide area networks.
Origin: A desire to store the database only on servers at institutes with many users.
Priority: 0.

UR-WEC-104 The WEC data system shall be able to unpack all WEC parameters in all measuring modes from the specified formats (see other UR).
Origin: The requirement to plot all WEC parameters. UK-3 in [Ref. 7].
Priority: 0

UR-WEC-105 The WEC data system shall be capable of deriving and treating WEC data in TM units or in physical units.
Origin: A desire to use the package to gain confidence in the derived data as well as using them for scientific purposes.
Priority: 1

[1] By personal we mean that the software is connected to the ISDAT data server at the local installation, but not necessariy made available for other ISDAT users

UR-WEC-106 The WEC data system shall contain facilities to search for specific measuring modes based on the instrument housekeeping information.
Origin: the desire to do event selection. See 2.1.7 page 3. See also [Ref. 7] and E-mail from Simon Walker 18 Jan 1994. .
Priority: 2 .

UR-WEC-107 The WEC data system shall be equipped with mechanisms to implement search algorithms based on experimental data.
Origin: A desire to find "characteristic" events. See 2.1.7 page 3.
Priority: 3.

UR-WEC-108 The WEC data system shall be capable of displaying[2] all WEC housekeeping data for a specified time[3].
Origin: The need to verify and understand data.
Priority: 1

UR-WEC-109 Not used

UR-WEC-110 The WEC data system shall be able to use RDM format as input.
Origin: The fundamental requirement to be able to analyse full time resolution data.
Priority: 0

UR-WEC-110a The WEC data system should be able to convert RDM to level 1[4] and to level 2[5] . If all PI/CoI's have copies of the RDM at their institute, then only the calibration files need transferring. This should cut down on network usage.
Origin: E-mail from Simon Walker 14 Jan 1994.
Priority: 1

UR-WEC-111a The WEC data system shall be able to use CDDS format as input.
Origin: A desire to make quick analysis before delivery of the RDM.
Priority: 1

UR-WEC-111b The WEC data system shall be able to use CSDS DB format (CDF) as input.
Origin: UK-3 in [Ref. 7].
Priority: 1

UR-WEC-112 Not used

UR-WEC-113 The WEC data system shall provide a mechanism to produce hard copies in black/white and colour [6].
Origin: A need to produce working copies, and publishable figures from the WEC data system.
Priority: 1

UR-WEC-114 The WEC data system shall be able to import data from other experiments or simulations, and display it together with WEC data.
Origin: A need to compare WEC data with external parameters, for example in connection with studies of auroral electrodynamics. (see paragraph 2.1.7 page 3 and page 4).
Priority: 1.

UR-WEC-114a The WEC data system shall be able to time-tag data to the highest available accuracy, using the additional information supplied in the auxiliary data files on the RDM.
Origin: Desire to perform cross-correlation of wave fields between different pairs of satellites.
Priority: 2

[2] This should preferrably be done in graphical format to allow the user to view periods of data when a general summary is required. From a plot like this, it should be possible to generate a data request. (see E-mail from Simon Walker 14 Jan 1994)
[3] See also UR-WEC-152
[4] Decommutated TM-units
[5] Physical units
[6] This may not be possible to implement in a portable system

UR-WEC-114b The WEC data system shall be able to join data sets, that is, make them available simultaneously with the same time resolution and time tags[7].
Origin: Necessary to apply numerical cross-correlation techniques.
Priority: 1.

UR-WEC-114c The WEC data system should provide a number of join algorithms. E.g. Fuzzy joins, interpolation.
Origin: E-mail from Simon Walker 14 Jan 1994.
Priority: 2

UR-WEC-114d The WEC data system should be able to do sub-sampling - read every Nth record.
Origin: E-mail from Simon Walker 14 Jan 1994.
Priority: 2

UR-WEC-114e The WEC data system should be able to do provide subsets - extract a user specified section of data from a data set..
Origin: E-mail from Simon Walker 14 Jan 1994.
Priority: 2

UR-WEC-114f The WEC data system should be able to do re-sampling.
Origin: E-mail from Simon Walker 14 Jan 1994.
Priority: 2

UR-WEC-115 The WEC data system shall be able to derive and display the satellite velocities.
Origin: The desire to compute phase velocities. See 2.1.7 page 3 and 3.
Priority: 1 .

UR-WEC-116 The WEC data system shall be able to derive and display the satellite aspect angles.
Origin: The desire to compute phase velocities and scale sizes. See 2.1.7 page 3 and 3.
Priority: 1 .

UR-WEC-117 The WEC data system shall be able to access and analyse data from all four satellites simultaneously, i.e. for example cross correlation or differences between parameters at different satellites shall be possible to display.
Origin: A desire to determine coherence length. See 2.1.7 page 3. UK-5 in [Ref. 7].
Priority: 1.

UR-WEC-118 The WEC data system shall be able to derive and display the satellite orientations with respect to a model magnetic field, TBD.
Origin: A desire to do polarisation determinations even when the measured B field is missing. See 2.1.7 page 3.
Priority: 3

UR-WEC-119 The WEC data system shall be able to derive and display the satellite orientations with respect to the measured magnetic field.
Origin: A desire to do polarisation determinations. See 2.1.7 page 3.
Priority: 1

UR-WEC-120 Not used

UR-WEC-121 The WEC data system shall be capable of deriving the positions of the four satellites in different, TBD, coordinate systems.
Origin: A need to compute for example spatial derivatives. See 2.1.7 page 3.
Priority: 1 .

UR-WEC-121a The WEC data system shall be capable of estimating the error when deriving spatial gradients (divergence and rotation) caused by the configuration of the Cluster tetrahedron.
Origin: A need to compute for example spatial derivatives. See 2.1.7 page 3.
Priority: 3 .

[7] See also UR-WEC-137

UR-WEC-122 The WEC data system shall be able of computing and displaying the Pointing flux.
Origin: The need to investigate the direction of waves. See 2.1.7 page 4.
Priority: 3.

UR-WEC-123 Not used

UR-WEC-124 The WEC data system shall contain magnetic field models, TBD, including predicted boundary locations.
Origin: This is needed to identify boundaries based on the cold plasma characteristics. See 2.1.7 page 5. WECdata report [Ref. 7] Ch 6, p 17.
Priority: 1

UR-WEC-125 The WEC data system shall be capable of displaying the WHISPER *ON* flag [8].
Origin: Needed for E field quality control. See 2.1.7 page 5.
Priority: 1

UR-WEC-126 The WEC data system shall be capable of displaying the ASPOC *ON* flag.
Origin: Needed for E field quality control. See 2.1.7 page 5.
Priority: 1

UR-WEC-127 Not used

UR-WEC-127a Not used

UR-WEC-128 Not used

UR-WEC-129 Not used

UR-WEC-130 The WEC data system shall contain presentation facilities as specified in the following requirements.

UR-WEC-130a 2D line plots at the finest time resolution.
Origin: Analysis of "spiky" events. See 2.1.7 page 3 and 3.
Priority: 1

UR-WEC-130b 2D line plots covering an orbit, after averaging of data.
Origin: The desire to get overviews for event selection.
Priority: 1.

UR-WEC-130c It shall be possible to present data as colour[9] coded 2D plots.
Origin: The need to present 3D data, for example power spectra as a function of time. See 2.1.7 page 3.
Priority: 1

UR-WEC-130d It shall be possible to present data in the form of hodograms.
Origin: The need to illustrate for example polarisation changes over time. See 2.1.7 page 3.
Priority: 2 .

UR-WEC-130e The WEC data system shall allow the user to plot parameter(s) as a function of other parameters. The output format should either mark the points to join them up in a line.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 2

UR-WEC-131 The WEC data system shall be able to rotate the presented data.
Origin: See [Ref. 6].
Priority: 3.

UR-WEC-131a The WEC data system should be able to calculate the variance of vectors and hence the minimum variance direction.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 2

[8] this is perhaps covered by UR 108
[9] due to the requirement to base graphics on Phigs, monochrome screens can not be used in general

UR-WEC-131b The WEC data system shall allow the user to perform coordinate transformations to vector fields.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 1

UR-WEC-131c The WEC data system shall allow the user to supply his own transformation matrix. (See also UR-WEC-131b).
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 2

UR-WEC-132 The WEC data system shall be able to display a variable number of panels.
Origin: See [Ref. 6].
Priority: 1.

UR-WEC-132a The user should have the functionality to customise the plots by changing items like line colour, width and style, symbols used and labels, log/non-log axes interactively.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 1

UR-WEC-133 The WEC data system shall be able to move around panels on the screen.
Origin: A desire to compare different parameters. See [Ref. 6].
Priority: 1.

UR-WEC-133a The WEC data system shall be able to plot different parameters on the same panel.
Origin: A desire to compare different parameters. See [Ref. 6].
Priority: 1.

UR-WEC-134 The WEC data system shall be able to present data with variable, fixed or preset scales.
Origin: See [Ref. 6].
Priority: 2 .

UR-WEC-135 The WEC data system shall be able to present data in a number of different colour scales.
Origin: See [Ref. 6].
Priority: 1.

UR-WEC-136 The WEC data system shall be able to interactively zoom in on parts of the screen.
Origin: See [Ref. 6].
Priority: 3 .

UR-WEC-137 The WEC data system shall allow the user to select time of periods of interest interactively from plots. Once defined, the user should be able to use these periods in further analysis (i.e. create subsets of data files).
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 2 .

UR-WEC-138 to 139 Not used

UR-WEC-140 The WEC data system shall contain analysis tools as specified in the following requirements.

UR-WEC-140a FFT analysis.
Origin: The necessity to do power spectral density presentations. See 2.1.7 page 3.
Priority: 1

UR-WEC-140b Cross correlation analysis.
Origin: The need to do phase velocity and scale size computations. See 2.1.7 page 3 and 3.
Priority: 1 .

UR-WEC-140c Cross spectral analysis.
Origin: The need to do phase velocity, velocity shear, and scale size computations. See 2.1.7 page 3 and 3 and 4.
Priority: 1 .

UR-WEC-140d Averaging[10].
Origin: The requirement to present whole orbits.
Priority: 1 for server (DBH)
Priority: 2 for "ISDAT filter" implementation .

UR-WEC-140e Low pass filtering.
Origin: See [Ref. 6].
Priority: 2 .

UR-WEC-140f High pass filtering.
Origin: See [Ref. 6].
Priority: 2 .

UR-WEC-140g Band pass filtering.
Origin: See [Ref. 6].
Priority: 2 .

UR-WEC-140h Wavelet analysis.
Origin: The necessity to do power spectral density presentations. See 2.1.7 page 3.
Priority: 2

UR-WEC-141 The WEC data system shall allow the user to combine parameters from (different) data sets, creating secondaty parameters. This could be as simple as calculating the ratio of two parameters to the use of full mathematical expressions and a parser.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 1 .

UR-WEC-141a The WEC data system shall provide a standard set of conversions, e.g. B-field to gyro freq. pointing flux etc.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 2(1) .

UR-WEC-142 The WEC data system shall allow the user to change the units of a field e.g. convert data from nT to T or Hz to rad/s. (This may also be required in conjunction with UR-WEC-141).
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 2

UR-WEC-143 The WEC data system shall deal with NULL data values properly.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 1

UR-WEC-144 The user shall have the choice of enforcing strict simultaneously between data sets when carrying out analysis[11]. Thus the usercan choose to try a quick analysis where data points are matched using criteria similar to that of fuzzy join or a strict simultaneously requiring one parameter to be interpolated (somehow) into a different time scale which could be computationally intensive.
Origin: E-mail from Simon Walker 14 Jan 1994
Priority: 2 .

UR-WEC-145 to 149 Not used

UR-WEC-150 Hard copies shall be labelled with production site, date of production, calibration file used, source code revision number.
Origin: The need to cope with calibration file and source code updates. See [Ref. 6].
Priority: 1.
Priority: 1

[10] This could also be used for smoothing data i.e. a weighted box car averaging method could be implemented (Simon Walker E-mail 14 Jan 1994)
[11] See also UR-WEC-114f

UR-WEC-151 Attitude for the different sensors shall be provided.
Origin: WECdata report [Ref. 7] page 17 Ch 6.
Priority: 1

UR-WEC-152 The WEC data system shall be capable of providing status information for all WEC instruments[12].
Origin: WECdata report [Ref. 7].
Priority: 1 .

UR-WEC-153 The WEC data system shall be capable of providing the EDI measurement mode.
Origin: WEC data meeting in Uppsala 1 June 1994.
Priority: 2 .

UR-WEC-154 to 200 Not used

UR-EFW-101 The software package shall provide a tool for interactive analysis of Langmuir probe sweeps, including probe theory.
Origin: The scientific need to derive plasma parameters from the EFW. See 2.1.7.
Priority: 2.

UR-EFW-102 The WEC data system shall be able to perform correlation analyses between EFW parameters and B field data.
Origin: See 2.1.7 page 3.
Priority: 3

UR-EFW-103 The WEC data system shall be able to integrate a specified parameter along the orbit (time).
Origin: Needed in studies of quasi parallel shocks. See 2.1.7 page 4.
Priority: 3.

UR-EFW-104 The WEC data system shall contain facilities to analyse and display ASPOC data.
Origin: An agreement between the EFW PI (Georg Gustafsson) and Klaus Torkar at the SWT meeting in December 1992.
Priority: 1

UR-DWP-101 The s/w shall access and return to the calling process the house keeping data relevant to an instrument or instruments.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-DWP-102 The s/w shall extract individual data sets from the telemetry frames.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-DWP-103 The s/w shall decompress the requested data set to produce level 1 data products.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-DWP-104 The s/w shall calibrate the data in order to produce level 2 products.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-DWP-105 The system shall extract and decompress data from the particle correlator.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-DWP-201 The s/w shall display the house keeping data to the user in a text format.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-DWP-202 The s/w shall be able to display some of the house keeping data fields graphically.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-DWP-203 The system shall display data on a energy vs time grid with colour representing the significance amplitude.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

[12] See also UR-WEC-108

UR-DWP-204 The system shall display data in the form of the significance amplitude as a function of time. The energy at which the correlation is made shall also be displayed.
Origin: E-mail from S Walker 3 Feb 1994. See section 2.7.

UR-EPH-POS-101 The user should be able to specify the time or the time interval for which position values will be computed.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-102 The user should be able to specify whether summary or accurate data are required.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-103 The user should be able to specify the time period between successive calculations.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-111 The system should be able to access Summary Parameter ephemeris data.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-112 The system should be able to access data from the RDM.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-121 The system should be able to calculate/produce ephemeris data from data stored on the RDM.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-122 The system should be able to interpolate between data points.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-123 It should be possible to read and display ephemeris data from other sources (e.g. SOHO, Geotail, Polar) for simultaneous time periods.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-124 A set of transformations should be available to the user.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-201 The user should be able to plot the position in a specified coordinate system.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-202 The satellite track should have time tags.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-203 The user should be able to superimpose plots representing model boundaries.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-204 The user should have the ability of showing the region being traversed.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-POS-205 It should be possible to plot the positions of S/C other than CLUSTER.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-SEP-101 It shall be possible to calculate the inter-spacecraft separation.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-SEP-102 It shall be possible to derive th ethetrahedron quality factor Q.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-SEP-201 It shall be possible to plot the relative positions of the four S/C.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-PA-101 It shall be possible to calculate the phase angle of the spacecraft.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

3.3 Performance requirements

UR-WEC-201 The WEC data system shall in normal cases behave as an interactive system when displaying data. With an interactive system is meant that a reasonable amount of data, < 1000 samples, shall appear on the screen within TBD seconds after the request in 80% of the requests when running in a local environment.
Essential.

UR-WEC-202 The user interface shall behave as an interactive interface, i.e. a response shall be given by the system within TBD seconds after a user input in TBD% of the cases.
Essential.

UR-WEC-203 It shall be possible to operate the system in "batch" mode.
Origin: A need to produce "standard" plots off-line.
Essential.

UR-WEC-204 to 300 Not used

UR-EPH-POS-301 The summary data should be accurate to 100 km. The accurate positional data shall have errors less than 1 km.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

UR-EPH-SEP-301 The separation distance shall be accurate to TBD km.
Origin: E-mail from S Walker 3 Feb 1994 Re. WECdata task 4.10. See section 2.8.

3.4 Deliverables

UR-WEC-301 Complete source code shall be available to WEC CoI:s.
Origin: A possible need to modify code to suit other UNIX workstations than those explicitly required.
Priority: 2.

UR-WEC-302 Installation manual shall be available to the WEC CoI:s.
Origin: The fact that no assistance in local installations is foreseen.
Essential.

UR-WEC-303 A users manual shall be available to WEC CoI:s.
Origin: The relatively large user community.
Priority: 2.

UR-WEC-304 A Programmers manual describing how to add user specific software is required.
Origin: Desire to interface to other analysis packages, as mentioned in UR-WEC-102.
Priority: 2.

UR-WEC-305 A detailed description of hardware requirements and recommendations for running the WEC data system on shall be available one year before the planned Cluster launch. The hardware recommendations shall include Workstation, memory, mass memory, input device, hard copy devices, supporting software.
Origin: Purchase planning.
Essential.

UR-WEC-306 to 400 Not used

3.5 Access requirements

UR-WEC-402 Distribution of instrument specific software modules shall be restricted.
Origin: WECdata report [Ref. 7].

UR-WEC-403 User password shall be provided for by the system.
Origin: WECdata report [Ref. 7].

UR-WEC-403 to 500 Not used

3.6 Constraint requirements

UR-WEC-501 The WEC data system package shall run on the UNIX workstations: SUN Sparcstations, HP9000 series with X11R5, and TBD UNIX on PC with more than 16 MB memory, and more than 400 MB magnetic disk space.
Origin: A desire to use hardware planned for other space projects.
Origin: UK-8 in [Ref. 7].
Essential.

UR-WEC-502 The
Essential. parts of the WEC data system shall not depend on any commercial software packages[13].
Origin: A requirement to freely distribute the package to many institutions. without licence restrictions.
Essential.

UR-WEC-503 The
Essential. parts of the WEC data system shall be implemented at the time of the Cluster launch.
Origin: A desire to support post launch instrument checkout.
Essential.

UR-WEC-504 Source code shall be written in C[14] or FORTRAN languages.
Origin: A desire to have portable source code. UK-8 in [Ref. 7].
Essential.

UR-WEC-505 The WEC data system shall be based on graphic user interfaces using window techniques based on X11.
Origin: A desire to use public domain, standard software. UK-7 in [Ref. 7].

UR-WEC-506 The WEC data system graphics user interface shall be based on Motif.
Origin: The desire to use vendor independent software.

UR-WEC-507 The WEC data system graphics shall be based on Phigs/PEX[15].
Origin: A desire to use standard software.

UR-WEC-508 The WEC data system shall be based on the principle of local data bases, i.e. the complete RDM data should be distributed to all WEC CoI:s, requesting data.
Origin: The judgement that a central EFW computing facility is neither affordable, nor desirable.

UR-WEC-509 The WEC data system shall not depend on any vendor specific software packages.
Origin: A requirement to be able to run the package on workstations of different brands.
Essential.

UR-WEC-510 Where applicable, the WEC data system shall follow CSDS standards.
Origin: WECdata report [Ref. 7].

[13] With the exception of the software explicitly requested in this document, i.e. Motif, C- and FORTRAN compilers
[14] It is foreseen to eventually extend the accepted languages to C++
[15] This restriction implies that only colour displays can be used, not monochrome screens

References

[1] STSP Cluster and Soho announcement of opportunity, 1987. AO-OSSA-1-87.

[2] *CEDAS Software Development - Project Plan.*

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[6] G. Holmgren. Minutes of the EFW meeting in Berkeley, December 1992. Data handling part.

[7] G. Holmgren. Cluster WEC detailed scientific data handling. Technical report, IRF-U, May 1993.

[8] S. R. Schmidt. Data delivery interface document for the cluster data disposition system. Technical report, ESA, 21 January 1994. CL-ESC-ID-0001 Issue 2.0.

A Acronyms

Acronym	Meaning
AC	Alternating Current
AFGL	Air Force Geophysics Laboratory
AI	Artificial Intelligence
AO	Announcement of Opportunity
APX	Alpha APX is a computer architecture
ASPOC	Active Spacecraft Potential Control
C	A programming language
CD-ROM	Compact Disc Read Only Memory
CDAW	Coordinated Data Analysis Workshop
CEDAS	Cluster EFW Data Analysis System
CFC	Centre Français Cluster
CoI	Co-investigator
CDDS	Cluster Data Disposition System
CSDS	Cluster Science data System, replaces CSDC
DB	Data Base
DC	Data Centre
DC	Direct Current
DD	Data Distribution
EFW	Electric Field and Wave Experiment
ESA	European Space Agency
ESANET	European Space Agency Network
ESIS	European Space Information System
ESTEC	European Space Technology Centre
FFT	Fast Fourier Transform
FORTRAN	FORmula TRANslator
GSFC	Goddard Space Flight Center
HP	Hewlett Packard
IDL	Interactive Data Language
IRF-U	Institutet för Rymdfysik, Uppsalaavdelningen
	Swedish Inst. of Space Phys., Uppsala Division
ISDAT	Interactive Science Data Analysis Tool
ISEE	International Sun-Earth Explorer
IMF	Interplanetary Magnetic Field

Table 4: Acronyms part 1

Acronym	Meaning
ISDAT	Interactive Science Data Analysis Tool
JSOC	Joint Science Operations Centre
KHOROS	Graphics software package
KTH	Kungliga Tekniska Högskolan Royal Institute of Technology
Matlab	Matrix Laboratory
MB	Mega-byte
MHD	Magnetohydrodynamics
PC	Personal Computer
PEX	Phigs Extended to X
PHIGS	Programmers Hierarchical Interactive Graphics System
PI	Principal Investigator
POSIX	Operating system
PPDB	Prime Parameter Data base
RDM	Raw Data Medium
SDC	Scandinavian Data Centre
SPDB	Summary Parameter Data Base
SPlots	Summary Plots
SSL	Space Sciences Laboratory
SWT	Science Working Team
TBD	To be defined
TM	Telemetry
UCB	University of California at Berkeley
Unix	Operating system
UR	User Requirement
VAX	A Computer architecture
WBD	Wide Band Data
WEC	Wave Experiment Consortium
WHISPER	Waves of High Frequency and Sounder for Probing of the Electron Density by Relaxation
X11R5	X-Windows, revision 5
s/w	software
2D	Two dimensional
3D	Three dimensional

Table 5: Acronyms part 2