The ACE Science Center

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Abstract. The Advanced Composition Explorer (ACE) mission is supported by an ACE Science Center for the purposes of processing and distributing ACE data, and facilitating collaborative work on the data by instrument investigators and by the space physics community at large. The Science Center will strive to ensure that the data are properly archived and easily available. In particular, it is intended that use of a centralized science facility will guarantee appropriate use of data formatting standards, thus easing access to the data, will improve communications within and to the ACE science working team, and will reduce redundant effort in data processing. Secondary functions performed by the Science Center include acting as an interface between the scientists and the mission operations team.

Keywords: ACE, space physics, composition, computing, archives

1. Introduction

The Advanced Composition Explorer, ACE, will perform comprehensive studies of the elemental, isotopic, and ionic charge-state composition of energetic nuclei in interplanetary space, at energies ranging from $\sim$1 keV/nucleon (solar wind) to $\sim$0.5 GeV/nucleon (cosmic radiation), including ions accelerated in the Sun, in interplanetary space, at the edge of the heliosphere, and in the galaxy. These measurements are being made from orbit about the L1 Lagrangian point, $\sim$0.01 astronomical units sun-ward of the Earth. The spacecraft was launched successfully on August 25th, 1997. ACE includes six high-resolution spectrometers and three monitoring instruments that characterize the environment in which a given composition measurement is made. Many of the instruments take advantage of the spacecraft's spin to scan for particle arrival direction distributions. The mission, the spacecraft, and each of the nine instruments are described in detail in a series of companion papers (Stone *et al.*, 1998a), (Chiu *et al.*, 1998) (Gold *et al.*, 1998), (McComas *et al.*, 1998), (Smith *et al.*, 1998), (Gloeckler *et al.*, 1998), (Stone *et al.*, 1998b), (Stone *et al.*, 1998c), (Mason *et al.*, 1998), (Möbius *et al.*, 1998).

The following sections describe the flow of the data from the spacecraft to the end users, the processing and the contents of the data, the standard interchange formats used to store and transmit the data, and other data processing tools. The emphasis is on the role of the ACE Science Center (referred to hereafter as 'the Science Center') in coordinating the data flow and formats.

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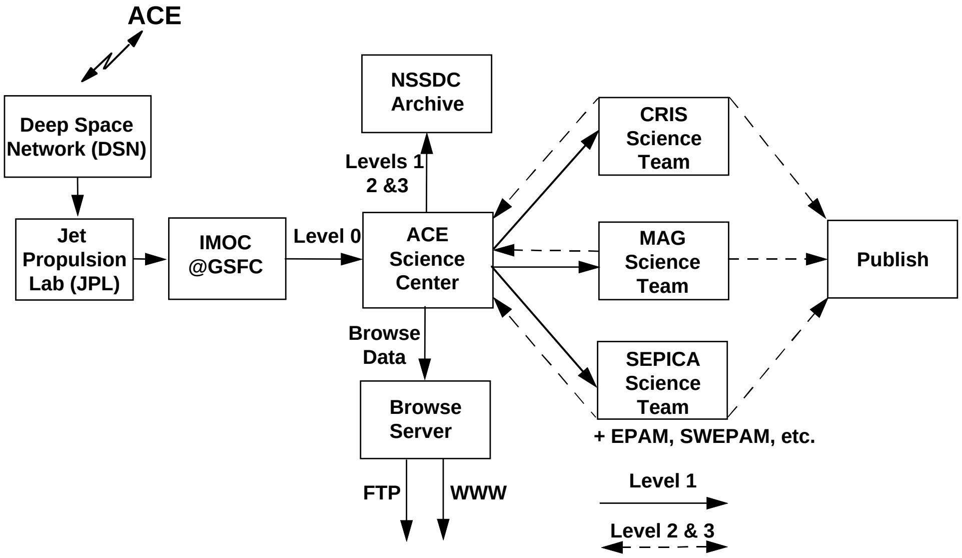

Figure 1. Flow of ACE data from the spacecraft to the scientific community.

2. The Data Flow and Processing

The data flow from the instruments to the scientific community involves spacecraft hardware, a number of NASA institutional facilities, and ACE facilities including the Science Center. It is illustrated schematically in Figure 1 and described below.

2.1. DATA TELEMETRY AND LEVEL ZERO PROCESSING

The ACE spacecraft Command and Data Handling (C&DH) system gathers data from the instruments and formats the data into minor and major frames. One minor frame (996 bytes) is read into the C&DH system each second and there are 16 minor frames per major frame. Section 3.1 describes the data read out from each of the nine instruments. The C&DH system also gathers data from various analog sensors and digital telltales, from the sun sensors and star sensor, and from the command system, *etc*. Most of the time the spacecraft is not in touch with the ground facilities and these data are stored in an onboard Solid State Data Recorder (SSDR). Typically one contact per day is initiated by ground facilities and lasts roughly two to four hours. The SSDR is large enough to allow contacts to be spaced by more than 50 hours when necessary. The SSDR contents are read out to the ground at a rate exceeding 10 minor frames per second while current data are being simultaneously telemetered to the ground and stored in the SSDR for the next contact. The telemetry is formatted into two virtual channels (CCSDS ’89) (real-time and playback) and received by the Caltech Jet Propulsion Laboratory Deep Space Network (DSN). The telemetry is then forwarded via the Internet to the ACE Integrated Mission Operations Center (IMOC) at the Goddard Space Flight Center (GSFC). There the data are reviewed in near real time for purposes of monitoring spacecraft and instrument status. The data then undergo level zero processing (per NASA's standard terminology) as soon as all the data contained within the current 24 hour time frame have been received. In level zero processing, duplicate data are removed from the data stream, data are time ordered, and data quality and accounting summaries are appended. The data are formatted into a 24-hour Science Routine Data Set File, and forwarded via the Internet to the Science Center, accompanied by a Standard Formatted Data Unit (CCSDS '92) header file.

2.2. LEVEL ONE AND BROWSE PROCESSING

At the Science Center, the data undergo level one processing, usually within a few days of receipt. In level one processing, the data are separated out by instrument and each instrument data set is formatted (using the NCSA HDF standard, see sections 4.1 and 4.2) in a fashion which is both consistent with the other instruments and customized to meet the special requirements of that data set and team. At this point in the processing, i.e., in level one, the data are supplemented with ancillary data including position, attitude, and spin phase of the spacecraft; command history and comments; calibration of the spacecraft clock; and documentation of the data items. Excepting the documentation, these ancillary data are all received by the Science Center from the IMOC. The level one data are archived at the Science Center, which is a Cosmic and Heliospheric discipline node of NASA's Space Physics Data System, and a copy is transmitted to the National Space Science Data Center (the NSSDC) for long term archiving. Each instrument team receives a copy of all the level one data, including, of course, that from their own instrument.

In addition to formatting, level one processing includes those data processing steps which are judged to be of sufficient simplicity that they can be understood, defined, and coded before launch, and do not require iterated processing with increasing experience. Examples of such steps include decompression of compressed rate scaler data and proper time labeling of data which are buffered for a number of minor frames within the instrument before readout. A counter-example (a process which clearly does not belong in level one) is application of calibration data to convert digital pulse heights from detector signals to engineering units. Experience indicates that calibrations are often adjusted repeatedly to improve resolution based on extended iterative study of the instrument response.

In parallel with the level one processing, the level zero data is processed to yield browse parameters. Browse parameters are a subset of ACE measurements which allow monitoring of the solar wind and large-scale particle and magnetic field behavior. They also allow the selection of time intervals of particular interest for more intensive study. Since it is considered important to distribute first-order ACE results as soon as possible, the browse parameters are delivered to the public domain immediately, at the expense of full verification. A description of the browse parameters and the forms in which they are made available to the public is provided in Section 3.2.

2.3. LEVEL TWO AND HIGHER LEVEL DATA PROCESSING

Data processing beyond level one is the responsibility of the individual instrument teams. Level two processing includes such operations as application of calibration data and detector response maps, organization of data into appropriate energy and time bins, and application of ancillary data (for example, conversion of magnetic field vectors to useful coordinate systems using the spacecraft attitude data). The Science Center attempts to facilitate these efforts within its resources, especially when high-level processing involves multiple instrument teams. For example, much of the anisotropy/flow data for the particle instruments, in particular for the Electron, Proton, and Alpha-particle Monitor (EPAM), will be computed in terms of the direction of the magnetic field. Thus the EPAM team will need high level results from the MAG team to do high level EPAM analysis. The Science Center can facilitate data sharing and communications with its substantial data storage capabilities and its data formatting experience. Another example is the high level processing for the Cosmic Ray Isotope Spectrometer, CRIS. Four institutions are involved in this processing, each contributing expertise and experience in a different sub-assembly of this very complex instrument. Communications and iteration of the data processing are being facilitated by the Science Center for this team.

Each instrument team is required to deliver level two data back to the Science Center, which will then make the data available to the other instrument teams, the space science community (as required by NASA), and the NSSDC for long term archiving. Delivery of level two data back to the Science Center is expected to begin about three months after the spacecraft enters orbit about the L1 Lagrangian point. Thereafter, roughly a two month lag time is expected between receipt of level one data by the instrument teams and delivery of level two data back to the Science Center. However, these delivery schedules may require revision if instrument checkout and debugging take longer than expected. In addition, the level two dataset is expected to be evolutionary, in the sense that an instrument team may enhance their level two data with additional products in the future, as the sophistication of their analysis increases.

Data processing beyond level two consists of publication or presentation-quality items, such as data plots and graphics, and the contents of talks and journal articles. These items will also be archived at the Science Center and the NSSDC.

2.4. REAL-TIME SOLAR WIND DATA

A parallel data flow scheme is mentioned here for convenient reference, although the Science Center plays a very minor role in this parallel flow. In addition to the normal telemetry, a small, selected subset of the data is being telemetered in real time from the spacecraft to ground stations operated for the Space Environment Center of NOAA, the National Oceanic and Atmospheric Administration (Zwickl *et al.*, 1998). These data are being made available by NOAA in near real time for purposes of monitoring interplanetary space weather and predicting geomagnetic activity. (It takes $\sim$1 hour for the solar wind and embedded magnetic field observed at ACE to propagate to the Earth, while the raw telemetry reaches NOAA in seconds.) These space weather data products may, like the browse parameters, also be considered useful by many people in the space science community. They are also available through the Science Center, but not in near real time.

3. The Contents of the Data

The ‘raw’ data, as telemetered from the spacecraft, are the ultimate description of the instruments and all higher level data products. They are described here, and, in more detail, in the instrument papers. The browse data are described here because they are expected to be the most popular product of the Science Center for the larger space science community. Level one data are not described; they contain little beyond the raw data and are not likely to be of use outside the ACE team.

3.1. THE RAW DATA

As mentioned above, each of the nine instruments is described in detail in a companion paper. Presented here is a uniform view of the data so that they may be compared. This overview is primarily given in terms of types of data and time resolution. For an overview of of the elemental, isotope and energy ranges covered by ACE see Stone *et al.*, 1998a.

Among the particle detectors there is a great deal of commonality in the raw data, although the analysis of the data from the solar wind instruments (SWEPAM, SWICS, SWIMS) frequently differs substantially from the analysis of the other particle instruments. The magnetometer (MAG) data are, of course, rather different from the data from the eight particle detecting instruments. In order to maximize and take advantage of the commonality of science and data processing, the instrument data can be organized in terms of the following four data types:

- Housekeeping and status data
  include the digitized readouts of analog parameters such as temperature, voltage, and current and the digital indicators of parameters such as command state, subsystem power on or off, *etc.* Some of these parameters are monitored by the instruments and included in their data output to the spacecraft; others are monitored by the spacecraft and added to the telemetry by the C&DH system. Since they describe the instrument or spacecraft rather than the physical phenomena measured by the instruments, they are generally of interest only to the instrument team and are not detailed here.

- Rate data

  specify a count of the number of times a particular logical condition in the instrument electronics was satisfied during a particular time interval, usually the interval since that counter was last read out. The use of the word ‘rate’ implies that the counter readout will eventually be normalized to the time interval. ACE rates can be subdivided into three major categories – singles, coincidence, and matrix rates – as detailed below.

  Any of these three rate types can be sectored or multiplexed. Sectored rates are counted according to the phase of the spin of the spacecraft, *i.e.*, the pointing direction of the telescope. Multiplexing is used to share valuable telemetry resources for several rates at the cost of less time resolution or less than 100% coverage. Multiplexing is very common for singles rates, but is also used for some coincidence and matrix rates on ACE.

  - Singles rates

    typically specify a count of particle detection events as seen in a single individual detector, as opposed to a rate of some logical coincidence of several detectors within a telescope or instrument. These rates are generally intended primarily for monitoring the health of a detector and are frequently multiplexed (sub-commutated) to avoid using too much telemetry. They usually reflect the particle environment (when the detector is healthy) and are of some general interest.

  - Coincidence rates

    typically specify a count of particle detection events as identified by some combination of detectors and are less subject to background due to detector noise. They also generally respond to a better defined range of particle charges and energies.

  - Matrix rates

    are counts of events identified by both a combination of detectors triggered and the signal sizes (pulse heights) in those detectors. The use of pulse height information allows these rates to be even more specifically identified with particular particle species and energies.

- Pulse height events

  are telemetry items containing pulse height information describing one particular ion as observed in one or more (frequently three or more) detectors. All ACE instruments observe more events than can be telemetered; thus the instruments employ priority systems to select the most interesting events for telemetry and it is therefore necessary to use rate information to calculate the flux of ions from the pulse height event data.

- Other

  The MAG instrument’s measurements of magnetic field can be thought of as

> similar to pulse height events for Level 0 processing, but processing at higher levels is very different for the two types of data. In addition, MAG occasionally measures and telemeters power spectra (Fourier transforms) of the magnetic field as a function of time for very short time intervals.

In Table I we report numbers of rate readouts and numbers of types of events, for the various instruments. The table contents are explained briefly below.

Table I. ACE Data Summary

Instrument	Matrix rates	Coincidence rates	Singles rates	Event Types
CRIS		78	32	64
EPAM	$12s_8$	$15s_8$+$19s_4$	$2s_4$	1
MAG				6 vectors/sec.
SEPICA	$36s_8$+49		$3s_8$+3	14
SIS		118	24	96
SWEPAM			23	
SWICS	$27s_8$	2	4	3
SWIMS	$3s_8$	1	7	3
ULEIS	$76s_8$	$3s_8$	$13s_8$	5

The table entries for rates specify the number of rates telemetered; for events, the number of kinds of events as determined by onboard priority buffers. The s_N after some rate numbers indicate that particular rate is sectored into N sectors. For example, $12s_8$ is a rate consisting of 12 individual items with 8 sectors each (a total of 96 values).

Using the terminology described above, CRIS has 64 coincidence rates which are tied to the 64 CRIS event priority buffers, and 14 coincidence rates which are not, for a total of 78 coincidence rates. CRIS also has 32 singles rates. Similarly, SIS has 96 coincidence rates which are tied to the 96 SIS event priority buffers, and 20 coincidence rates which are not, for a total of 116 coincidence rates. SIS also has 2 programmable coincidence rates and 24 singles rates. The CRIS and SIS event priority buffers are defined in Stone *et al.*, 1998b,c. CRIS and SIS rates are not sectored, *i.e.* no spacecraft spin-phase information is recorded.

EPAM has sectoring information for all rates. Matrix rates select particular ions and energies and are subdivided into 8 sectors per spacecraft spin period. Some coincidence rates are sectored by 4, others by 8. The coincidence rates include separate rates of ions, and electrons at various energies from multiple telescopes directed at various angles from the spacecraft spin axis. The singles rates are multiplexed. EPAM pulse height events are prioritized using 8 of the matrix rates. They are sectored by 8, with 2 events being reported per sector.

SEPICA reports 16 coarse and 20 fine mesh matrix rates, each with 8 sectors, and 49 unsectored fine mesh matrix rates. The coarse rates normalize the event selection in the priority system. The fine mesh matrix rates furnish more detail about the ion species and energy. SEPICA pulse height events are sectored by 4, with up to 33 events being reported per sector, prioritized by 14 of the coarse matrix rates.

All SWICS and SWIMS matrix rates are sectored into 8 bins. Each of the two instruments reports 3 basic matrix rates, which normalize the PHA event selection. SWICS also reports 24 fine mesh matrix rates.

SWEPAM has 16 ion rates and 7 electron rates which are (technically) singles rates. These rates are read out frequently as SWEPAM scans the voltage (which corresponds to particle energy per charge) and the azimuthal space (due to spacecraft spin). This parametric information is analyzed on the ground to yield a science result which looks like sectored matrix rates (and then analyzed further to yield solar wind velocity, density *etc*). SWEPAM telemeters no events.

ULEIS has 76 matrix rates of ions of various species and energies, each of which are which are sectored by 8. Six pulse height events are reported per sector, for a total of 48 events per spacecraft spin period. Five onboard event priority buffers determine the events selected for telemetry.

MAG magnetic field vectors are crudely analogous to particle detector PHA events. The instrument reports a continuous data stream of 6 vectors per second. There are no rate equivalents.

3.2. THE BROWSE PARAMETERS

Browse parameters are a subset of measurements by the ACE instruments which are created at the Science Center during level one processing. They are delivered to the public domain as soon as possible. Their purpose is to allow monitoring of the solar wind and large-scale particle and magnetic field behavior, and selection of interesting time periods for more intensive study. Interesting time periods might include solar energetic particle events, or the passage of an interplanetary shock. An additional use of the browse parameters is to investigate relationships between the data from the various ACE instruments, and between ACE data and data from other sources.

The browse parameters include unsectored fluxes of ions at many different energies and electrons at a few energies. They also include the interplanetary magnetic field, and solar wind parameters such as proton speed and temperature. They therefore furnish a very abbreviated description of what is being observed by the ACE instruments, without the relatively high cost of storing and analyzing all the level one data. Eventually they may be supplemented with event data from the particle detectors, but experience with the flight data is a prerequisite for delivering useful products of that type.

Because the browse parameters are intended to be delivered to the public domain within a few days of receipt of the raw data from the spacecraft, they are not subjected to any prior scrutiny by the science teams. Their production is automatic, and the data are not routinely checked for accuracy before release. Therefore the browse parameters are not suitable for serious scientific work, and should not be cited without first consulting the appropriate ACE instrument team. However, the algorithms used to create the browse parameters are subject to revision, and their reliability is expected to improve with time. The browse parameters will probably be the most popular Science Center product for the larger community outside the instrument teams, particularly during the early stages of the mission, so early delivery is considered more important than full verification.

The best time resolution for the browse parameters is generally limited by data collection cycles in the instruments. CRIS and SIS have separate 256-second cycles and SWICS has a 12-minute cycle. EPAM, ULEIS and SEPICA have separate 128-second cycles, each cycle containing data for 10 consecutive spacecraft spins. SWEPAM has a 64-second cycle and MAG browse data is reported with 16-second time resolution. The SWIMS instrument does not contribute to the browse parameters.

In addition to the cycle/averaging periods noted above, all the browse parameters are averaged to common one-hour and one-day periods, and the data from EPAM, MAG, SEPICA, SWEPAM and ULEIS are also averaged to a common 5-minute period. These common periods are in time phase with UTC clock, *i.e.*, at integral 5-minute, hour and day values.

The charged particle fluxes in the browse data include H, He, C, O, Mg+Si, Ne–Fe, and iron-group fluxes, in various energy bands. The current list is shown in Table II. This list may be augmented in the future, and the energy bands may be revised by the instrument teams as the data analysis proceeds.

The solar wind parameters include the proton speed, proton density, radial component of the proton temperature tensor, and the He++/proton ratio, all from SWEPAM, and the following parameters from SWICS: He speed, He and oxygen thermal speed, coronal temperature, and the He/O and Fe/O density ratios. The interplanetary magnetic field vector and magnitude from MAG are reported in both RTN and GSE coordinate systems. It should be noted that the attitude, position and velocity of the ACE spacecraft are also made available to the public by the Science Center, in various coordinate systems.

A selection of the browse parameter data is shown in Figure 2, for a period of high solar activity in November 1997.

4. Science Techniques

4.1. DATA INTERCHANGE STANDARDS

The use of data interchange standards is an important tool in making data freely available to the ACE team or to the space science community. Some standards are imposed by NASA regulations, in other cases a choice from a plethora of possible standards had to be made by the team. Different standards are optimal for different levels of processing of the data, but we have striven to compromise between using a minimal number of standards and supporting a heterogeneous community.

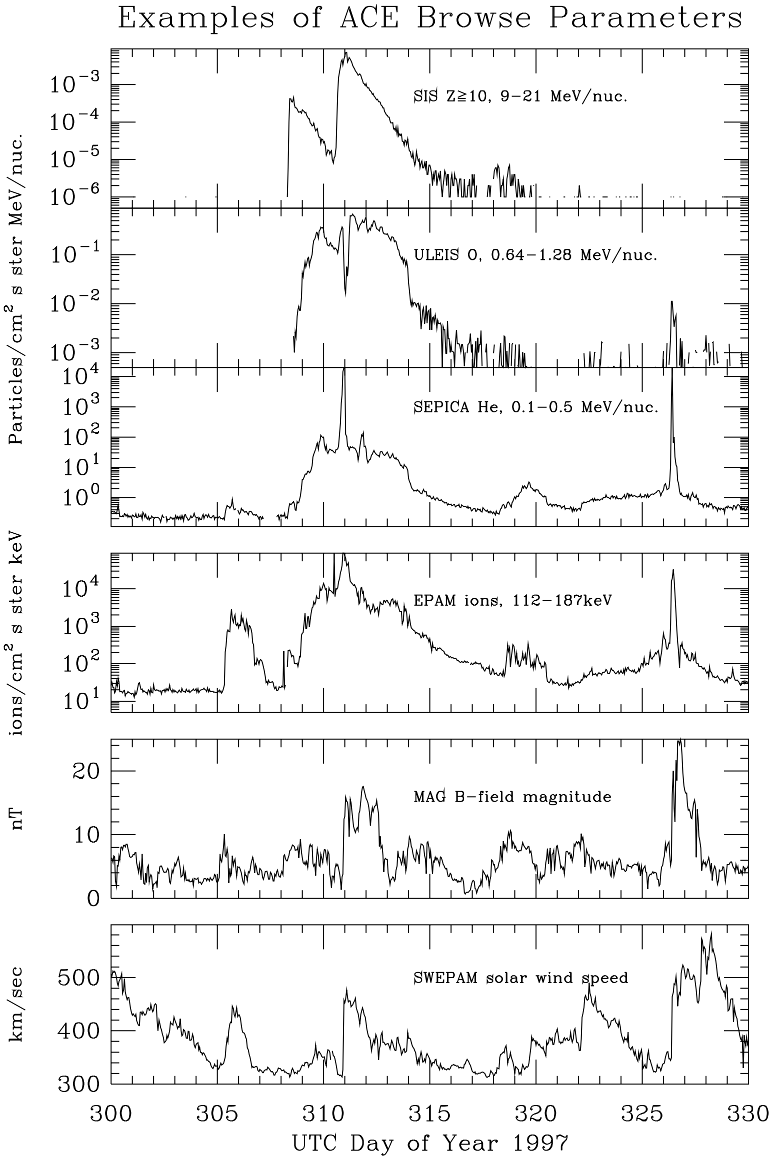

Figure 2. A selection of browse parameters from the ACE instruments, for the period around the November 4th and 6th solar particle events. Each instrument contributes at least several additional browse parameters. For instance, the components of the magnetic field vector are also available from MAG. The CRIS instrument is not designed to function during periods of high solar activity, so CRIS data are not shown. SWICS browse parameters were not yet available.

Table II. Browse Parameter Charged Particle Fluxes and Energy Bands

Instrument	Electrons (MeV)	Ions (MeV)
EPAM	0.04-0.05	0.05-0.07
	0.18-0.32	0.11-0.19
		0.31-0.58
		1.06-1.91

Instrument	H	He	C	O	CNO	Ne–Fe	Fe group
			(MeV/nucleon)				
CRIS						100-400	
						> 300	
SIS					7-10	9-21	
					10-15		
SEPICA	0.1-0.6	0.1-0.5	1.0-15	0.8-17		0.5-11*	0.3-4.9
	0.6-5.4	0.5-8.4					
ULEIS		0.64-1.28^{3}					
	0.64-1.28	0.64-0.91^{4}		0.64-1.28			0.64-0.91
	0.16-0.32	0.08-0.11^{4}		0.09-0.16			0.08-0.16

ULEIS reports three helium browse parameters; one for ^{3}He, and two for ^{4}He. The superscripts on the energy ranges indicate the isotope. The SEPICA entry in the Ne-Fe column is really a Mg+Si flux. All the energy ranges quoted are subject to revision by the instrument teams.

As noted in Section 2 above, the data flow from the spacecraft to the ground is based on standards specified by the Consultative Committee for Space Data Systems (CCSDS) of which NASA is a member. Each spacecraft minor frame is encapsulated in a CCSDS packet (CCSDS ’89) and transmitted (eventually) via a CCSDS virtual channel (CCSDS ’89). The DSN checks and removes the error protection coding attached to each packet and forwards the data to the IMOC using the TCP/IP standard made familiar by the Internet. Uplink transmission of commands to the spacecraft from the ground also follows CCSDS standards. References to CCSDS standards can be obtained from the Consultative Committee for Space Data Systems Secretariat, Communications and Data Systems Division, Code OS, NASA Headquarters, Washington, D. C. 20546. All of these standards are largely invisible to the ACE team including the Science Center.

At the IMOC the Level 0 processing encapsulates the spacecraft packets in Standard Formatted Data Units (SFDUs) per another CCSDS standard (CCSDS ’92). After the data are received by the ACE team, all further data sets (e.g., Level 1, 2, 3, and browse) are stored and transmitted per the HDF (Hierarchical Data Format) standard of the NCSA (the National Center for Supercomputing Applications). Some data sets are translated into other standards for the convenience of particular user communities that have settled on other standards. In particular, the browse parameter files are expected to be of use to a large community, so it is important to make them available easily. They are being translated into the Common Data format (CDF)(NSSDC '92) (with the assistance of the National Space Science Data Center) for the convenience of the ISTP (International Solar Terrestrial Physics) program, which uses CDF for their equivalent Key Parameter files. They are also being made available in ASCII via the internet (see Section 4.2), since we expect that to be easiest to access mode for the largest possible community.

The ACE team imposes additional standards of self-documentation on top of the facilities furnished with HDF. These rules are inspired by the Caltech Tennis standard (Garrard, 1993) and by experience with earlier missions, such as Voyager and HEAO. These rules demand self-documentation of each data item within a data set and a record of the pedigree of the data (i.e., what program created a data file, what other data files were input to that program, *etc*). In Tennis, these rules were both enforced and facilitated by the tennis library of input/output functions (i/o). In the HDF i/o library, the enforcement function is missing, but adequate tools are present to facilitate these rules. The major advantage of HDF over Tennis, in the judgement of the ACE team, is substantial support for a wide variety of operating systems and computer types. It also has a much larger tool library.

4.2. TOOLS AND DATA DELIVERY

The HDF standard is supported by the National Center for Supercomputing Applications at University of Illinois, Champaign-Urbana. It comes with an i/o library which is supported for a large variety of operating systems and computers and a library of tools for browsing, displaying and indexing of HDF data sets. The standard is sufficiently popular that tools are being created and made available by users as well as the NCSA. For instance, the Science Center has created and contributed tools for mapping C language structure declarations into descriptions of HDF data sets. It is also noteworthy that Research Systems, Inc. and Fortner Software LLC, have both incorporated an HDF interface into their popular data analysis and visualization tools, IDL and Noesys (reg. trademarks).

The Science Center has adopted Unix as its preferred operating system, with most of the machines being 64-bit Sun workstations running the Solaris dialect of Unix. Many of the ACE instrument teams are using similar hardware and operating systems, but not all. The intention is to use standards which are not operating system dependent, while, at the same time, doing whatever is reasonable to reduce variety among the team to simplify system administration. The Science Center does have several Hewlett Packard Unix workstations and a number of Apple MacIntosh and Windows compatible personal computers available for guest investigators and for communications with investigators that prefer those systems. As noted above, the

HDF i/o library is supported for a wide variety of operating systems, so data communications should not be OS dependent.

Of course, the internet and the World Wide Web are the tools of choice at this time for interfacing users to the data and the documentation. At this time the Science Center web address is

http://www.srl.caltech.edu/ACE/ASC/index.html.

The Web site provides documentation for the data, catalogs of the data files, plots of browse parameters to facilitate the selection of data files, and ancillary data such as spacecraft position and attitude. As explained below, the ACE data files themselves (except for the browse parameter data) are not available to anonymous users, but identified users will be granted access promptly. Immediate access to the level one data is via the internet (ftp), and level one CD-ROMs are distributed to the instrument teams roughly every three weeks.

Although the primary responsibility for mission operations, including commanding and health monitoring, rests with the Flight Operations Team at GSFC, the Science Center has a secondary goal of providing flexibility in monitoring instrument health. Each instrument team has the option of monitoring the health of their instrument from their home institution, in real time, using the same ground support equipment they used for integration and testing. To achieve this, the Science Center receives a copy of the spacecraft telemetry from GSFC via the internet during each DSN contact, and makes it available to each instrument team, also via the internet. This is possible because the Science Center is running a subset of the MOC (Mission Operations Center) system software used both at the IMOC and at the spacecraft Integration and Test facility at APL. The use of common software for these three purposes has saved a great deal of money and is described by (Stone *et al.*, 1998a) and (Snow *et al.*, 1996).

Catalog tools for the ACE data are not yet well defined — it is preferable to wait until some examples of level two data are available before defining the requirements for catalog tools. At this time, these tools are expected to resemble the 'incremental data set' tools of the Planetary Data System (King *et al.*, 1993), which have the very useful feature that they link data files to the relevant documentation and calibration files. Another possibility is the development of additional tools by NCSA, specifically aimed at HDF files.

4.3. POLICY ISSUES

The ACE team has chosen to emphasize collaborative science and sharing of data within the team and with the larger space physics community. The browse data in particular are being made available very promptly, even at the risk of inadequate verification. Some evolution of browse parameter definitions/computation will almost certainly occur over the life of the mission as a result of user feedback and extended verification activities. In many cases, this evolution will be handled by adding new parameters; in some cases, improved parameters may be substituted. Users are advised to maintain close contact with instrument teams when analyzing ACE data, especially if attempting to do careful science based on browse parameters.

In order to facilitate communications with users, the Science Center will make a substantial effort to keep track of all users and will discourage anonymous data transfers.

The Science Center has a limited allocation of office space and computer facilities available to Guest Investigators, either formally designated and funded by NASA or selected by informal negotiations with the instrument teams.

The Science Center has actively coordinated with the Space Physics Data System organization (Garrard *et al.*, 1995) and will continue to do so, either with SPDS or the potential Space Science Data System which might succeed it.

5. Conclusions

The ACE team, working through the ACE Science Center, are planning to investigate the composition and dynamics of the interplanetary medium and all the various energetic particle populations permeating the interplanetary medium in a coordinated and collaborative fashion. The team is making every effort to allow a larger community to participate in these studies. The tools used in that effort include data interchange standards, standard visualization tools, Web interfaces for data access, a variety of storage and/or communications media, and open channels of communication with scientists.

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