

# Mission Archive Plan for the Advanced Composition Explorer

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## 1. Introduction

This document describes the Mission Archive Plan (MAP) for the Advanced Composition Explorer (ACE) mission. The [ACE Science Center](#) (ASC), located at the Caltech Space Radiation Laboratory (SRL), is responsible for the archiving and distribution of ACE data while the mission is active, and for managing the implementation of this MAP.

## 2. Definitions of ACE Data Levels

We first define the various ACE data levels, since the definitions we have used since the beginning of the mission may not coincide exactly with those used for other missions.

- **Level 0:** The raw telemetry data are time-ordered, duplicate data are removed, and the data are formatted into a 24-hour Level 0 data file containing all the science and housekeeping data transmitted by the spacecraft. Production of Level 0 data is performed by the ASC at Caltech, using raw telemetry files obtained directly from NASA's Deep Space Network (DSN).
- **Level 1:** At the ASC, the data are separated out by instrument and structured in a fashion that is both consistent with the other instruments and customized to meet the special requirements of that data set and instrument team. **Although Level 1 data are publicly available, special expertise is required to obtain scientifically usable measurements from the Level 1 data.**
- **Ancillary data** include position, attitude, and spin phase of the spacecraft, and calibration of the spacecraft clock that are essential for the production of higher-level data products.
- **Browse data** are automatically generated at the ASC during Level 1 processing using simple algorithms provided by the instrument teams, and are made available to the community as soon as possible, usually within a day or two. Use or citation of these data in scientific publications is not supported by the ACE science team.
- **Level 2 data** are publication-quality data produced by the instrument teams and repackaged at the ASC into a common data format and made available via the [ASC website](#) and via [CDAWeb](#) at the [NASA Space Physics Data Facility \(SPDF\)](#).
- **Level 3 data** include a wide variety of data, plots, and lists, provided by ACE team members and others. A full description of all these products is beyond the scope of this document; see [The ACE Level 3 web pages](#) for details. Additions to and enhancements of the Level 3 data occur from time to time.
- **Real-Time Data:** [ACE Real-Time Solar Wind \(RTSW\) Data](#) from NOAA's [Space Weather Prediction Center](#) (SWPC) provides up to an hour's advance warning of unusual solar activity, such as solar flares and coronal mass ejections, which can cause geomagnetic storms.

Four ACE instruments supply data to NOAA's SWPC for RTSW processing. The instruments are:

- EPAM - Energetic Ions and Electrons
- MAG - Magnetic Field Vectors
- SIS - High Energy Particle Fluxes
- SWEPPAM - Solar Wind Ions

The RTSW data are generally available from the SWPC website a few minutes after the data are telemetered from the spacecraft.

### 3. Current Status of Data Products, Documentation, and Archiving

**Level 0 Data:** The Level 0 data are archived as follows but not otherwise distributed:

- Complete synced copies of the Level 0 data set are maintained on two RAID disk servers on computers in separate locations on Caltech campus. Both copies are regularly backed-up and the backup media are stored off-site.

**Level 0 Documentation:** The Spacecraft Telemetry Frame Format and the Interface Control Document between the ASC and the ACE Mission Operations Center are online at <http://www.srl.caltech.edu/ACE/ASC/spacecraft.html>.

**Level 1 Data:** Level 1 data are formatted in HDF4, with archiving at the ASC the same as for the Level 0 data. The SPDF archives the Level 1 data via [rsync](#) from the ASC, and each science team also maintains an archive of these data.

**Level 1 Documentation:** The ACE Level 1 data are organized to meet the individual requirements of the nine ACE instrument teams, with a library of C subroutines to read/write the data structure from/to the HDF format data files. Documentation is maintained online at <http://www.srl.caltech.edu/ACE/ASC/level1/lv1docs.htm>.

**Ancillary data:** The data are available in HDF4 or ASCII via the ASC website, with archiving at the ASC the same as for the Level 0 data. The ASC also converts the ACE attitude and orbit data in various coordinate systems to ISTP-compliant CDF format, and delivers the CDF data files to the SPDF for archiving and distribution via [CDAWeb](#).

**Browse data:** These data are superseded by the Level 2 data as soon as the Level 2 data becomes available. Although the Browse data are archived at the ASC and SPDF, their use is deprecated in favor of the Level 2 data, when the Level 2 data become available.

**Level 2 Data:** Each instrument team delivers Level 2 data to the ASC every ~1 – 3 months where they are reformatted into HDF4. The HDF4 format is primarily for use by the ASC web server back-end software. The ASC also converts almost all the Level 2 data from each instrument to ISTP-compliant CDF format, and these CDF-format data are all available from the SPDF via [CDAWeb](#). The Level 2 archiving procedure at the ASC is the same as for Level 0, and the SPDF maintains a mirror of the Level 2 HDF4 and CDF data files via [rsync](#) from the ASC.

Instrument	Level 2 Data Products	Time Resolution	
		ASC	SPDF
MAG – Magnetometer	Magnetic field vector; RMS values of underlying high-resolution measurements	1s; 16s; 4min; 1 hr; 1 day; 27 day.	1s; 16s; 4min; 1 hr;
SWEPAM – Solar Wind Electron Proton Alpha Monitor	Solar-wind proton velocity, density, and temperature. <sup>4</sup> He/H <sup>+</sup> ratio	64s; 1 hr; 1 day; 27 day	64s; 1 hr
SWICS 1.1 – Solar Wind Ion Composition Spectrometer prior to August 23 2011 ( <b>see note below</b> )	H and He density. Bulk and thermal ion speeds of H, He, C, O, Fe. He <sup>+</sup> distribution functions. Abundances: He/O, C/O, N/O, Ne/O, Mg/O, Si/O, S/O, Fe/O. Charge states: C <sup>+6</sup> /C <sup>+4</sup> , C <sup>+6</sup> /C <sup>+5</sup> , O <sup>+7</sup> /O <sup>+6</sup> , Q<C>, Q<O>, Q<Mg>, Q<Si>, Q<Fe>. Charge-state distributions: C, O, Ne, Mg, Si, Fe.	12min (protons); 1 hr; 2 hr; 1 day	12min (protons); 1 hr; 2 hr;

SWICS 2.0 – Solar Wind Ion Composition Spectrometer after August 23 2011 (see note below)	He Bulk and thermal ion speeds. Charge states: C <sup>+6</sup> /C <sup>+5</sup> , O <sup>+7</sup> /O <sup>+6</sup> , O <sup>+8</sup> /O <sup>+6</sup> , Q<Fe>. Abundances: Fe/O	2 hr	2hr
EPAM – Electron, Proton and Alpha Monitor (see note below)	Spin-averaged intensities from 5 telescopes. Ions with 0.05 to 5 MeV: 8 energy ranges. Electrons with 38 to 312 keV: 4 ranges. He, CNO, & Fe in 2 ranges.	12 sec; 5 min; 1 hr; 1 day; 27 day	12 sec; 5 min; 1 hr;
ULEIS – Ultra Low-Energy Ion Spectrometer	Solar/interplanetary particles. Seven species in ~10 energy ranges, 0.04 - 4 MeV/nuc, including <sup>3</sup> He/ <sup>4</sup> He.	1 hr; 1 day; 27 day	1 hr
SEPICA – Solar Energetic Particle Ion Composition Spectrometer	Solar/interplanetary particles. Nine species in ~5 energy ranges; 0.3 to 5 MeV/nuc.	2-min; 1 hr	1 hr
SIS – Solar Isotope Spectrometer	Solar particles, anomalous and galactic cosmic rays. Nine species from He to Fe, in 8 energy ranges; ~6 to >100 MeV/nuc.	256s; 1 hr; 1 day, 27 day	256s; 1 hr
CRIS – Cosmic Ray Isotope Spectrometer	Galactic cosmic rays: 24 species from B to Ni, in 7 energy ranges; ~60 to >400 MeV/nuc.	1 hr; 1 day; 27 day	1 hr, 1 day

Table 1 lists the Level 2 data products available from the ASC and the SPDF. All of these products are registered at the [Heliophysics Data Portal](#). The ACE Level 2 data are all times-series data, and almost all cadences available from the ASC have been converted to CDF format and are also available from the SPDF. The few exceptions are cadences that are rarely used. We work on converting these exceptions to CDF format as time allows. The instrument teams still occasionally re-release Level 2 data, due to new calibrations, or improved data processing software. Whenever this happens, the ASC also ensures that new versions of CDF-formatted data are promptly delivered to the SPDF.

The SWICS Level 2 data deserve a special note: SWICS 1.1 is the SWICS instrument prior to August 23, 2011, when a radiation and age-induced hardware anomaly altered the instrument's operational state. SWICS 2.0 is the SWICS instrument for the time period after the anomaly. The SWICS team has recently delivered a major new release of the Level 2 data for both these “instruments”, using completely redesigned analysis methods (Shearer et al. ApJ, Volume 789, Issue 1, p. 60, 2014). The data were delivered to the ASC in a different format than before, and the SWICS 2.0 data is an entirely new data set. This required a re-write of the ASC ingest software for SWICS Level 2 data. The software re-write is complete, and the SWICS 1.1 and SWICS 2.0 data are now available from the ASC, and from the SPDF in CDF format.

The EPAM Level 2 data also deserve a special note: the content of the Level 2 data from this instrument was defined early in the mission by the EPAM instrument team, and consisted of “spin-averaged” intensities at 5-minute and 1-hour cadences. In 2015, intensities at 12-second cadence were added to the EPAM Level 2 data set. The ASC provides these spin-averaged intensities to the community, and delivers these data to the SPDF in CDF format. However, the EPAM instrument actually produces “sectored” data, i.e. the data gathered during each spin of the spacecraft is binned into 16 sectors (look-directions) by the instrument. The EPAM instrument team contracts with [Fundamental Technologies LLC \(FTECS\)](#) for data processing, analysis, and distribution of the EPAM data. FTECS now provides sectored and spin-averaged EPAM rates at 12-second, 5-minute, hourly and daily cadences, and calibrated fluxes at 17-minute, hourly, and daily cadence. FTECS also provides PHA derived spectra for protons, alphas, C, N, O, Ne and Fe. These data are provided via the [FTECS website](#), and also via the [Virtual Energetic Particles Observatory \(VEPO\)](#). Full documentation of these data is also maintained by FTECS and the VEPO, and

the data and documentation are being archived at the SPDF, and registered at the [Heliophysics Data Portal](#).

In addition to the “per-instrument” Level 2 data products, the ASC also provides several “merged” data products, derived directly from the per-instrument data. Table 2 lists these products. They have not yet been converted to CDF or delivered to SPDF.

Instrument	Level 2 Data Products	Time Resolution	
		ASC	SPDF
MAG/SWEPAM	Same as for MAG and SWEPAM in Table 1	64 seconds	Data not yet converted to CDF for delivery to SPDF
SWEPAM/SWICS	Same as for SWEPAM in Table 1. The proton speed and density from SWICS are used when the SWEPAM data are unavailable.	12 minutes	
MAG/SWEPAM/SWICS/EPAM	Same as for MAG, SWEPAM, SWICS and EPAM in Table 1.	1 hour	

**Level 2 Data Documentation:** The Level 2 data are documented in several different forms:

- In terms of SPASE-compliant XML metadata that are registered with several virtual observatories, e.g. the [Virtual Heliospheric Observatory](#) (VHO) and the [VEPO](#), as well as the [Heliophysics Data Portal](#).
- In online web pages at <http://www.srl.caltech.edu/ACE/ASC/level2/index.html>
- In the metadata annotations that are included in all Level 2 HDF files.
- In the metadata that are included in all CDF files provided to the SPDF.
- In the headers of all ASCII data files downloaded from either the ASC or CDAWeb.
- An archive of the software used by the instrument teams to produce Level 2 data from the Level 1 and Ancillary data is maintained at the ASC.

**Level 3 Data:** These data/plots/lists come in different formats from different sources, hosted mostly by the ASC. The archiving procedure for the Level 3 data at the ASC is the same as for Level 0. We have recently worked with the SPDF to arrange for the ASC Level 3 data archive to be mirrored via rsync by the SPDF, and this mirror is now operational. We have also made contact with the maintainers of the Heliophysics Data Portal to arrange for registry of these Level 3 data products. Documentation of the Level 3 data is provided by the creators, and maintained with the data.

**Real-Time Data (RTSW):** NOAA’s Space Weather Prediction Center provides online access only to the most-recent ACE RTSW data. They do not provide a mission-length archive of these data to the public. The ASC does maintain an archive of these data, and the ACE team recognizes the potential use of this archive for enabling or testing of various space weather models. However, concerns remain about the preliminary nature and primitive calibrations used to process these data. Therefore the ACE team has decided to make this RTSW data archive available on the web by request, via a password. See the [ACE RTSW web page](#) hosted by the ASC.

**Other ACE Science Center documentation and software:** Data processing scripts, processing environment, settings, etc. are archived at the ASC on two servers in separate locations on the Caltech campus, and these systems are backed-up separately. This includes the software for producing the Level 0, Browse, and Level 1 data, the Level 2 data ingest software, and the data distribution and web services software.

Many documents are available online at the ASC. These include telemetry formats, interface docs, requirements docs, design docs, test plans, PDF versions of the mission, spacecraft, and instrument papers published in Space Science Reviews, weekly Flight Operations Team reports, the ACE bibliography, and ASC data processing procedure docs. ITAR-sensitive documents are maintained offline.

#### 4. Current Status of the Data Distribution System

The ASC distributes Browse, ancillary, Level 2 and Level 3 data and plots from [the ASC website](#). The Level 2 data, ancillary data (attitude and orbit data), plus the most-recent Browse data, are also distributed via [CDAWeb](#). The SPDF is also archiving the ACE Level 3 data, and plans to provide access to these data via CDAWeb. Both the ASC and CDAWeb enable download of ASCII data and plots, as well as HDF and CDF files.

ACE data (or pointers to the data) are also accessible via several virtual observatory channels, including the [Virtual Heliospheric Observatory \(VHO\)](#), the [Virtual Energetic Particles Observatory \(VEPO\)](#), and the [Virtual Magnetospheric Observatory \(VMO\)](#).

These virtual observatories and the SPDF also provide access to several value-added data products derived from ACE data, for example:

- [OMNIWeb Plus](#) – ACE Magnetic field, Plasma, Energetic particle data are included in OMNIWeb Plus, along with data from other missions
- [Field/plasma-merged 4-min ACE data](#) set created at SPDF as part of preparing ACE data for OMNI
- [Multi-source spectral plots \(MSSP\)](#) of energetic particle H and He fluxes. Data from the EPAM, SEPICA, SIS and ULEIS instruments on ACE are included.

#### 5. Steps needed to complete the mission archive

If the ACE mission were to terminate tomorrow, a number of unfinished tasks would remain before the full ACE data set would be ready to be served in its final version from a Resident Archive (RA), and/or delivered to the permanent archive. We list these here in priority order, and indicate the current schedule for completion of these tasks

Obtain final versions of Level 2 data from each instrument team (occasional reprocessing does still occur as our understanding of instrument calibrations evolves)	Ongoing
Ensure data are readily available via VOs through continuing VO-integration work and improvement of SPASE-compliant metadata descriptions.	Ongoing
Incorporate any new Level 3 data products from the instrument teams.	Ongoing
Complete the conversion of all Level 2 data products at all time-resolutions to CDF format for delivery to the SPDF and CDAWeb (see Table 1).	December 2017
Finalize the archive of software used by each instrument team to produce Level 2 data from the Level 1 data. Work to improve software comments and documentation of algorithms.	Ongoing

#### 6. Plan for Transition of the ASC to a Resident Archive (RA)

**The ASC will, if necessary, take on the role of ACE RA upon termination of the mission.** The following current ASC functions encompass the RA functions described in the [Heliophysics Data Management Policy](#) and the ASC will be capable of transferring seamlessly to RA at end of mission:

1. Produce, distribute, and archive ACE Level 1 data from the raw telemetry data.

2. Distribute and archive ACE Browse and Level 2 data received from the instrument teams.
3. Provide ACE Level 2 data to the SPDF in ISTP-compliant CDF format.
4. Distribute and archive ACE Level 3 data received from the instrument teams.
5. Maintain the integrity of the data by safeguarding against data loss.
6. Participate in the development of Virtual Observatory standards, tools, and services.
7. Provide comprehensive mission and data documentation.
8. The ASC provides a library of C functions and programs to read data directly from the HDF files, and the SPDF provides and supports tools for reading Level 2 data in CDF format.
9. The ASC staff responds to user inquiries regarding the usability or availability of data, and forwards science inquiries to the appropriate ACE science team member.