STEREO

Solar-Terrestrial Probes (STP) Mission
Project Data Management Plan

460-PLAN-0039

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

Signature Page

STEREO Project Data Management Plan

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Project Scientist	Date
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IMPACT Principal Investigator	Date
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PLASTIC Principal Investigator	Date
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SECCHI Principal Investigator	Date
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S/WAVES Principal Investigator	Date
______________________________	______________
Mission Archive Lead	Date
______________________________	______________
Program Manager	Date
______________________________	______________
Operating Missions Program Executive	Date
______________________________	______________
Program Scientist	Date
______________________________	______________
Archive Project Scientist	Date

By signing this document, signatories are certifying that the content herein is acceptable direction for managing the project’s data and that they will ensure its implementation by those over whom they have authority.

Table 1. Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approval Date)
Baseline	March 2002	Original
Revision 1	May 2020	Rewrite for 2020 Senior Review

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1.0 INTRODUCTION

This document describes the Project Data Management Plan (PDMP) for the Solar-TErrestrial RElations Observatory (STEREO) mission. STEREO is a National Aeronautics and Space Administration (NASA) Solar Terrestrial Probes (STP) mission launched on October 25, 2006.

1.1 Purpose and Scope

This PDMP is designed to be consistent with the STEREO Level-1 Requirements Document. It will describe the generation and delivery of STEREO mission data and science data products to the STEREO Science Center (SSC) and elsewhere, institutional responsibilities for data analysis, and the transfer of archival data products to the Space Physics Data Facility (SPDF) and the Solar Data Analysis Center (SDAC) active archives. Covered in this plan are:

1. Brief description of the mission and instruments
2. Description of the data flow
3. Description of the science data products
4. Processing requirements and facilities
5. Policies for access and use of STEREO data
6. Data product documentation

1.2 Plan Development, Maintenance, and Management Responsibility

The STEREO Project Scientist, Dr. Therese Kucera, is responsible for the development, maintenance, and management of the PDMP through the life of the mission. The point of contact for the PDMP is Dr. William Thompson. The STEREO PDMP will be modified and updated as required in accordance with the Configuration Management Plan for the STEREO mission.

All but one of the four instruments on STEREO have U.S. Principle Investigators. The Principle Investigator for the radio instrument, S/WAVES, is based at the Observatoire de Paris in France, but flight operations are based out of the University of Minnesota, and telemetry processing is performed at the NASA Goddard Space Flight Center.

1.3 Change Control

The SDO PDMP will be modified and updated as required in accordance with the Configuration Management Plan for the STEREO mission and the NASA Science Mission Directorate's Heliophysics Division PDMP.

1.4 About this document

An overview of the STEREO mission objectives and operations is described in Section 2.0. The four STEREO instruments are described in Section 3.0, including the observation requirements at launch, how the instrument capabilities evolved over the course of the mission so far, and an overview of the data acquisition process. Section 4.0 describes the data products delivered by each of the instrument team, and how these data are distributed. The STEREO ground system is described in Section 5.0, with particular attention to the Mission Operations Center and the STEREO Science Center. The data flow to and from the spacecraft, along with details on the data handling and timeline, is outlined in Section 6.0. Finally, the information formerly described in the Mission Archive Plan in previous Senior Reviews can be found in Section 7.0, describing how the data are processed and archived, along with information about available analysis tools.

1.5 Relevant Documents

Table 2. Relevant Documents

Title	Document Number	Publication Date
STEREO Level-1 Science Requirements, NASA Headquarters Solar Terrestrial Probes Program Plan	460-PLAN-0005, Appendix A-3	25 June 2001
STEREO Mission Requirements Document, NASA-GSFC	460-RQMT-0001	August 2000
STEREO MOC to POC and to SSC ICD, JHU/APL	7381-9045	10 December 2001
The STEREO Mission	*Space Science Reviews*, Volume 136, Issues 1-4	2008

2.0 MISSION OVERVIEW

An Announcement of Opportunity to provide instruments for the STEREO mission was published on April 28, 1999 (AO 99-OSS-01) by NASA Headquarters. The STP office at NASA's Goddard Space Flight Center (GSFC) has overall responsibility for the mission; Johns Hopkins University's Applied Physics Laboratory (JHU/APL) is the spacecraft provider and mission integrator. For the purposes of this document, "spacecraft" refers to the bus subsystems without instruments, while each spacecraft plus instruments will be referred to as an "observatory."

Four instrument teams were selected for development as a result of the Announcement of Opportunity: Plasma and Suprathermal Ion Composition (PLASTIC) from the University of New Hampshire, University of Bern, Max Planck Institute for Extraterrestrial Physics, and GSFC; Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI) from the Naval Research Laboratory, Lockheed-Martin Advanced Technology Center, GSFC, University of Birmingham, Rutherford-Appleton Laboratory, Centre Spatial de Liege, Max-Planck-Institut fur Aeronomie (MPAe), and Institute d'Astrophysique Spatiale; STEREO WAVES (S/WAVES) from Observatoire de Paris, GSFC, University of Minnesota, and University of California at

Berkeley (UCB); and In-situ Measurements of Particles and CME Transients (IMPACT) from UCB, GSFC, California Institute of Technology, University of Maryland, University of Kiel, Centre d'Etude Spatiale des Rayonnements, Jet Propulsion Laboratory, European Space Research & Technology Centre, MPAe, and Los Alamos National Laboratory.

The twin STEREO spacecraft were launched Wednesday, October 25th, 2006 at 8:52 p.m. EDT on a Delta II 7925-10L rocket from Cape Canaveral Air Force Station in Florida. Communications with Solar Terrestrial Relations Observatory-B (STEREO-B) were lost on Oct. 1, 2014, due to multiple hardware anomalies affecting control of the spacecraft orientation. Communications with STEREO-B were re-established on Aug. 21, 2016, during a monthly attempt to reach the spacecraft using NASA's Deep Space Network. During the next weeks, the NASA and the Johns Hopkins APL STEREO teams worked tirelessly to discover the spacecraft's current conditions and to recover the spacecraft fully. The attempt to recover the spacecraft was not successful. STEREO-B has now been out of contact since Sept. 23, 2016. Four years after the initial loss of communications anomaly with the Behind observatory, NASA directed that periodic recovery operations cease with the last support on October 17, 2018. STEREO-A continues to operate nominally.

2.1 Mission Objectives

The primary goal of the STEREO mission is to advance the understanding of the three dimensional structure of the Sun's corona, especially regarding the origin of coronal mass ejections (CMEs), their evolution in the interplanetary medium, and their dynamic coupling with the environment at Earth. CMEs are the most energetic eruptions on the Sun, and they are responsible for the most severe geomagnetic storms and the largest energetic particle events. They may also be a critical element in the operation of the solar dynamo because they appear to remove dynamo-generated magnetic flux from the Sun.

The ejection of well-defined clouds of material from the Sun out through the corona was discovered in the early 1970's by the OSO-7 and Skylab coronagraphs. Although studies continued with coronagraphs on NASA's Solar Maximum Mission, the USAF P78-1, and the ESA/NASA Solar and Heliospheric Observatory, these investigations were limited to near-Earth vantage points that best showed CMEs that missed Earth. However, with two observatories sent in opposite directions away from the Sun-Earth line, the STEREO mission finally allowed unambiguous observation of those CMEs that directly impact Earth. STEREO also for the first time provided a stereoscopic view of the three-dimensional corona and the interplanetary medium and thereby advance the Sun-Earth Connection understanding of the heliosphere begun by the International Solar-Terrestrial Physics program.

The CME clouds can be sensed remotely and with in situ measurements, and both techniques are necessary to gain an understanding of the physical processes associated with their initiation and propagation. The STEREO mission consists of two identical observatories launched into heliocentric orbits that move symmetrically away from the Sun-Earth line, one ahead of Earth (STEREO-A) and the other behind Earth (STEREO-B). Each observatory carries both remote and in situ instrumentation designed to measure various aspects of CMEs. The original science goals included both stereoscopic measurements of individual CMEs as well as quadrature measurements whereby CMEs are imaged remotely by instrumentation on one observatory and measured in situ by instrumentation on the other platform.

The remote sensing instrumentation image the initiation of CMEs in the low corona by measuring intensities in extreme ultraviolet, white light, and at radio wavelengths. Remote sensing telescopes track the propagation of CMEs from the low corona away from the Sun out to the distance of Earth. In situ high-energy particle measurements are made as the magnetohydrodynamic shocks accelerate electrons and ions during propagation of the CME through the inner heliosphere. In situ magnetic field and electron, proton, and ion measurements are made as the shock and CME encounter the location of each observatory.

The STEREO mission provides the first imaging of the three dimensional structure of the Sun's corona and the inner heliosphere, and it provides critical information toward understanding the causes of the most severe geomagnetic storms. There were no science requirements to launch STEREO at a specific phase of the solar activity cycle, since CMEs appear at all times. But with the fleet of spacecraft (e.g., SOHO, ACE, Ulysses, TRACE, GOES, IMAGE, etc.) that were already in place, STEREO's launch in October 2006 provided the CME measurements needed for comprehensive studies of the Sun-Earth Connection.

2.2 Launch, Orbit and Operations

The STEREO mission payload consists of two identical observatories, each containing two instrument suites and two additional instruments. The observatories are Sun-pointed and three-axis-stabilized. The STEREO mission summary is shown Table 1.

Table 3. STEREO Mission Summary

Orbit Description	Heliocentric STEREO-A orbits ahead of Earth STEREO-B orbits behind Earth
Launch Date	October 26, 2006
Launch Vehicle	Delta II 7925-10L
Nominal Mission Duration	2 years after heliocentric orbit insertion
Potential Mission Life	50 year expendables
Spacecraft + Instrument Mass	473 kg per observatory (dry)
Attitude Determination	Roll angle from star sensor Fine pointing from Guide Telescope as part of SECCHI suite
On-Board Data Storage Capacity	1 Gbyte

The two STEREO observatories were launched on October 26, 2006 stacked on a single Boeing Delta II 7925-10L expendable vehicle. From low Earth orbit, the stack was spun up by the third stage solid rocket and was sent into a translunar orbit. After several phasing orbits around the Earth-Moon system, on December 15, 2006, the STEREO-A observatory was injected into heliocentric orbit; and on January 21, 2007, the STEREO-B observatory was sent into its heliocentric orbit. The time during the lunar phasing orbits was used for deployments, outgassing, instrument and subsystem commissioning, and other early-orbit checkout activities.

The nominal data return from each observatory is five (5) gigabits (Gb) per 24 hours. With heliocentric orbits, the baseline is for the instruments to acquire data continuously, without interruptions of eclipses, South Atlantic Anomaly passages, etc. The nominal operations concept calls for a single six (6) hour contact through a Deep Space Mission System (DSMS) 34-meter X-band antenna with each observatory per 30 hours. During these 6-hour contacts, some real-time data are routed from the DSMS station directly to the MOC. Those data could comprise up to 32 kilobits per second (kbps) and include spacecraft and instrument housekeeping, some real-time science data for commissioning and trouble-shooting activities, and the real-time space weather beacon data. The real-time data are made available to the instrument teams and SSC for further processing and online access.

During the initial operations phase, the instrument teams were co-located with the Mission Operations Team (MOT) in the MOC at APL. After commissioning, each instrument team returned to their home institution where they established a remote Payload Operations Center (POC) for all future instrument commanding and telemetry reception. The instrument team may relocate to the MOC for limited periods of critical operations, trouble-shooting, etc.

3.0 SCIENCE INSTRUMENTATION

The diverse and rich payload of STEREO exceeds brief description, but Table 2 shows some of the salient measurements offered by these instruments and their nominal data rates. The far-reaching payload is necessary to accomplish the challenging goals of understanding the initiation and propagation of CMEs and their interaction with Earth.

Onboard communication between the spacecraft subsystems and the Instrument Data Processing Units is through a MIL-STD 1553 bus. The primary science data, instrument housekeeping data, and space weather beacon data are all returned in CCSDS-formatted, fixed length (272 byte) telemetry packets. Each subsystem and instrument has an assigned range of Application Identifiers (ApIDs) to transmit their telemetry data to the SSR.

Table 4. Approximate Telemetry Allocations for STEREO Mission, per observatory

Instrument/Subsystem Name	Range	Average Data Rate
PLASTIC (Plasma composition)	Ions in the energy-per-charge range from 0.2 up to 100 keV/e	3.2 kbps
IMPACT (In situ suite)		3.2 kbps
STE	2-100 keV electrons	
SWEA	~0.05-3 keV electrons	
MAG	+/- 500 nT	
SEP	Energetic electrons, protons, & ions	

SECCHI (Remote sensing suite)		45 kbps
EUVI	Extreme UV emission from disk and low corona	
COR1	White-light corona from 1.4-4.0 Rs	
COR2	White-light corona from 2-15 Rs	
HI1	White-light corona from 12-80 Rs	
HI2	White-light corona from 80-215 Rs	
S/WAVES	Interplanetary radio burst tracking 2 kHz to 16 MHz	2.0 kbps
Spacecraft Housekeeping		3.0 kbps
Space Weather Beacon		0.6 kbps
	TOTAL AVERAGE DATA RAGE	**57 kbps**

3.1 IMPACT Suite

3.1.1 Instrument Measurement Requirements

The IMPACT investigation is a multi-instrument package (Luhmann et al., 2008) that fulfills many of the in-situ measurement needs for STEREO, illustrated by *Figure 1*. It continues to provide magnetic field, suprathermal electron, and solar energetic particle (SEP) information to allow distributed diagnostics of solar wind and interplanetary transients from 1 AU sites separated from Earth –the primary goal of the mission. The strength and orientation of the interplanetary magnetic field at the longitudinally separated STEREO locations, combined with the suprathermal (several 100s of eV) electron measurements help determine whether the local magnetic fields of the interplanetary CME, the ICME, are rooted at the Sun at one or both ends or disconnected. Such magnetic topology information tells us about the coronal origins of the CME/ICME and also about the role of processes such as reconnection at the Sun and in the interplanetary medium. Higher energy electron, and also ion, detectors provide information on whether the local field connects to a flaring active region. Detection of SEP events at the two locations, with high time resolution and directional information over the energy range from 10s of keV to ~100 MeV, allow remote sensing of the CME-initiated shock location and strength as it travels into the heliosphere. SEP ion composition measurements make it possible to distinguish between electron and heavy ion-rich flare-accelerated particles and solar wind particles accelerated at the interplanetary shock. The lowest energy SEP ions also provide information on the ambient suprathermal ion “seed” populations that may feed the higher energy SEP production at the CME related shocks. With the plasma ion composition measurements from PLASTIC (Galvin et al., 2008), and the radio and plasma waves investigation S/WAVES (Bougeret et al., 2008), opportunities exist for in-situ plasma microphysics diagnostics on local shock structures and waves, as well as comparisons of radio remote sensing and SEP remote sensing of coronal shocks. The seven IMPACT instruments and their measurements are summarized in Table 5.

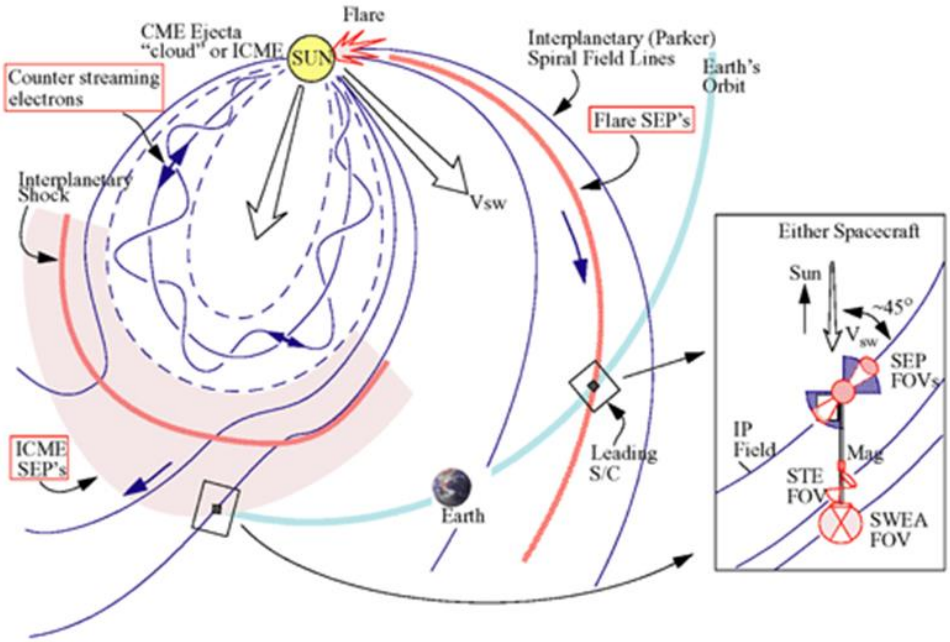


Figure 1. Illustration of the interaction of a flux rope-like interplanetary CME (ICME) structure inferred from pre-STEREO measurements with the ambient solar wind. Counterstreaming suprathermal electron beams within the ejecta have been used to deduce its structure and size. An interplanetary shock is formed when the ejected mass of plasma and field moves sufficiently fast with respect to the ambient solar wind ahead. This shock often is a source of solar energetic particles that race ahead of it along the spiral interplanetary field lines to arrive at 1 AU well before the ICME and shock. The inset shows how the instruments of the IMPACT investigation on STEREO, described later in the text, are configured to make in-situ measurements of the structures and particle populations in this picture at each spacecraft location

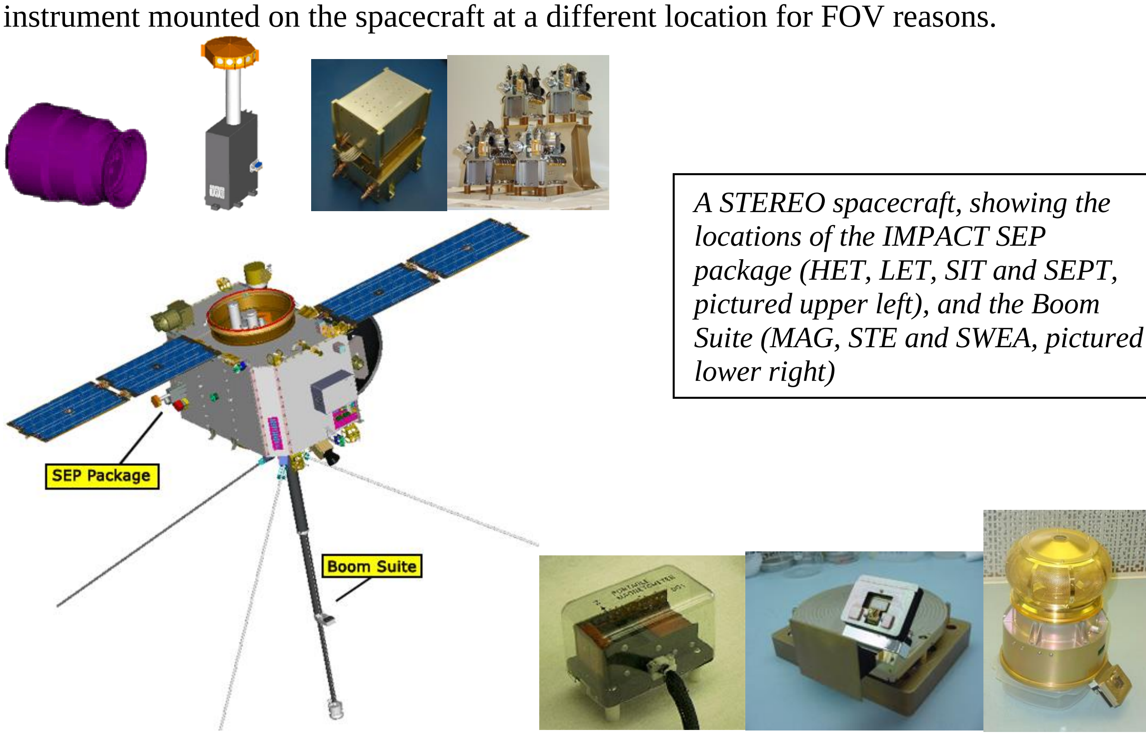
Table 5. IMPACT instruments and measurements

Experiment	Instrument	Measurement	Energy or Mag. field range	Time Res.
SW	STE	Electron flux and anisotropy	2-100 keV	10 s
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	~0-3 keV	3D=30s 2D=8s Moment.2s
MAG	MAG	Vector field	±500nT, ±65536 nT	1/8 s
SEP	SIT	He to Fe ions	0.03-5 MeV/nuc	30 s
		^{3}He	0.3-0.8 MeV/nuc	30 s
	SEPT	Diff. electron flux	30-400 keV	1 min
		Diff. proton flux	60-7000 keV	1 min
		Anistropies of e,p	As above	1 min

	LET	Ion mass numbers 2-28 & anisotropy	2-40 MeV/nuc	1 min.
		^{3}He ions flux & anistropy	2-15 MeV/nuc	1 min.
		H ions flux & anistropy	2-13 MeV	1 min.
	HET	Electrons flux	1-6 MeV	1 min.
		H	13-100 MeV	1 min.
		He	13-100 MeV	1 min.
		^{3}He	15-60 MeV/nuc	1 min

3.1.2 Instrument Description

The IMPACT Investigation (Luhmann et al., 2008) consists of 7 instruments provided by a multi-institutional, international team: SWEA (Solar Wind Electron Analyzer); STE (Suprathermal Electron Telescope); MAG (Magnetometer); SEPT (Solar Electron Proton Telescope); SIT (Suprathermal Ion Telescope); LET (Low Energy Telescope); HET (High Energy Telescope). These instruments are all described in detail in the Space Science Reviews 2008 special STEREO issue 'The STEREO Mission' (ed. C.T. Russell, 2008) The first three are located on the IMPACT boom/mast that extends a total of 4.5 meters antisunward on each spacecraft. (MAG is 3 meters from the spacecraft, SWEA is at the end of the boom, at 4.5 meters). The latter four instruments make up the SEP subsystem which is mounted on the spacecraft body. The SEP instruments are packaged together except for a part of the SEPT instrument mounted on the spacecraft at a different location for FOV reasons.



A STEREO spacecraft, showing the locations of the IMPACT SEP package (HET, LET, SIT and SEPT, pictured upper left), and the Boom Suite (MAG, STE and SWEA, pictured lower right)

Figure 2. IMPACT locations

Solar Wind Plasma Electron Analyzer (SWEA)
SWEA (Sauvaud et al., 2008) is an electrostatic analyzer, originally designed to measure the distribution function of the solar wind electrons from below an eV to several keV, with high spectral and angular resolution over practically the full spherical range. SWEA consists of a hemispherical top-hat electrostatic analyzer (ESA) that provides a 360 deg. field of view in a plane, combined with electrostatic deflectors to provide nearly 4 pi coverage when SWEA is mounted at the end of the STEREO boom. The inner plate radius is 3.75 cm and the plate separation is 0.28 cm. The resulting energy resolution dE/E is 18%, and the geometric factor is 0.01 cm2 ster E (eV). SWEA compensates for the effects of spacecraft potential on the lowest energy particles by having an outer hemisphere that can be biased according to the plasma density measured by the PLASTIC solar wind ion instrument (Galvin et al., 2008). However, soon after commissioning it was discovered that permanent charging of an internal surface prevented accurate measurement of the electrons below ~45 eV (Fedorov et al., 2011). The important suprathermal electron function has remained intact. This capability allows the measurement of anisotropies used to diagnose the topology and connectivity of the local magnetic fields, including those during the passage of CME generated disturbances, when the interplanetary field rotates far out of the ecliptic plane.

Suprathermal Electron Telescope (STE)
STE (Lin et al., 2008) is an electron telescope that covers electrons in the energy range ~2-20 keV, which are present as a superhalo on the solar wind electrons, and as CME shock-accelerated, or flare-accelerated populations extending beyond the SWEA energy range. STE utilizes passively cooled silicon semiconductor devices (SSDs) which measure all energies simultaneously. The STE consists of two arrays of four SSDs in a row, each ~0.1 cm^2 area and ~500 microns thick. Each array looks through a rectangular opening that provides a ~20X80 degree field of view for each SSD with the 80 degree direction perpendicular to the ecliptic. Adjacent FOVs are offset for a total FOV of ~80X80 degrees. The two arrays, labeled STE-U for upstream-directed, and STE-D for downstream-directed, are mounted back-to-back - looking in opposite directions, centered about 25 deg. from the average Parker Spiral field direction. STE is located just inboard of SWEA on the STEREO boom to clear its field of view and remain in shadow. After commissioning, it was found that STE-U could not produce usable measurements due to sunlight contamination from unforeseen sources of glint in its FOV. STE-D has operated since the beginning of the mission, providing information on electrons in this energy range

Magnetometer (MAG)
The IMPACT MAG magnetometer system (Acuña, et al., 2008) is a simplified version of the magnetometers flown on Mars Global Surveyor and Lunar Prospector. It is a tri-axial flux gate design that is mounted on the STEREO ~4m boom just inboard of the SWEA and STE instruments. The flux gate sensors use a ring core geometry, with magnetic cores consisting of molybdenum alloy. The units are compact, low power, and ultra-stable. To optimize sensitivity at the low field values to be found in interplanetary space, the magnetometer dynamic range is divided into 8 ranges that are automatically switched whenever the field being measured exceeds a predetermined level. In its usual heliocentric orbit operations, the MAG measures fields up to 500 nT.

Solar Electron Proton Telescope (SEPT)

SEPT (Müller-Mellin, et al., 2008) consists of two dual, double-ended magnet/foil solid state detector particle telescopes that cleanly separate and measure electrons in the energy range 20-400 keV and protons from 20-7000 keV, while providing anisotropy information through use of several fields of view. Each SSD detector in SEPT is 300 microns thick and 0.53 cm2 in area. A rare-earth permanent magnet is used to sweep away electrons for ion detection, while a parylene foil transmits electrons but stops protons. SEPT is divided into two pieces for field-of-view reasons. The SEPT-E telescope is housed with the rest of the SEP Package on the body of the spacecraft. It looks in the ecliptic plane along the Parker Spiral magnetic field direction, both forward and backward. SEPT-N/S is housed separately at a different spacecraft location, and looks out of the ecliptic plane perpendicular to the nominal magnetic field, both north and south. The viewing cones for the SEPT telescopes are each ~60 degrees.

Suprathermal Ion Telescope (SIT)

SIT (Mason et al., 2008) is a time-of-flight ion mass spectrometer that measures elemental composition of He-Fe ions over the energy range ~30 keV/nucleon to 2 MeV/nucleon. The Field of View angles are 17X44 degrees, with the 44 deg angle in the ecliptic plane, centered ~60 deg from the spacecraft-Sun line to avoid sunlight while still intercepting insignificant numbers of Parker Spiral field controlled energetic ion fluxes The telescope analyzes ions that enter through thin entrance foils and stop in a solid state detector. A time-of-flight approach for determining the composition utilizes start and stop times obtained from secondary electrons entering a microchannel plate system. The MCP and SSD areas are each 6.0 cm^2. The SIT geometric factor allows study of even small SEP events.

Low Energy Telescope (LET)

LET (Mewaldt et al., 2008) is a special double-fan arrangement of 14 solid state detectors designed to measure protons and helium ions from ~1.5 to 13 MeV/nucleon, and heavier ions from ~2 to 30 MeV/nucleon. LET uses a standard dE/dx vs. E technique, identifying particles that stop at depths of ~20-70 microns and ~70-2000 microns corresponding to two general energy ranges. The large field of view spans from 20 deg above to 20 deg below the ecliptic plane, and extends 65 deg to either side of the forward and backward Parker Spiral field directions in the ecliptic plane. LET's large geometric factor also ensures the detection of even small SEP events.

High Energy Telescope (HET)

HET (von Rosenvinge et al., 2008) also uses the solid state detector, dE/dx vs. E approach, but in a six-detector, more traditional linear arrangement designed to measure protons and helium ions to 100 MeV/nucleon, and energetic electrons to 5 MeV. HET identifies particles that stop at depths of 1 to 8 mm in the detectors. Some information is also obtained on heavier nuclei up through Fe using the dE/dx vs E signatures and ranges together, and penetrating particles are analyzed. HET's field of view covers a 47.5 degree cone around the Parker Spiral field direction.

3.1.3 Instrument Observation Requirements

Table 6. IMPACT Observation Requirements

Experiment	Instrument	Measurement	Energy or Mag. field range	Time Res.
SW	STE	Electron flux and anisotropy	2-100 keV	10 s
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	~0-3 keV	3D=30s 2D=8s Moment.2 s
MAG	MAG	Vector field	±500nT, ±65536 nT	1/8 s
SEP	SIT	He to Fe ions	0.03-5 MeV/nuc	30 s
		^{3}He	0.3-0.8 MeV/nuc	30 s
	SEPT	Diff. electron flux	30-400 keV	1 min
		Diff. proton flux	60-7000 keV	1 min
		Anistropies of e,p	As above	1 min
	LET	Ion mass numbers 2-28 & anisotropy	2-40 MeV/nuc	1 min.
		^{3}He ions flux & anistropy	2-15 MeV/nuc	1 min.
		H ions flux & anistropy	2-13 MeV	1 min.
	HET	Electrons flux	1-6 MeV	1 min.
		H	13-100 MeV	1 min.
		He	13-100 MeV	1 min.
		^{3}He	15-60 MeV/nuc	1 min

The table above reflects the original design delivered for launch. IMPACT's in-situ instruments operate in a generally passive mode, with occasional uploading of on-board table updates and calibration factors for quantities computed before data transmission to the ground, including the Beacon data products.

Beacon data are produced at the STEREO Science Center (SSC) where final processing and correction steps are made using software provided by, and updated by, the IMPACT team. These data provide access to near realtime solar wind electron, interplanetary magnetic field, and SEP quantities particularly useful for space weather predictions and predictive modeling. The 1-min averaged IMPACT beacon data are listed in the table below.

IMPACT Beacon Data at Launch

Beacon Data from IMPACT include the following:

MAG:
B vectors in nT, 6 samples/minute in spacecraft coordinates. Beacon Data Processing software transforms the data into other coordinate systems as well (e.g. STEREO Solar Orbital and HGRTN).

STE:
For STE-U:
Solar electron fluxes at 5 (modifiable) energies at 1 sample/minute.
Non-solar electron fluxes at 5 energies at 1 sample/minute.
For STE-D:
Electron fluxes at 5 energies at 1 sample/minute.
Units $\#/cm^2/s$

SWEA:
Moments calculated from 2 second integration once per minute. Moments include:
Electron density in $cnts/cm^3$
Electron bulk velocity in km/s (in STEREO Solar Orbital and HGRTN)
Electron pressure tensor in eV/cm^3
Electron heat flux vector in $eV/cm^2/s$ (in STEREO Solar Orbital and HGRTN)

Pitch Angle Distributions (with respect to B field) at 2 (modifiable) energies in 12 look directions once per minute, units $cnts/cm^2/s$

SEP:
SEP status
Note: For all SEP fluxes, units are $1/cm^2$-s-ster-MeV or $1/cm^2$-s-ster-Mev-nucleon.
In addition all SEP quantities given in raw counts for statistical analysis

SEP-SEPT:
Electron flux at 2 energies in 4 look directions averaged over 1 minute.
Electron flux at 2 energies summed over 4 look directions averaged over 1 minute.
Ion flux at 2 energies in 4 look directions averaged over 1 minute.
Ion flux at 2 energies summed over 4 look directions averaged over 1 minute.

SEP-LET:
Proton flux at 1 energy in 2 look directions averaged over 1 minute.
Proton flux at 2 energies summed over all look angles averaged over 1 minute.
He flux at 2 energies in 2 look directions averaged over 1 minute.
He flux at 1 energy summed over all look angles averaged over 1 minute.
3He flux at 2 energies summed over all look angles averaged over 1 minute.
CNO flux at 3 energies summed over all look angles averaged over 1 minute.
Fe flux at 4 energies summed over all look angles averaged over 1 minute.

SEP-HET:
Electron flux at 1 energy averaged over 1 minute.
Proton flux at 3 energies averaged over 1 minute.
He flux at 3 energies averaged over 1 minute.
CNO flux at 2 energies averaged over 1 minute.
Fe flux at 1 energy averaged over 1 minute.

SEP-SIT:
HE flux at 4 energies averaged over 1 minute.
CNO flux at 4 energies averaged over 1 minute.
Fe flux at 4 energies averaged over 1 minute.

IMPACT (in general):
Instrument status.

3.1.4 Instrument Observation Capabilities

Table 7. IMPACT observation capabilities

Experiment	Instrument	Measurement	Energy or Mag. field range	Time Res.
SW	STE	Electron flux and anisotropy	2-100 keV	10 s
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	50eV-3 keV	3D=30s
MAG	MAG	Vector field	±500nT, ±65536 nT	1/8 s
SEP	SIT	He to Fe ions	0.03-5 MeV/nuc	30 s
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		H ions flux & anistropy	2-13 MeV	1 min.
	HET	Electrons flux	1-6 MeV	1 min.
		H	13-100 MeV	1 min.
		He	13-100 MeV	1 min.
		^{3}He	15-60 MeV/nuc	1 min

The above table reflects the post-launch, post-commissioning state of the IMPACT measurements after, several operational issues modified the original plan in the table in section 3.1.3. STE-U was found to be blinded by sunlight. Subsequently, data return from STE-U was disabled. However, STE-D remains unaffected as it is situated in shadow on the back side of the spacecraft. SWEA thermal electron (<45 eV) measurements were compromised by unforeseen internal charging related to coatings used in the electrostatic system (Fedorov et al., 2011) and the permanent shadowing of the boom instruments by the spacecraft. While this represented a partial loss of functionality, SWEA has consistently produced its planned, nearly 4pi suprathermal electron data throughout the mission.

Because of the issues with STE-U and SWEA, the planned Beacon data quantities were modified as listed in the table below.

IMPACT Beacon Data In Flight

Beacon Data from IMPACT include the following:

MAG:
B vectors in nT, 6 samples/minute in spacecraft coordinates. Beacon Data Processing software transforms the data into other coordinate systems as well (e.g. STEREO Solar Orbital and HGRTN).

STE:
For STE-D:
Electron fluxes at 5 energies at 1 sample/minute.
Units #/cm^2/s

SWEA:
Moments for electron energies above 45eV only calculated from 2 second integration once per minute. Moments include:
Electron density in cnts/cm^3
Electron bulk velocity in km/s (in STEREO Solar Orbital and HGRTN)
Electron pressure tensor in eV/cm^3
Electron heat flux vector in eV/cm^2/s (in STEREO Solar Orbital and HGRTN)

Pitch Angle Distributions (with respect to B field) at 2 (modifiable) energies in 12 look directions once per minute, units cnts/cm^2/s

SEP:
SEP status
Note: For all SEP fluxes, units are 1/cm^2-s-ster-MeV or 1/cm^2-s-ster-Mev-nucleon.
In addition all SEP quantities given in raw counts for statistical analysis

SEP-SEPT:
Electron flux at 2 energies in 4 look directions averaged over 1 minute.
Electron flux at 2 energies summed over 4 look directions averaged over 1 minute.
Ion flux at 2 energies in 4 look directions averaged over 1 minute.

Ion flux at 2 energies summed over 4 look directions averaged over 1 minute.

SEP-LET:
Proton flux at 1 energy in 2 look directions averaged over 1 minute.
Proton flux at 2 energies summed over all look angles averaged over 1 minute.
He flux at 2 energies in 2 look directions averaged over 1 minute.
He flux at 1 energy summed over all look angles averaged over 1 minute.
3He flux at 2 energies summed over all look angles averaged over 1 minute.
CNO flux at 3 energies summed over all look angles averaged over 1 minute.
Fe flux at 4 energies summed over all look angles averaged over 1 minute.

SEP-HET:
Electron flux at 1 energy averaged over 1 minute.
Proton flux at 3 energies averaged over 1 minute.
He flux at 3 energies averaged over 1 minute.
CNO flux at 2 energies averaged over 1 minute.
Fe flux at 1 energy averaged over 1 minute.

SEP-SIT:
HE flux at 4 energies averaged over 1 minute.
CNO flux at 4 energies averaged over 1 minute.
Fe flux at 4 energies averaged over 1 minute.

IMPACT (in general):
Instrument status.

3.1.5 Data Acquisition

As noted above, IMPACT provides data to the STEREO Beacon data set providing near real-time solar wind data. These data are a subset of the full IMPACT data set which is written to the spacecraft's solid state recorder and later downlinked to the ground. The data flow on the ground is summarized in the following figure:

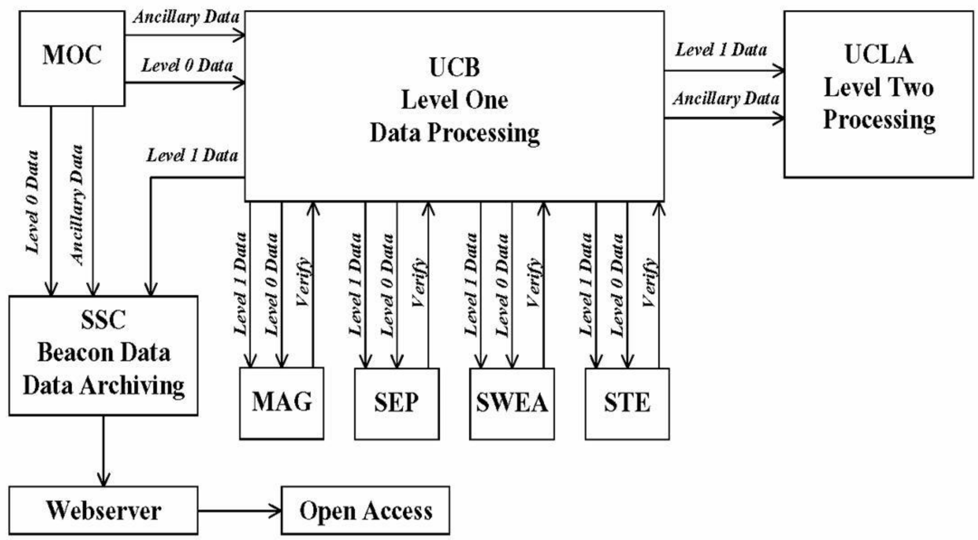

Figure 3. IMPACT data flow

The rates of normal data acquisition for each instrument are noted above. MAG, SWEA and STE can also contribute to "burst" mode data at much higher time resolutions.

The IMPACT burst mode is used to capture high time resolution data during "events," and play it back slowly as part of the IMPACT telemetry system. Instrument modules provide a continuous stream of high time resolution data to the Burst System, which is in a circular RAM buffer. A criterion function based on IMPACT, PLASTIC and S/WAVES data indicates when an event occurs and the event size. The best event over each consecutive three-hour interval is then sent as the next burst. This involves three buffers; one for the transmitting burst event, one for the current best burst event, and one for the current data while looking for a better burst event. Most of the 3 Mbyte RAM is used for these Burst buffers. The buffered burst data include data from 5 min before to 5 min after the sample satisfying the preprogrammed burst criteria. The time resolution of the IMPACT burst mode data is 2 s for SWEA and STE, and 32 Hz (~0.03 s) for MAG. Saved burst data are passed to the Burst System by the instrument modules in the form of CCSDS telemetry packets. Burst data are processed in the IDPU in parallel with the normal SWEA, STE and MAG data, so there is no interruption to the normal Level Zero data stream from IMPACT.

The data are subjected to the burst event criteria computation that is part of the Instrument software. The burst criteria are passed to the Burst System, which uses them to decide what data are kept for transmission. At the time of launch, the burst criteria were set to be a weighted sum of individual burst criteria from MAG, SWEA, STE, PLASTIC, and S/WAVES:

- The MAG criteria required sudden changes in the MAG field vector in the early part of the mission. The criteria now requires sudden changes in the MAG field intensity as of Aug 2009 for STA and May 2009 for STB.
- The SWEA criteria requires sudden changes in the SWEA count rates around 400 eV.
- The STE criteria requires increases in the STE count rate, integrated over energy and direction.
- The PLASTIC criteria requires sudden changes in the computed solar wind velocity vector.
- The S/WAVES criteria requires increases in electric field fluctuation power in selected frequency bands.

These criteria can be reprogrammed after experience is gained with the data.

3.2 PLASTIC

The basic data products from PLASTIC are the composition, distribution functions, and time history of selected solar wind and suprathermal positive ions. Solar wind measurements and identification of structures are possible under nearly all types of solar wind conditions, including high-speed streams, interplanetary CMEs, and slow solar wind.

A PLASTIC Data Center is maintained at UNH. The PLASTIC team has a designated data manager (DM) who is responsible for overseeing the routine processing of data, from the collection of Level-0 data to the production of science-quality data and summary plots.

The Level-1 data is obtained at UNH by applying software that decommutates, decompresses, and, where necessary, re-orders the Level-0 data. The DM is responsible for quality checking the data and recording any irregularities. The Level-1 data contain all of the measurements in raw units. Software and calibration files to convert the data to physical units, along with documentation are delivered electronically to the SSC archive.

The second stage of data processing provides Level-2 and Level-3 products. Level-2 (key parameter data) consists of 1 min to 1 hour summary data sets containing the most frequently used quantities from PLASTIC, such as solar wind ion plasma moments and solar wind proton bulk parameters. Level-3 products result from scientific analyses of the PLASTIC data.

Level-2 processing creates the combined, averaged set of data that is the basis for most scientific research using PLASTIC. Summary data include: solar wind proton density, velocity (speed, flow directions), and kinetic temperatures.

The PLASTIC team maintains a web site at UNH with access to specialized PLASTIC plots and data products. The archival data follows the agreed-upon standards and includes the software used to produce the data, and documentation and software needed to access the data. These data and routines are sufficient for complete public access to the data.

3.2.1 Instrument Measurement Requirements

The PLASTIC L1 mission science requirements based on two STEREO observatories (and hence reference two points separated in longitude), were the following for the prime mission:

Science Objective (MRD, 460-RQMT-001)	**L1 Requirement (MRD, 460-RQMT-001)**
Solar Wind Temperature	Obtain a time series of the solar wind temperature accurate to +/- 10% at two points separated in solar longitude
Solar Wind Density	Obtain a time series of the solar wind density accurate to +/- 10% at two points separated in solar longitude.
Solar Wind Speed	Obtain a time series of the solar wind speed accurate to +/- 10% at two points separated in solar longitude.

PLASTIC provides the solar wind ion bulk parameters (Density, Speed, Kinetic Temperature) for both ambient and transient conditions. The primary ion species constituent of the solar wind is protons (90-99%). The secondary component is alphas. Species with Z>2 constitute about 0.1% of the solar wind ions. Hence for solar wind dynamics, solar wind protons are the primary key parameter to be measured. The temperature, density and speed are determined as moments of the distribution function. Depending on the operational mode, PLASTIC also provides information on pickup ions (particularly helium) and dominant solar wind ions (e.g., iron).

3.2.2 Instrument Description

The PLASTIC sensor is an electrostatic analyzer with time-of-flight measurements (Galvin et al., 2008). The sensor is comprised of three structural elements: Entrance System (Energy/charge Analyzer), Time-of-Flight/Energy (TOF/E) Chamber and its Housing, and the Electronics Box (EBox). The Entrance System selects incident particles for subsequent analysis by their incoming direction and by their energy-per-charge (E/Q) value. The Time- of-Flight/Energy Chamber contains the ion optics, detectors, detector electronics, and the signal processing board. A time of flight measurement is based on start and stop signals. Energy measurement is based on solid state detector (SSD) signals, above a commandable threshold. The Electronics Box contains all of the digital electronics, the remaining analog electronics, the power supplies, and connections to spacecraft power and to the IMPACT Instrument Data Processing Unit (IDPU). (The PLASTIC microprocessor was descoped by the Project.)

The PLASTIC sensor incorporates three distinct entrance apertures, with particular field of view (FOV) and geometrical factor (GF) combinations:

- The *Solar Wind Sector* (SWS) *Small Channel*

- The *Solar Wind Sector* (SWS) *Main Channel*
- The *Suprathermal Ions Wide-Angle Partition Sector* (WAP)

Each FOV/GF is combined with an instrument ion optics section optimized for a particular type of ion population. The PLASTIC *Solar Wind Sector* (SWS) (both channels) provides a 45° field of view in the azimuth (nominally ecliptic) plane, centered on the Sun–spacecraft line, and up to ±20° in elevation (nominally polar) direction through the use of electrostatic deflectors. The two SWS channels have different geometrical factors suited to the high flux solar wind and low intensity solar wind ions, respectively. The Wide-Angle Partition (WAP) covers the regions of the azimuthal plane not covered by the SWS with an elevation FOV of 6° and no deflectors.

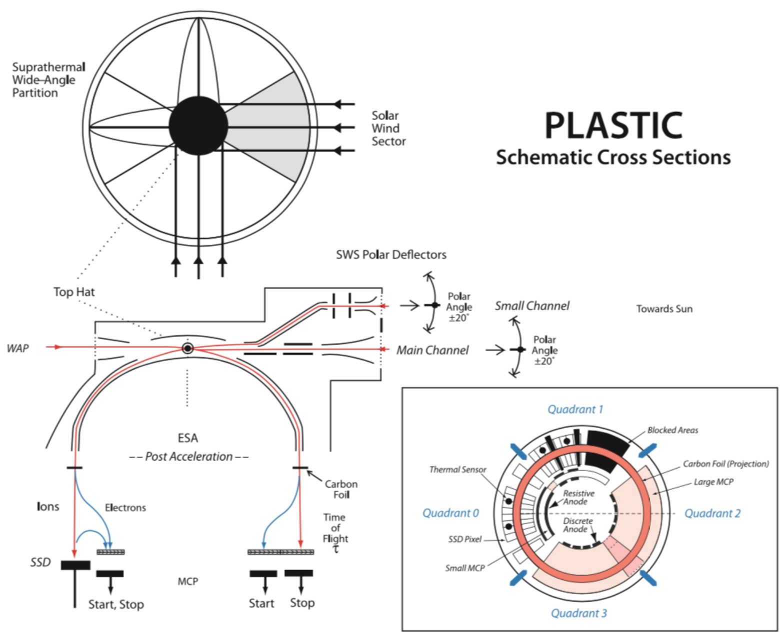

Figure 4. PLASTIC Schematic Cross Sections

The SWS and WAP share a common 360° toroidal top-hat electrostatic analyzer (ESA) with its azimuth entrance in the ecliptic plane. At the detector level, this full circular geometry is subdivided into four 90° quadrants (designated Q0, Q1, Q2, and Q3). Each quadrant has its own 90° annular Micro-channel Plate (MCP). Quadrants Q0 and Q1 have solid state detectors.

Measurements include single rates, coincidence rates (for higher post acceleration voltages), pulse height analysis (for higher post acceleration voltages), and housekeeping.

Coincident rates are commandable to ten different trigger modes, including TOF ‘start’, position, energy.

PLASTIC covers the full azimuthal range (i.e., in the ecliptic plane) at all times, but needs to step through energies-per-charge and polar angles. The polar angle steps from +20 to – 20 degrees in 1.33 degree steps (32 steps). In normal operations mode (mode 3), the ESA voltage is stepped in logarithmic increments in 128 steps. For each E/Q step, the ESA sits at one voltage, while the deflector voltages sweep through their full set of values. Then the ESA voltage continues to the next E/Q step in the cycle. Each deflection step takes 12.8 msec.

Because all solar wind ions flow with approximately the same speed, the E/q selection of the entrance system acts to separate solar wind ions by mass/q. Because the heavy ions are normally not fully ionized, their mass/q is normally larger than 2. Thus the heavy ions are observed at the higher E/q steps than H+, and to some extent, He++. Because there is a large difference in fluxes of H+, He++ and heavy ions, there are two entrance systems for the solar wind ions. One entrance has a large geometric factor, for the low abundance heavy ions, and one entrance has a small geometric factor for higher fluxes, for example, the H+ and possibly He++ ions. At the high E/q steps, where the solar wind heavy ions are observed, the main, large geometric factor, aperture is used. At lower E/q steps, the instrument may switch to the “S-channel” (“small-aperture”) low geometric factor aperture to measure the protons. The E/Q step at which to switch between the two entrance systems is determined by the DPU based on the count rate.

3.2.3 Instrument Observation Requirements

The PLASTIC observational functional requirements defined to meet the original mission L1 science requirements for solar wind (SW) ions are given below.

Table 8. PLASTIC observation requirements

PLASTIC Functional Parameter	**Solar Wind Requirement (c.f. 460-PERFSPEC-005)**
E/Q Measurement Range	0.5-7.5 keV/e (H+, Vp = 310 -1700 km/s) 0.5 – 15 keV/e (He+2, VHe = 220-1200 km/s) 0.5 to 80 keV/e for suprathermal ions
E/Q Bandwidth	< 10% (SW)
Azimuthal FOV	± 20º (SW)
Polar FOV	± 15º (SW)
Angular Resolution	± 5º (SW)
Mass Range Covered	1-56 amu (SW, H-Fe)
M/Q Range Covered	1-20 amu/e (SW)
E/Q Cadence	5 minutes or less (SW protons)

3.2.4 Instrument Observation Capabilities

Table 9. PLASTIC observation capabilities

Primary measurement	Primary Mission	Current (as of 3/2020)
E/Q Measurement Range	0.24 – 88 keV/e	0.24 – 45 keV/e (03/2020)*
E/Q Bandwidth	6%	6%

Azimuthal FOV	± 22.5º (SW)	± 22.5º (SW)
Polar FOV	± 20º (SW, Main E/Q <40 keV/e , reduced for > 40 keV/e)	± 20º (SW, Main E/Q <40 keV/e, reduced for > 40 keV/e)
Angular Resolution	± 2º (SW, polar), ± 5º (SW, azimuth with pulse height analysis)	± 2º (SW, polar), ± 5º (SW, azimuth with pulse height analysis)
Mass Range Covered (solar wind, pickup ions)	1-56 amu (SW, PUI)	Range covered unchanged but SSDs are currently disabled (03/2020)*, pending evaluation. Protons and alphas identified through m/q.
M/Q Range Covered	1-30 amu/e (SW, PUI)	1-30 amu/e (SW, PUI)
E/Q Cadence	1-minute (SW protons)	1-minute (SW protons)
Temperature, Density Accuracy	10 % (Vp > 300 km/s)	±10% (Vp>300), pending evaluation due to higher background contribution (3/2020)*
Speed Accuracy	5%	5%, pending evaluation due to higher background contribution (3/2020)*

* In December 2019, PLASTIC experienced an enhancement in its background rates, attributed to an outgassing incident of unknown origin. This has resulted in an increased load on certain power supplies, creating current increases which have triggered current limiters. Operational modes are being explored that decrease the overall current draw while providing science data (e.g., as of 03/2020 we are testing an operational mode that reduces the upper voltage value of the SWEEPS and turns off the SSDs. As such, the upper E/Q value of the instrument has currently been reduced from 80 keV/e to 45 keV/e, which impacts the suprathermal E/Q range, but not the solar wind ion E/Q range. The disabling of the SSDs has alleviated the current draw on the post acceleration (PAC) power supply, as the SSD power supply resides on top of the PAC supply. This disables the energy measurement used for mass determination. Mass information is not needed for solar wind protons and alphas, but may impact other species.) These reduced operational modes are expected to be modified in the future as the background stabilizes.

3.2.5 Data Acquisition

Telemetry. Telemetry products and product time resolution are commandable, to accommodate different telemetry resource allocations, particularly when the Earth-Spacecraft distance increases.

Sensor Operations. The PLASTIC instrument has six operational modes:

Mode 0: Halt mode, exit from mode 3.
Mode 1: Set DAC registers. Use this mode to read DAC registers from Logic Board RAM and write to DAC board one time.
Mode 2: Run register sequences. Use this mode to read Actel FPGA Register Sequence from Logic Board EEPROM and write to FPGA one time.
Mode 3: Normal science mode.
Mode 4: Retrace mode. Sets up instrument for next sweep.
Mode 5: Read DAC registers. Use this mode to read DAC registers from DAC board and store in Logic Board RAM one time.

Sensor Event Logic. The PLASTIC instrument has ten event selection modes, including criteria on time-of-flight signals, energy signals, and position signals.

Telemetry Data Products. PLASTIC has five telemetry modes: Science mode, Engineering mode, Memory Dump, Proton Mode (subset of Science), and Uncompressed Proton Mode. Normal data products are in the Science Telemetry mode.

The level 1 data are described in the PLASTIC Level 1 Data Document (available from the SolarSoft library). APIDs are the following:

300-36F	PLASTIC	
312	Raw Messages	PLASTIC
313	Digital Housekeeping	PLASTIC
315	Raw PHA Events	PLASTIC
316	Monitor Rates Normal	PLASTIC
317	Monitor Rates Hi-Resolution	PLASTIC
318	PLASTIC Memory Dump	PLASTIC
319	Matrix Rate Heavy Ion overhead data	PLASTIC
31A	Matrix Rate Z>2 H (block 20)	PLASTIC
31B	Matrix Rate Z>2 H (block 21)	PLASTIC
31C	Matrix Rate Z>2 L (block 22-29)	PLASTIC
31D	Matrix Rate Z>2 L (block 2A-2E)	PLASTIC
31E	Matrix Rate WAP-SSD_TCR	PLASTIC
31F	Matrix Rate WAP-SSD_DCR	PLASTIC
320	Matrix Rate WAP-noSSD_DCR	PLASTIC
321	Matrix Rate SW_Priority_Rates	PLASTIC
322	Matrix Rate WAP_Priority-SSD	PLASTIC
323	Matrix Rate WAP_Priority-noSSD	PLASTIC
324	Matrix Rate SW-All / H-Alpha	PLASTIC
325	Matrix Rate SW-H(Doubles) / H+ Peak	PLASTIC
326	Matrix Rate SW-Alpha(Doubles) / H++ Peak	PLASTIC
327	Matrix Rate SW-Alpha(Triples) / H++ TCR	PLASTIC
370-37F	PLASTIC Beacon	
370	Beacon	PLASTIC
200	IMPACT shared housekeeping	IMPACT

Level 2 and Level 3 products are described in the PLASTIC Level 2 Data Document and PLASTIC Level 3 Data Document, respectively, also available from the SolarSoft library.

Table 10. PLASTIC Data Products Flow and Delivery

Data Type	**Processing Time (Location)**	**Data Format**
Check & verify Level-0, catalog	<3 hours (UNH)	Packet
Level-1 processing	24 hours (UNH)	
Transfer Level-1 data, software, and documentation to SSC archive	+1 month (UNH)	Text [ASCII]

Data [binary]		
Process Level-2 (summary database)	3 months (UNH)	
Transfer Level-2 data products to SSC archive	+1 month (UNH)	Text [ASCII]
Data [binary]		
Create Level-3 value-added products	Science driven (UNH & elsewhere)	

3.3 SECCHI Suite

The telescopes in the SECCHI Instrument Suite are capable of taking extreme ultraviolet (EUV) emission images of the chromospheric disk and in the low corona, and of taking Thomson-scattered (TS) visible light images in the low corona, the upper corona and the interplanetary medium. The intensity measurements of the EUV emission images are related to the density along the line of sight (LOS) and the temperature of the solar structures on the solar disk and in the low corona. The total brightness measurements of the TS visible light images are related to the density along the LOS in the coronal and heliospheric regions. The visible light signal is the sum of the Thomson-scattered light from electrons, light scattered by dust, starlight, and instrumental straylight.

To determine the origins of CMEs and solar wind acceleration, the SECCHI Instrument Suite measures solar features on the chromospheric disks. These features include solar prominences, coronal holes, coronal loops, solar active regions, and X-ray bright points. The SECCHI Instrument Suite observes the emissions of solar plasma over an overall temperature range of at least 0.08 to 2.8 10^6 K.

3.3.1 Instrument Measurement Requirements

Table 11. SECCHI measurement requirements

Science Objective	**L1 Measurement Requirement & ID**	**Instrument Requirement**
CME Initiation Time	Determine the CME initiation time to an accuracy of order 10 minutes (**1A**)	(EUVI) Take a series of sun-centered EUV images in the low corona (COR1) Take a series of sun-centered white light images from 1.3 to 3 Rs
CME Initiation Location	Determine the location of CME initiation to within +/- 5º of solar latitude and longitude (**1B**)	(EUVI) Take a series of sun-centered EUV images in the low corona from two vantage points

		(COR1) Take a series of sun-centered white light images from 1.3 to 3 Rs from two vantage points (COR2) Take a series of sun-centered white light images from 3 to 15 Rs from two vantage points
CME Mass	Determine the evolution of the CME mass distribution and the longitudinal extent to an accuracy of +/- 5º as it propagates in the low corona, the upper corona and the interplanetary medium (**2C**)	(EUVI) Take a series of sun-centered EUV images in the low corona from two vantage points (COR1) Take a series of sun-centered white light images from 1.3 to 3 Rs from two vantage points (COR2) Take a series of sun-centered white light images from 3 to 15 Rs from two vantage points (HI1) Take a series of sun-centered white light images from 15 to 80 Rs from two vantage points (HI2) Take a series of sun-centered white light images from 80 to 215 Rs from two vantage points
CME and MHD Shock Speed	Determine the CME and MHD shock speeds accurate to +/- 10% as it propagates in the low corona, the upper corona and the interplanetary medium (**2D**)	
CME and MHD Shock Direction	Determine the CME and MHD shock direction to within +/- 5º of latitude and longitude as the CME evolves in the low corona, the upper corona and the interplanetary medium (**2E**)	
Solar Wind Speed	Obtain a time series of the solar wind speed accurate to +/- 10% at two points separated in solar longitude (**4J**)	(HI2) Take a series of sun-centered white light images from 80 to 215 Rs from two vantage points

3.3.2 Instrument Description

The SECCHI payload is described in detail in Howard et al. 2008. It comprises five telescopes summarized in Table 12 and their data acquisition modes are discussed in Section 3.2.5.

Table 12. Top level description of the SECCHI instrument payload

Name	Instrument Type	Parameters Measured
Extreme Ultraviolet Imager (EUVI)	Normal incidence EUV telescope (Ritchey-Chrétien)	Images of the solar disk and low corona to +/- 1.7 Rs in four wavelength bands (He II 30.4 nm, Fe IX 17.1 nm, Fe XII 19.5 nm, Fe XV 28.4 nm), using a 2048x2048 CCD detector with 1.6 arc sec pixels
Inner Coronagraph (COR1	Internally occulted refractive coronagraph	White light images of total and polarized brightness of the corona from 1.1-4 Rs, using a 2048x2048 CCD detector with 3.75 arc sec pixels

Outer Coronagraph (COR2)	Externally occulted coronagraph	White light images of total and polarized brightness of the corona from 2.4-15 Rs using a 2048x2048 CCD detector with 14.7 arc sec pixels
Heliospheric imager -1 (HI1-)	Wide-field telescope	White light images of total brightness of the corona/inner heliosphere 3.98º –23.98º from Sun center using a 2048x2048 CCD detector with 35 arc sec pixels
Heliospheric imager -2 (HI-2)	Wide-field telescope	White light images of total brightness of the heliosphere 18.68º –88.68º from Sun center using a 2048x2048 CCD detector with 2 arc min pixels

3.3.3 Instrument Observation Requirements

The observation requirements and capabilities for each SECCHI instrument are presented in the following tables.

Table 13. EUVI Instrument Observation Requirements and Capabilities

		Capability	
Instrument Parameter	**Requirement**	**Prime Mission**	**Current**
FOV	≥ 0.90º	0.91º	0.91º
Spatial Resolution (arcsec)	≤ 4.0	2.53	2.53
Array Size	2048 x 2048	2048 x 2048	2048 x 2048
Exposure time (sec)	0.8-7 (17.1 nm) 0.1-10 (19.5 nm) 8-25 (28.4 nm) 3-18 (30.4 nm)	4 (17.1 nm) 16 (19.5 nm) 32 (28.4 nm) 4 (30.4 nm)	8 (17.1 nm) 8 (19.5 nm) 32 (28.4 nm) 4 (30.4 nm)
Acquisition Time (sec) [incl. exposure, readout, and compression]	≤ 16 (17.1 nm) ≤ 19 (19.5 nm) ≤ 50 (28.4 nm) ≤ 43 (30.4 nm)		
Bandpass (nm)	17.1, 19.5, 28.4, 30.4	17.1, 19.5, 28.4, 30.4	17.1, 19.5, 28.4, 30.4

Table 14. COR1 Instrument Observation Requirements and Capabilities

		Capability	
Instrument Parameter	**Requirement**	**Prime Mission**	**Current**
FOV	≥ 2.13º		
Inner FOV cutoff	≤ 1.45	1.4	1.,4
Spatial Resolution (arcsec)	≤ 15.5	7.5	7.5

Array Size	1024 x 1024	1024 x 1024	1024 x 1024
Exposure time (sec)	0.1-10	1.7	2.1
Acquisition Time (sec) [incl. exposure, readout, and compression]	≤ 18.5 (pB seq)		
Instrumental Background (MSB)	$\leq 1.0 \times 10^{-6}$	5.0×10^{-7}	
Bandpass (nm)	650-660	650-660	650-660
Polarization Angles for pB Image	-60º, 0º, 60º	-60º, 0º, 60º	-60º, 0º, 60º
Polarization Angles for total B Image	0º, 90º	0º, 90º	0º, 90º

Table 15. COR2 Instrument Observation Requirements and Capabilities

		Capability	
Instrument Parameter	**Requirement**	**Prime Mission**	**Current**
FOV	≥ 8º	8º	8º
Inner FOV cutoff (Rs)	≤ 2.8	2.5	2.5
Spatial Resolution (arcsec)	≤ 35.2	14.7	14.7
Array Size	2048 x 2048	2048 x 2048	2048 x 2048
Exposure time (sec)	2-8	6	6
Acquisition Time (sec) [incl. exposure, readout, and compression]	≤ 58 (pB seq)	11	11
Instrumental Background (MSB)	$\leq 2 \times 10^{-11}$	9×10^{-12}	9×10^{-12}
Bandpass (nm)	650-750	650-750	650-750
Polarization Angles for pB Image	-60º, 0º, 60º	-60º, 0º, 60º	-60º, 0º, 60º
Polarization Angles for total B Image	0º, 90º	0º, 90º	0º, 90º

Table 16. HI 1 Instrument Observation Requirements and Capabilities

		Capability	
Instrument Parameter	**Requirement**	**Prime Mission**	**Current**
FOV	≥ 20º	20º	20º
Spatial Resolution (arcsec)	≤ 141	70	70
Array Size	1024 x 1024	1024 x 1024	
Exposure time (sec)	10 – 25	40	40

Acquisition Time (min) [incl. total exposure, readout, and compression for summed image]	≤ 34	30	30
Instrumental Background (MSB)	≤ 1 x 10^{-13} (15.8 – 80 Rs)	1 x 10^{-14}	1 x 10^{-14}
Bandpass (nm)	630 – 730	630 – 730	630 – 730

Table 17. HI 2 Instrument Observation Requirements and Capabilities

		Capability	
Observation Parameter	**Requirement**	**Prime Mission**	**Current**
FOV	≥ 69.2º	70º	70º
Spatial Resolution (arcsec)	≤ 487	129	129
Array Size	1024 x 1024	1024 x 1024	1024 x 1024
Exposure time (sec)	10 – 25	50	50
Acquisition Time (min) [incl. total exposure, readout, and compression for summed image]	≤ 100	82	82
Instrumental Background (MSB)	≤ 1 x 10^{-14} (80 – 215 Rs)	3 x 10^{-15}	3 x 10^{-15}
Bandpass (nm)	400 – 1000	400 – 1000	400 – 1000

3.3.4 Instrument Observation Capabilities

The capabilities of all SECCHI instruments at the end of the prime mission and currently are compared in Table 13 through Table 17.

3.3.5 Data Acquisition

Before discussing the data acquisition strategy of each SECCHI instrument, it is necessary to explain the on-board data flow for the overall suite. The SECCHI-part of the onboard solid-state recorder (SSR1) is partitioned in two sections; the larger partition (SSR1) holds the synoptic data while a smaller partition, SSR2, acts as an event buffer where high-cadence data are stored and overwritten until an event flag freezes the buffer. SECCHI images flow into three separate streams: (1) synoptic images (the bulk of the data) are stored in SSR1; (2) high-cadence data are stored in SSR2 from EUVI and COR1; (3) highly compressed images from all telescopes are transmitted continuously to the ground via the space weather beacon (SW). Per observing plan, some images are stored in SSR1, others in SSR2 and some go into SW. The images are transferred into the camera electronics where they are compressed, using the ICER algorithm (with varying degrees of compression depending on available telemetry). Other modes are available, such as windowing, summing, or lossless compression as discussed for each instrument below.

The EUVI (Wuelser et al. 2004) observes the chromosphere and low corona in four different EUV emission lines between 17.1 and 30.4 nm. The images record the emission over the full disk and up to 1.7 Rs off-limb. The synoptic cadence currently is 2.5 min (19.5 nm), 10 min (30.4 nm) and 2 hours (17.1 nm, 28.4 nm). High cadence data is stored in SSR2 as follows: 75 sec (17.1 nm), 5min (30.4 nm, 28.4 nm), no 19.5 nm. Beacon images (SW) are formed and transmitted in 19.5 nm at 10 min cadence and in 30.4 nm (since May 2017) at 2 hour cadence. The cadence of the EUVI images varies during the mission depending on the available telemetry. EUVI records a set of lossless images in the four wavelengths once daily.

COR1 (Thompson et al. 2003) observes the off-limb white light corona around the solar disk from 1.4 to 4 Rs. The instrument acquires only polarized images since the polarizer is always in the beam. The standard operation for the majority of the mission is a sequence of three images at −60◦,0◦, and +60◦ (pB sequence). All three images are transmitted to the ground and then combined to produce total and polarized brightness images for further analysis. The synoptic cadence for each triplet is 5 mins. Currently COR1 acquires only ‘double’ images, which are the sum of two images at 0◦ and +90◦ taken in rapid succession and summed on chip. These correspond to a total brightness image. The images are taken at 10 min cadence, binned to 512x512, ICER compressed, and transmitted to ground. COR1 images are also taken at 5-min cadence in SSR2

COR2 (Howard et al. 2008) observes the off-limb white light corona around the solar disk from 2.5 to 15 Rs. Similar to COR1, COR2 acquires only polarized images. COR2 ‘double’ images are obtained at 15-min cadence interrupted by a pB sequence once an hour. To reduce stray light, the double image is the sum of 3 images at 0º and 3 images at 90º, each at 2-sec exposure, collected on-chip. The total exposure is 6 sec. all ‘double’ images are stored in SSR1 and a copy is further compressed and transmitted through the SW beacon.

HI-1 (Eyles et al. 2009) observes the outer corona and heliosphere over the ram (anti-ram) spacecraft side for STEREO-A(-B), respectively, from 4° to 24° elongation. Because of the very weak science signals, the HI-1 images are sums of 30 individual 40-sec exposures. The exposure duration is 30 min and the cadence is 40 min. The images are summed on a dedicated image buffer to form a 24-bit image, they are lossless compressed and transmitted to the ground. A single 40-sec exposure image is acquired every 2 hours, is highly compressed and transmitted through the SW beacon.

HI-2 (Eyles et al. 2009) observes the outer corona and heliosphere over the ram spacecraft side for STEREO-A and the anti-ram spacecraraft side for STEREO-B, from 20° to 90° elongation. Because of the very weak science signals, the HI-2 images are sums of 99 individual 50-sec exposures. The exposure duration is 82 min and the cadence is 2 hours. The images are summed on a dedicated image buffer to form a 24-bit image, they are lossless compressed and transmitted to the ground. A single 50-sec exposure image is acquired every 2 hours, is highly compressed and transmitted through the SW beacon.

3.4 S/WAVES

The primary institution for S/WAVES science data processing is GSFC. S/WAVES provides a broad range of radio data from 2 kHz to 16 MHz for solar radio bursts and some other sources of radio emission in the solar system.

3.4.1 Instrument Measurement Requirements

Radio spectrometers require that the environment have a low level of electromagnetic interference. In order to determine the source directions of the radio events, knowledge of the spacecraft orientation is required. In general, radio spectrometers don't have other measurement requirements, and STEREO provides all that is needed.

3.4.2 Instrument Description

The S/WAVES instrument includes a suite of state-of-the-art experiments that provide comprehensive measurements of the three components of the fluctuating electric field from ~2 Hertz up to 16 MHz. The instrument has a direction finding or goniopolarimetry capability to perform 3-D localization and tracking of radio emissions associated with streams of energetic electrons and shock waves associated with Coronal Mass Ejections (CMEs). The components of the instrument are the High Frequency Receiver (HFR), the Low Frequency Receiver (LFR), and the Time Domain Sampler (TDS), as described by Bougeret et al., 2008.

3.4.3 Instrument Observation Requirements

The S/WAVES minimal observation requirements are to have access to the data from the 3 antennas with consistent timing for merging of the data. The S/WAVES team has the software that is required for calibrating the data and using the 3 datasets for direction determination of the detected radio bursts.

3.4.4 Instrument Observation Capabilities

The radio emission detected by S/WAVES includes solar radio bursts, which includes the type II radio bursts associated with CME-driven shocks, the type III radio bursts associated with flare accelerated electrons, and some type III storms consisting of many type III bursts, radio emission from Jupiter, and auroral radio emission from Earth when in the same quadrant as Earth. If the radio signals are sufficiently intense, then the differences between the signal levels on the three antennas can be used to determine the direction to the radio source, as well as an estimate of its angular size from STEREO. In situ electrical plasma waves, such as Langmuir waves are also detected by S/WAVES. The component of S/WAVES called the Time Domain Sampler (TDS) can record the amplitude of these waves at time resolutions of as much as 250,000 samples per second. This allows detailed analysis of the plasma waveforms. Another item that S/WAVES can detect, primarily with the TDS, is the change in the spacecraft or antenna photoelectron sheath caused by the impacts of dust particles. The TDS provides useful observations of the dust impacting the spacecraft

3.4.5 Data Acquisition

S/WAVES measures the fluctuation electric field present on three orthogonal monopole antennas mounted on the back (anti-sunward) surface of the spacecraft. Each monopole antenna unit is a 6m long Beryllium-Copper (BeCu) "stacer" spring. The three units deploy from a common baseplate that also accommodates the preamplifier housing. The three electric monopoles are connected to low noise and high impedance preamplifiers located close to the base of the deployment mechanism. This is required to minimize the effect of the base capacity, which can severely limit the sensitivity of the receiver. The data from the preamplifiers is transferred to a digital signal processing unit. Auto-correlations and complex cross-correlations are calculated for the digital data. The resulting calculations are compressed into 12-bit words and sent to the DPU in a compressed floating point format.

4.0 DATA PRODUCTS

4.1 IMPACT Suite Science Data Products

Inst. Name	Parameters Measured [Baseline performance]	Instrument Type	Instrument Status
MAG	Magnetic field vectors in the range +/- 512 nT, with an accuracy of 0.1 nT, at 8 samples/second in normal mode, at 32 samples/second in burst mode	Fluxgate magnetometer	OK
STE	Suprathermal halo/super-halo electron fluxes over electron energies 5 to 100 keV along the nominal interplanetary field direction with at least 1 minute time resolution. Measurements include fluxes, energy spectra, and direction of arrival.	Solid state detector	Since commissioning unable to provide electron measurements in the upstream direction
SWEA	Core (bulk solar wind) and halo (strahl) electron fluxes with a 360 X 60 degree or better field of view at energies 20 to 1000eV, with angular resolution of at least 45 X 45 degrees and 1-minute sampling	Electrostatic analyzer	Since commissioning, unable to reliably measure electron fluxes at energies below 45eV
SEPT	Electron fluxes in the energy range 20-400 keV and proton fluxes from 20-7000 keV along the Parker Spiral magnetic field direction and out of the ecliptic plane perpendicular to the nominal magnetic field. Each detector has a viewing cone angle of about 60 degrees.	Solid state detector	OK
SIT	Elemental composition of He-Fe ions over the energy range ~30 keV/nucleon to 2	Mass spectrometer	

	MeV/nucleon with a field of view of 17X44 degrees		
LET	Proton and helium ion fluences from ~1.5 to 13 MeV/nucleon, and heavier ion fluences from ~2 to 30 MeV/nucleon in a field of view of 40X130 degrees	Solid state detector	
HET	Proton and helium ion fluences to 100 MeV/nucleon, and energetic electron fluences to 5 MeV with a viewing cone angle of 47.5 degrees oriented along the Parker spiral	Solid state detector	

4.1.1 IMPACT Suite Science Data Products Functional Description

Data Level	Data Format	Brief Description	Source
Level 1	CDF	Calibrated, highest time resolution data in scientific units	Berkeley
Level 2	CDF, ASCII	Varies by instruments but is generally either lower time resolution data or data rendered more scientifically useful by additional processing. See table below.	UCLA, Caltech
Level 3	ASCII	Event lists	UCLA

Data Level	MAG	SWEA	STE	SEPT
L1	Calibrated magnetic field vectors at 8Hz for normal data, 32HZ for burst mode	Calibrated electron fluxes at 30s resolution	Calibrated electron fluxes at 10s resolution	Calibrated electron and proton fluxes at 1min resolution
L2	Calibrated magnetic field vectors at lower time resolutions than L1 merged with PLASTIC solar wind parameters	Pitch angle distributions and electron moments at energies above 45eV at 10s resolution	Does not apply	Does not apply

Data Level	SIT	LET	HET
L1	Calibrated ion fluences at 30s resolution	Calibrated ion fluences at 1min resolution	Calibrated election and ion fluences at 1min resolution
L2	Calibrated ion fluxes averaged to lower time resolutions	Calibrated ion fluences averaged to lower time resolutions	Calibrated electron and ion fluences averaged to lower time resolutions

4.1.2 IMPACT Suite Science Data Distribution

Level-1 data are obtained by running the Level-0 data through the calibration and IMPACT data processing software at UCB. The latter are collected by the ODM from each instrument provider prior to launch and updated as necessary. The Level-1 data, together with calibration and basic processing software and documentation are submitted electronically to the SSC archives. The Level-1 data for IMPACT are also referred to as high (time) resolution data, and they contain all of the measurements made by IMPACT instruments, expressed in physical units.

The second stage of data processing occurs at the IMPACT summary data access site at UCLA, which provides Level-2 and Level-3 products and archiving. The Level-2 (“key parameter”) data set consists of synchronized one-minute summary data sets containing the most frequently used quantities (e.g., electron plasma moments, magnetic field, vector components, solar energetic particle fluxes in specific energy ranges, suprathermal electron fluxes versus energy and angle) from IMPACT. (Some higher level PLASTIC data are also available at UCLA, as detailed below.) Level-3 products result from basic analyses of the IMPACT data, for example shock identifications and characterizations. The timeline for data processing is provided in Table 18.

Table 18. IMPACT Data Products Flow and Delivery

Data Type	Processing Time (Location)	Data Format
Check & verify Level-0, catalog	<3 hours (UCB)	Packet
Run calibration on Level-0 to Level-1	24 hours (UCB)	
Transfer Level-1 data, software, and documentation to SSC archive	2 months (UCB)	Text [ASCII] Data [binary]
Process Level-2 (summary database)	2.5 months (UCLA)	
Transfer Level-2 products to SSC archive	2.5 months (UCLA)	Text [ASCII] Data [binary]

Create Level-3 value-added products	3 months (UCLA)	
Transfer Level-3 products to SSC archive	3 months (UCLA)	Text [ASCII] Data [binary]

Open access to the Level-2 summary data, which is the workhorse for most scientific research, is through the existing UCLA data display and dissemination system (www-ssc.igpp.ucla.edu[1]). Specialized data products and displays are accessed through hyperlinked instrument provider web sites. These data are also available in CDF format from the STEREO Science Center website.

4.2 PLASTIC Science Data Products

Inst. Name	Parameters Measured [Baseline performance]	Instrument Type	Instrument Status
PLASTIC (PLasma And SupraThermal Ion Composition)	Ions in the energy-per-charge range from 0.5 up to 80 keV/e	Electrostatic Analyzer with Time-of-flight/Energy spectrometer	Solar wind proton and suprathermal ions (up to 45 keV/e) available. Remaining science products recovery in progress (03/2020).

4.2.1 PLASTIC Science Data Products Functional Description

The basic data products from PLASTIC are the distribution functions, and time history of the solar wind and suprathermal positive ions. Solar wind measurements and identification of structures are possible under nearly all types of solar wind conditions, including high-speed streams, interplanetary CMEs, and slow solar wind.

Level 1 data are the highest-resolution, complete data set. They have the epoch time and instrument section decommutated, counts decompressed, and entries separated into meaningful products (solar wind proton moment array, reduced proton and alpha distributions, heavy ion species count rate arrays, pulse height data, housekeeping, etc.), but are not fully converted into physical units (such as flux) that require the incorporation of detection efficiencies which may change over the life of the mission (due to gain changes in the detectors). Level 2 data products include the most frequently used quantities from PLASTIC in physical units. Validated Level 2 products currently include solar wind protons, alphas, and selected minor ions. Level 3 data products typically result from directed scientific analysis, and include specific intervals (such as identified ICMEs) and other value-added products. Validated Level 3 products currently include He+ Phase Space Densities, He+ Relative Fluxes, He+ SW Frame Velocity Count Distributions,

[1] The UCLA web server was shut down over security issues in 2019, requiring a migration to a new system. The new system is expected to in operation within the next few months.

and He++ Phase Space Densities. There are also validated Level 3 event lists for Suprathermal Events, Alfven Waves, and Small Transients.

PLASTIC Data Products

Data Level	Sample Filename	Description
L0	plastc_ahead_2020_001_1_05	Time-ordered raw data, with communication artifacts removed
L1	STA_L1_PLA_20200101_001_V10	Science data decommutated and decompressed, but not fully converted into physical units
L1	STA_L1_PLA_HK_20200101_001_V10	Housekeeping data decommutated and decompressed, but not fully converted into physical units
L1	STA_L1_PLA_CL_20200101_001_V10	Raw classifier data decommuted and decompressed
L1	STA_L1_PLA_SC_20200101_001_V10	Spacecraft housekeeping data
L1	ahead_2020_001	All L1 data decommuted and decompressed, but not fully converted into physical units
L2	STA_L2_PLA_1DMax_1min_20190101_ V11 STA_L2_PLA_1DMax_10min_20190101_ V11 STA_L2_PLA_1DMax_1hr_20190101_ V11	Proton bulk parameters derived from 1D Maxwellian fit to a single detector rate (no coincidence required), corrected for background and dead time
L2	STA_L2_PLA_OBMom_1min_20140101_ V02 STA_L2_PLA_OBMom_10min_20140101_ V02 STA_L2_PLA_OBMom_1hr_20140101_ V02	Proton bulk parameters derived from an on-board calculation that computes weighted sums of the proton counts in each energy/angle bin. Ground calibrations are then applied to account for instrument asymmetries not included in the on-board calculation.
L2	STA_L2_PLA_Alpha_RA_1DMax_10min_ 2010_ V02 STA_L2_PLA_Alpha_RA_1DMax_1hr_ 2010_ V02	Alpha bulk parameters derived from 1D Maxwellian fit to a single Coincidence rate
L2	STA_L2_PLA_Iron_Abundance_2hr_2010_ V01	Iron kinetic properties derived from the matrix rates associated with iron. The raw rates are converted into densities using the geometrical factor determined in pre-launch calibrations. The Fe speed and thermal speed are derived from a 1D Maxwellian fit to the dominant peak in the MR09 matrix rate.

L2	STA_L2_PLA_Iron_Q_2hr_20100101_V02	Iron charge state distributions and average charge state derived from the PHA data from the "main channel" accumulated over 2 hours.
L3	STA_L3_PLA_HePlus_24hr_2017_V06	An overview of the long-term behavior of He+ pickup ions, useful for the selection of interesting event periods. The data set provides 24h averages of efficiency corrected He+ counts per second in four ranges of V/Vsw.
L3	STA_L3_PLA_HePlus_F_Vsw_10min_ 20170101_ V06 STA_L3_PLA_HePlus_F_Vsw_01hr_20170101_ V06 STA_L3_PLA_HePlus_F_Vsw_24hr_20170101_ V06	Averages of He+ phase space density as a function of V/Vsw in 51 velocity ranges, where V and Vsw are the particle speed and bulk speed of solar wind protons, respectively.
L3	STA_L3_PLA_HePlus_SW_VelCtDist_5min_20 130101_V02	Pickup-ion (PUI) He+ velocity distributions in the solar wind (SW) frame of reference.
L3	STA_L3_PLA_He2Pl_F_Vsw_01hr_20090101_ V05	Alpha particle (He2+) phase space densities (PSD) in the spacecraft frame of reference as a function of V/Vsw in 51 velocity ranges, where V and Vsw are the particle speed and bulk speed of solar wind protons, respectively.
L3	STA_L3_PLA_AlfvenWaveList_V01	The table lists some Alfvén waves observed by the STEREO spacecraft from year 2007 to year 2014. They are identified while searching for small solar wind transients (STs).
L3	STA_L3_PLA_SmallTransientList_V01	Small Transient List
L3	STA_L3_PLA_SuprathermalList_V05	Automatically identified suprathermal proton events measured on the Wide Angle Partition without a Solid State Detector (WAP non-SSD) portion of the STEREO/PLASTIC instrument.

4.2.2 PLASTIC Science Data Distribution

Data Level	Space-craft	Sample Filename	Cadence	Volume (MB)	Dates Released	Form at
L0	STA	plastc_ahead_2020_001_1_05	1 min 5 min	40/day	2007-present	Binary
L0	STB	plastc_behind_2020_001_1_05	1 min 5 min	40/day	2007-10/1/2014	Binary
L1	STA	STA_L1_PLA_20200101_001_V10	1 min 5 min	130/day	2007-present	CDF ASCII
L1	STB	STB_L1_PLA_20200101_001_V10	1 min 5 min	130/day	2007-10/1/2014	CDF ASCII
L1	STA	STA_L1_PLA_HK_20200101_001_V10	1min	4/day	2007-present	CDF ASCII
L1	STB	STB_L1_PLA_HK_20200101_001_V10	1min	4/day	2007-10/1/2014	CDF ASCII
L1	STA	STA_L1_PLA_CL_20200101_001_V10	Variable	1.5/day	2007-present	CDF ASCII
L1	STB	STB_L1_PLA_CL_20200101_001_V10	Variable	1.5/day	2007-10/1/2014	CDF ASCII
L1	STA	STA_L1_PLA_SC_20200101_001_V10	10 sec	1/day	2007-present	CDF ASCII
L1	STB	STB_L1_PLA_SC_20200101_001_V10	10 sec	1/day	2007-10/1/2014	CDF ASCII
L2	STA	STA_L2_PLA_1DMax_1min_20190101_V11 STA_L2_PLA_1DMax_10min_20190101_V11 STA_L2_PLA_1DMax_1hr_20190101_V11	1 min 10 min 1 hr	.4/day	2007-8/2019	CDF ASCII
L2	STB	STB_L2_PLA_1DMax_1min_20190101_V11 STB_L2_PLA_1DMax_10min_20190101_V11 STB_L2_PLA_1DMax_1hr_20190101_V11	1 min 10 min 1 hr	.4/day	2007-9/2014	CDF ASCII
L2	STA	STA_L2_PLA_OBMom_1min_20140101_V02 STA_L2_PLA_OBMom_10min_20140101_V02 STA_L2_PLA_OBMom_1hr_20140101_ V02	1 min 10 min 1 hr	.3/day .1/day .1/day	2007-12/2014	CDF ASCII
L2	STB	STB_L2_PLA_OBMom_1min_20140101_V02 STB_L2_PLA_OBMom_10min_20140101_V02 STB_L2_PLA_OBMom_1hr_20140101_ V02	1 min 10 min 1 hr	.3/day .1/day .1/day	2007-9/2014	CDF ASCII
L2	STA	STA_L2_PLA_Alpha_RA_1DMax_10min_2010_ V02 STA_L2_PLA_Alpha_RA_1DMax_1hr_2010_ V02	10 min 1 hr	.2/month .3/year	2007-12/2010	CDF ASCII
L2	STB	STB_L2_PLA_Alpha_RA_1DMax_10min_2010_ V02 STB_L2_PLA_Alpha_RA_1DMax_1hr_2010_ V02	10 min 1 hr	.2/month .3/year	2007-12/2010	CDF ASCII
L2	STA	STA_L2_PLA_Iron_Abundance_2hr_2010_V01	2 hr	.2/year	2007-12/2010	CDF ASCII

L2	STA	STA_L2_PLA_Iron_Q_2hr_20100101_V02	2 hr	.8/year	2007-7/2011	CDF ASCII
L2	STB	STB_L2_PLA_Iron_Q_2hr_20100101_V02	2 hr	.8/year	2007-7/2011	CDF ASCII
L2	STA	PLA_STA_Iron_QStates_20191015	1 hr	0.3/day	2007-2019	PNG
L3	STA	STA_L3_PLA_HePlus_24hr_2017_V06	24 hr	.04/year	2007-7/2017	CDF ASCII
L3	STA	STA_L3_PLA_HePlus_F_Vsw_10min_ 20170101_ V06 STA_L3_PLA_HePlus_F_Vsw_01hr_ 20170101_ V06 STA_L3_PLA_HePlus_F_Vsw_24hr_ 20170101_ V06	10 min 1 hr 24 hr	20/year 4/year .2/year	2007-7/2017	CDF ASCII
L3	STA	STA_L3_PLA_HePlus_SW_VelCtDist_ 5min_20130101_V02.cdf	5 min	30/year	2007-8/2013	CDF ASCII
L3	STA	STA_L3_PLA_He2Pl_F_Vsw_01hr_ 20090101_ V05	1 hr	4/year	2007-12/2009	CDF ASCII
L3	STA	STA_L3_PLA_AlfvenWaveList_V01	Variable	.06	2007-7/2014	ASCII
L3	STB	STB_L3_PLA_AlfvenWaveList_V01	Variable	.06	2007-5/2014	ASCII
L3	STA	STA_L3_PLA_SmallTransientList_V01	Variable	.04	2007-8/2014	ASCII
L3	STB	STB_L3_PLA_SmallTransientList_V01	Variable	.04	2007-8/2014	ASCII
L3	STA	STA_L3_PLA_SuprathermalList_V06	Variable	.2	2007-2019	ASCII
L3	STB	STB_L3_PLA_SuprathermalList_V05	Variable	.3	2007-9/2011	ASCII

All PLASTIC data products listed above are archived in the SSC. The PLASTIC data policy is to have completely open access to all data, including the calibration data used to process the data.

4.3 SECCHI Suite Science Data Products

Data Level	Data Format	Brief Description	Source
Level-0.5	FITS	Uncompressed images. Values are raw counts (DN). FITS header contains all information in science telemetry plus any ancillary information necessary to interpret the data	NRL POC
Level-1	FITS	Calibration applied “on the fly”. Values are physical units (COR, HI) or calibrated DN (EUVI).	User Workstation using SolarSoft
Level-2	FITS	Data products which are a result of combining 2 or more (non-calibration) images. Includes browse images, movies, polarized Brightness images, Carrington maps, etc. May or may not be calibrated.	User Workstation using SolarSoft or NRL POC
Level-3	FITS	Derived quantities: Electron density, temperature ratios, emission measures, etc.	User Workstation using SolarSoft

Level-4	ASCII	Event lists (CMEs, Comets)	

4.3.1 SECCHI Suite Science Data Products Functional Description

SECCHI science data consist of 2048 x 2048-pixel images which may be 2x2 or 4x4 binned. All of the data are measurements of brightness or luminescence, in digital counts (DN). The science data product is stored and distributed as uncalibrated, uncompressed Flexible Image Transport System (FITS) files, in which a binary data array is preceded by an ASCII header. The contents of the FITS file headers are described in detail in the SECCHI FITS Header Definition and include keywords to indicate instrument attitude and orbit information, all instrument settings associated with the image, information on all onboard and ground processing steps, and image statistics.

Science packets from Level-0 that are recombined into a single file and decompressed to form an image are called Level-0.5 data. At this stage and beyond, the data is formatted as FITS. Individual images and browse movies are available utilizing a standard compression technique (e.g., PNG or MPEG).

The SECCHI Level-0.5 images consist of three types of science data: (1) Emission line intensity images from EUVI at various wavelengths; (2) Total brightness images from HI1 and HI2, which include F-corona, K-corona, and stray light; and (3) Polarized brightness (pB) images, pB component images, and Brightness (B) from COR1 and COR2. Additional calibration FITS images are available such as darks, calibration LEDs, door-closed, and images from various rolls and offpoints.

The SECCHI routine processing for Level-0.5 data consists of those calibration steps that are considered to be well-understood and which are reversible. The images have been oriented to put the spacecraft north, which usually corresponds to ecliptic north, at the top of the image, but no interpolations are done at this Level-0.5 stage. This is currently the primary distributed data product. The remaining calibration steps are available as an Interactive Data Language (IDL) software procedure and library that is freely available as part of SolarSoft (Freeland and Handy, 1998). Data suitable for most scientific analyses is attainable by using the easy-to-use IDL routine SECCHI_PREP. This routine produces calibrated Level-1 FITS files.

Calibration activities for the SECCHI telescopes are now complete. Pointing and flat-fielding (including vignetting) calibrations have been established for all telescopes. Geometric distortion corrections have been implemented for all applicable telescopes (COR2, HI1, and HI2), as have the shutterless readout corrections for HI1 and HI2. Photometric calibrations have been implemented for all telescopes.

One copy of each Level-0.5 FITS image is kept as part of the SECCHI archive until replaced by a superior version (if any)—in other words, the “quick-look” becomes “final” if no new packets are returned. The same procedure is followed for browse products.

4.3.2 SECCHI Suite Science Data Distribution

The SECCHI data policy is to have completely open access to all data, including the calibration data and the procedures to calibrate and further process the data. SECCHI data products are produced at NRL's Payload Operations Center (POC). Community analysis of STEREO observations occurs via the open Internet, with data requested from the SSC and/or NRL. Processing of SECCHI data consists of two major task groups: routine processing and calibration processing. Autonomous routines run continuously at the NRL POC to acquire and process Level-0 housekeeping and science data packets from the MOC. All SECCHI image telemetry data are converted to FITS files upon receipt of version 02 of the Level-0 telemetry files, about 2 days from the date of observation. SECCHI images are available over the open Internet as soon as the routine processing steps have been completed, about 8 hours after receipt of the data packets necessary to form an image. These data are automatically delivered to the SSC from NRL via a daily mirror, where they are available via both the Web and via the Virtual Solar Orbservatory. Data is mirrored to partner institutions in Maryland, California and the UK. Level-1 calibrated data is obtained by applying IDL procedures and auxiliary data to the user's specification. These procedures, calibration files and auxiliary data are updated as necessary throughout the mission and are freely available via Internet access as part of the SolarSoft software library (SSW) and database (SSWDB). Community analysis of STEREO observations occurs via the open Internet, with data requested from the SSC and/or the NRL.

Table 19. SECCHI Data Products Flow and Delivery

Data Type	Duration (Owner)	Data Format
Level-0	2 days (APL)	Packet file
Level-0.5 Pipeline Recombine Level-0 packets into image (Level-0.5)	8 hours (NRL)	FITS
Browse images and movies	--	PNG, MPEG
Catalogue/Database	--	ASCII text -and- Web-accessible MySQL database
Level-1 processing	As needed (anywhere)	FITS files plus IDL routine and libraries
Transfer Level-0.5 data, Level-1 software, and documentation to SSC archive	Daily (GSFC)	FITS, PNG, ASCII, etc.

4.4 S/WAVES Science Data Products

4.4.1 S/WAVES Science Data Products Functional Description

Level-0 data is acquired electronically through automated processes. A knowledgeable person examines the scientific data five days per week. Daily graphical displays give an excellent picture of instrument performance and potentially interesting scientific events. The data processing software is based on the successful object-oriented model created for the Wind/WAVES experiment (https://solar-radio.gsfc.nasa.gov/wind/index.html).

Level-1 data consists of two products: (1) daily summary plots consisting of 24-hour dynamic spectra that is automatically produced; and (2) daily 1-minute averaged data files for each frequency. All of these data, as well as the software tools and documentation to manipulate them, are available for access through the open Internet.

Level-2 data consists of specific time periods containing scientifically interesting events that have been identified, such as Type II/IV radio bursts. Typically, such events should be found within a few days of receipt of the data, and catalogues and representative spectral graphic outputs are generated and published on the web as the events are identified.

Level-3 data consists of further analysis of specific scientifically interesting events. These may include direction finding and tracking of radio bursts, and in situ analysis of plasma wave events.

A rough estimate of the data volume produced by S/WAVES (including all levels described above) is 20 GB per year.

TABLE 6 - S/WAVES Data Products Flow and Delivery

Data Type	Processing Time (Locations)	Data Format
Check Level-0	24 hrs (GSFC)	Packet
Level-1 processing	24 hrs (GSFC)	
Transfer Level-1 data, software, and documentation to SSC archive	1 day (GSFC)	1-minute averages [IDL save sets, ASCII] Daily Summary Plots [PNG, PDF, Postscript] Text (ASCII)
Process Level-2	2 months	
Transfer Level-2 products to SSC archive	2 months	Text [ASCII] Plots [PNG, PDF, Postscript]

4.4.2 S/WAVES Science Data Distribution

The table above gives information about the S/WAVES data distribution. One source of the data is the web site https://solar-radio.gsfc.nasa.gov/ The data are also available from the STEREO

SSC web site and the NASA SPDF. In addition, S/WAVES data is available at the French CDPP site. This site includes radio source direction files. The SWAVES data policy is to have open access to all available data. As soon as the new SWAVES CMAD document is completed, calibration data will also be openly available.

5.0 GROUND SYSTEM

5.1 Ground System Architecture

The STEREO ground system consists of several operations centers which each play a role in the STEREO science mission. These operations centers are distributed across the world and consist of the Mission Operations Center (MOC), four Payload Operations Centers (POCs), the STEREO Science Center (SSC), the Flight Dynamics Facility (FDF), and the Deep Space Mission System (DSMS) which operates the Deep Space Network (DSN). The STEREO ground segment provides the means for these operations centers to perform their individual tasks as well as to communicate necessary data products between centers and the observatories. *Figure 5* depicts the STEREO ground segment teams and interfaces. The STEREO Mission Operations Center is located at the Johns Hopkins University/Applied Physics Laboratory in Laurel, MD, and is the center that operates the observatory bus and serves as the collection and distribution point for the instrument commands and telemetry. The Payload Operation Centers are the instrument operations centers that generate the commands for each of the four STEREO instrument suites and monitor instrument health and safety. These centers are located at the Naval Research Laboratory in Washington, DC; the University of California–Berkeley in Berkeley, CA; the University of Minnesota in Minneapolis, MN; and the University of New Hampshire in Durham, NH. These are the home bases for the instrument POCs, but they are able to operate remotely when necessary and also maintain a presence at the MOC. The SSC, located at the Goddard Space Flight Center in Greenbelt, MD, provides science coordination and serves as the STEREO archive. Also located at GSFC is the Flight Dynamics Facility (FDF), which performs STEREO navigation services. The DSMS is operated by the Jet Propulsion Laboratory in Pasadena, CA, with ground stations in California, Madrid, Spain, and Canberra, Australia.

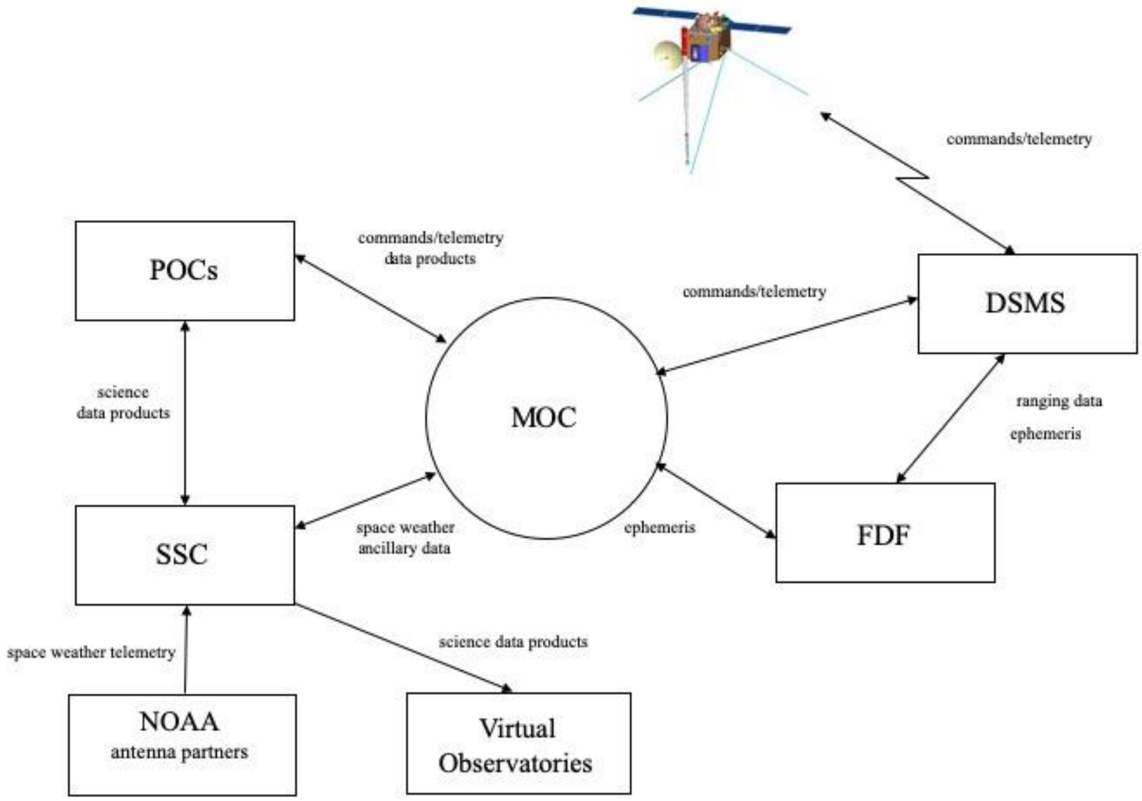

Figure 5. STEREO Ground System Architecture

5.2 STEREO Mission Operations Center

The MOC has the primary responsibility of management of the spacecraft bus including the development of command messages and the uplink to the spacecraft by way of the DSMS. Recovery of spacecraft bus engineering (state-of-health) telemetry and the performance analysis based on this telemetry is also performed at the MOC. The MOC receives instrument command messages from the POCs and, after verification that the command ApIDs are appropriate for the POC they came from, queues these for uplink to the spacecraft based on start and expiration times appended to the command messages by the POC. The MOC does not directly verify any instrument commands and does not decommutate or analyze any instrument telemetry aside from currents and temperatures observed from the spacecraft side of the instruments. Each POC is individually responsible for the health and safety of its instrument. The MOC does control the instrument power and can power off an instrument at the request of the POC. In addition, an instrument can autonomously request to be powered down through the spacecraft fault protection system.

Real-time telemetry from each STEREO spacecraft flow from the spacecraft into the DSMS and are routed through the Restricted IONet to APL on a low-latency delivery path with complete data delivery not guaranteed. These data are flowed to the Ops DMZ network where they can be viewed in real-time by the spacecraft engineering team or the POCS either locally or remotely. The data are stored for several days on the data servers where they can be played back via instant replay in the MOC or across the internet at the request of the POCs. The SSR playback data are recorded at the Central Data Recorder (CDR) at JPL where they are sent to the MOC in half-hour segment Intermediate Data Record (IDR) files over the internet. These data are guaranteed complete and are the data that are used to populate the raw archive and generate Level-0 data. Daily, and upon complete playback of the SSR and MOC receipt of all the IDR files from the CDR, Level 0 data are processed for each of the instrument POCs and the spacecraft housekeeping data. Level-0 data are time ordered with duplicates removed. Each day Level 0 files are produced for the previous day, the preceding day, the day before that, and for 30 days earlier. This allows for the delivery of data that may have resided on the SSR for a few days and it expected that the file from 30 days ago will be final delivery with the complete data for that day. Due to the volume of data in the SECCHI POC partitions, each of these Level 0 files are produced in 4-hour segments where all the other Level 0 files are produced for a 24-hour period. Once generated, the Level 0 files are placed on the STEREO Data Server (with 24 hours from receipt of the IDR files from the DSMS) where they can be retrieved by the POCs and SSC. These files are maintained on the SDS for 30 days, when they can be removed after receipt of the Archived Products List from the SSC indicating that they have retrieved the data.

5.3 STEREO Science Center

The SSC has four primary functions: (1) it is the focal point for archiving STEREO data; (2) it is the processing center for the space weather beacon data; (3) it is the central point for science coordination between the instruments and other spacebased and groundbased campaigns; and (4) it is the focal point for mission-related education, public outreach, and public affairs.

During the mission lifetime and for some period thereafter the data will be considered scientifically useful, and they will be readily available electronically to the public from the SSC. At some point in the future—certainly years and perhaps decades after the end of the mission—the data will be used less frequently by scientists. At that time, the data and software will be transferred to the Permanent Archive designated by NASA Heliophysics MO&DA management. The remote sensing and in situ data being actively delivered to the SSC and SPDF form the major core of what will become the STEREO long term archive.

The SSC archive will include all levels of telemetry data from all sources, mission support data, and software and documentation necessary to manipulate the data. The archive will include data from all phases of the mission. Sources and estimates of data volumes have been described in previous sections.

During the DSMS contacts real-time space weather beacon data are captured by the MOC, electronically transferred to the SSC, and processed at the SSC and made available for use by NOAA's Space Environment Center, the U.S. Air Force (USAF) and the public. Antenna partners cover as much as possible the remaining time when each STEREO observatory is not in contact through DSMS. These antenna partners include international facilities (National Institute of Information and Communication Technology, Koganei, Japan; *Centre National d'Etudes Spatiales*, Toulouse France; Korean Space Weather Center, Jeju, South Korea), educational facilities (Johns Hopkins University Applied Physics Laboratory, Laurel, MD) and even amateur stations (DL0SHF, Kiel-Ronne, Germany; AMSAT-DL/Bochum Observatory, Germany). The data from antenna partners are sent electronically directly to the SSC for further processing and online access.

After the SSR playback, any gaps in the real-time beacon data during the previous 24 hours are filled in from the Level-0 data. The real-time beacon data are displayed graphically and are made available electronically as data files. The data files allow modelers of space environment conditions to have "live" data streams for input into their prediction algorithms. The beacon data are automatically generated from the data stream using decommutation algorithms provided by the instrument teams. These data should be considered "quick-look" quality since they are based on preliminary calibrations and are not be routinely checked for accuracy. They may even be subject to revision without notice, so the STEREO space weather beacon realtime data should only be cited with appropriate qualifiers.

A browse archive of the STEREO space weather beacon data is maintained at the SSC for the life of the mission. The beacon browse archive is generated from the Level-0 packets. The archive is designed to allow researchers to select interesting time periods for further study and to allow space weather modelers to have a realistic data stream post facto. Like the real-time beacon data, the archived beacon data may be subject to revision and should only be cited with appropriate qualifiers. During the early operations and commissioning phase, the STEREO instrument data was of degraded or uncertain quality while instrument and spacecraft subsystem check-out took place. This may also happen during anomalies and contingency operations. Information about data quality is available on the SSC website.

Table 20. Space Weather Beacon Data Products Flow and Delivery

Data Type	**Processing Time (Location)**	**Data Format**
Real-time packet reception and decommutation (IMPACT, PLASTIC, S/WAVES)	~1 minute (SSC)	Time-series plots [GIF] Data files [CDF, IDLSAVE]
Real-time packet reception and assembly into image (SECCHI)	~ 5 minutes (SSC)	Images [FITS, JPEG]
Check & verify Level-0, catalog	<3 hours (SSC)	Packet
Level-0 to Browse archive	<3 hours (SSC)	Time-series plot [GIF] Images [FITS,JPEG] Movies [MPEG]

6.0 DATA FLOW

6.1 Overview of End-to-End Data Flow

Figure 6 shows the flow of data from the spacecraft to the active archive in the Solar Data Analysis Center (SDAC). Full resolution science data is collected from the spacecraft through the DSMS antennas. Realtime telemetry, which consists of spacecraft and instrument housekeeping, science data from IMPACT, PLASTIC and S/WAVES, and the much smaller beacon telemetry stream, is relayed to the MOC via a socket connection. In turn, the instrument POCs use socket connections to stream the realtime telemetry from the MOC for instrument health monitoring. The SSC also uses the same system to collect realtime telemetry for space weather beacon processing. The full telemetry played back from the solid state recorder is delivered via file transfer, where it is organized by the MOC into daily telemetry files. These telemetry files are mirrored from the MOC to the SSC, along with the various ancillary data products produced by the MOC. The instrument teams can download via https these telemetry files either from the SSC or directly from the MOC.

Outside of DSN contacts, each spacecraft broadcasts a low rate beacon stream. A number of volunteer antenna partners around the world collect these beacon streams, and send them as telemetry frames via socket connections to the SSC. Software at the SSC extracts the telemetry packets from the frames, combines them with the beacon packets coming through the telemetry channel from the MOC during DSN contacts, removes duplicate packets, sorts them into time order, and writes them out into telemetry files with a format that mimics that of the telemetry files provided by the MOC. Additional software, using routines delivered by the instrument teams, reads these telemetry packets and writes them out into CDF files for the in situ instruments, FITS files for SECCHI, and IDLSAVE files for S/WAVES. From these formatted data products are generated plots in GIF format, and images in JPEG format. Both the formatted data files and the GIF/JPEG browse products are made available immediately on the SSC website at stereo-ssc.nascom.nasa.gov. The whole pipeline processing from spacecraft frame to data files to browse products occurs within five minutes for SECCHI images, and one minute for the other instruments.

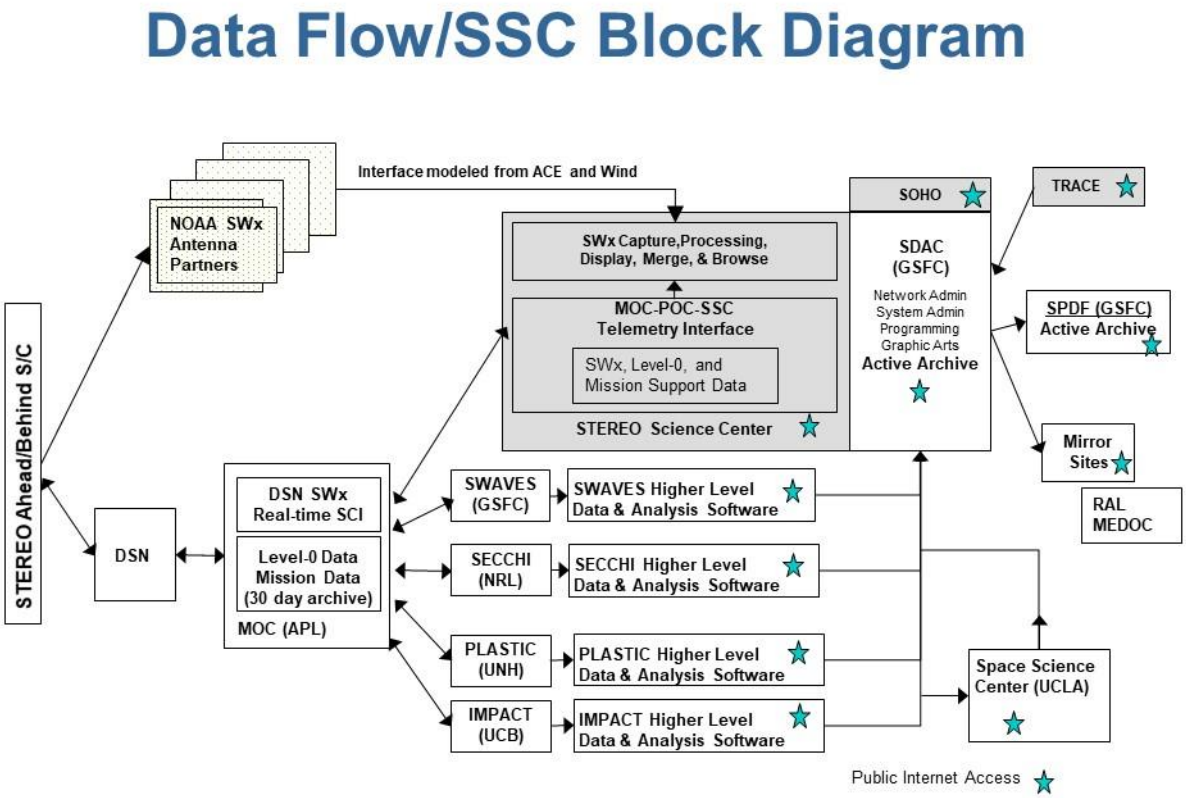

Figure 6. STEREO data flow and STEREO Space Science Center block diagram.

6.1.1 Data Flow to Spacecraft

STEREO operations are primarily synoptic. Coordination with other missions mainly consists of making sure that operations that would interrupt science measurements, such as momentum dumps, are scheduled as much as possible outside of periods of interest. For this purpose, the STEREO Science Center maintains a science operations calendar listing major spacecraft and science events. For example, the STEREO mission keeps track of Parker Solar Probe perihelion passes and Venus fly-bys, and schedules STEREO spacecraft activities outside of these periods.

There are also periods when the instrument teams, primarily SECCHI, schedule special observations outside of their normal synoptic program. These activities do not require coordination with the spacecraft or with the other instruments, but are tracked in the science operations calendar.

Special spacecraft maneuvers for calibration or science purposes are planned and scheduled by the MOC in coordination with the instrument teams. The primary science maneuvers are the stepped calibration rolls used to calibrate the SECCHI COR1 and COR2 coronagraphs, which occur four times a year: once each at perihelion and aphelion, and at the two midpoints between those two orbital extremes.

6.1.2 Data Flow from Spacecraft

The complete set of relevant STEREO mission data covered by this document can be defined as belonging to one of the categories shown in Table 21. A more detailed description of higher-level data for each instrument is provided in other sections of this document.

Table 21. Definitions of Data Types for STEREO.

Level-0 Data Sets	The complete packet telemetry stream from each observatory for a 24-hour period. There are five such data sets produced for each observatory (one file each for IMPACT, PLASTIC, S/WAVES, and spacecraft subsystems, and six files for SECCHI). Each file contains all ApIDs in that instrument's range that have been received in the MOC, sorted according to ApID, in time-order, with duplicates removed.
Spacecraft Engineering Data	Spacecraft housekeeping parameters routinely decoded into engineering units
Higher Level Science Data	Useful science data extracted from the Level-0 stream. Higher levels are defined differently for each instrument based on the type of measurement.
Space Weather Beacon Data	The continuous stream of highly compressed measurements and images from each observatory.
Mission Support Data	Ancillary data and files relevant to the mission.
Software Tools, Models, and Documentation	Relevant software tools and models, along with documentation, necessary to read and manipulate Level-0 and higher level science data.

The STEREO Level-0 data consists of the complete set of telemetry received by the MOC. Level-0 data are assembled at the MOC and are made available electronically to the instrument and subsystem teams and to the SSC. Higher-level scientific data are available electronically for the international community of scientists and the public at the individual instrument team processing facilities and at the SSC, which is co-located with the Solar Data Analysis Center (SDAC) at GSFC. These higher levels of data, along with the software routines and documentation necessary to access and manipulate them, are frequently mirrored from the instrument team working archives to the SSC. All of these services are available electronically to the public via the open Internet. At the end of the active life of the data, all relevant mission data (Table 21) will be transferred from the SSC to the Permanent Archive designated by NASA MO&DA management.

During the DSMS contacts (and perhaps from antenna partners) real-time space weather beacon data are captured and processed at the SSC. Gaps in the real-time beacon data are filled-in from the Level-0 data to provide a browse archive of the beacon data for the mission lifetime. Details of the real-time beacon data and the browse archive are described in the SSC section of this document.

As soon as feasible following the SSR playback, the data are transferred from the DSMS Central Data Recorder to the MOC for initial Level-0 processing. Level-0 products are produced for each observatory separately, and they cover a 24-hour period (00:00 through 23:59 Universal Time). There is one Level-0 file produced for each of the IMPACT, S/WAVES, and PLASTIC POCs containing all of their ApIDs for a 24 hour period, and there are 6 Level-0 files containing all SECCHI ApIDs (one file for each 4 hour segment of a 24 hour period). There are additional Level-0 files for the spacecraft subsystems. Each day these Level-0 data sets are produced for the current day, the day prior to the current day, the day two days prior to the current day, and a day 30 days prior to the current day. Any data received that does not come from the current day through 30 days prior will be flagged as out of range and produce an out of range Level-0 data set. When this file is produced, the affected POCs and the SSC will be notified that they have out of range data that can be retrieved. If data is retrieved that falls between the current Level-0 data sets, the affected POC and the SSC will be notified so that they can perform a playback from the MOC archive and retrieve the data.

Mission Support Data consists of those files of ancillary information that are necessary to satisfy the science requirements of the mission. Most of these data are generated at the MOC and are available electronically for the POCs and SSC. Examples of these data include: data completeness assessment; time-keeping history; attitude history file; command history file; stored command buffer report; event history log; daily status report; ephemeris generation file; telemetry data description; DSMS schedules; track plans; and as-run track plans.

After processing at the MOC, the instrument POCs transfer those Level-0 data electronically to their respective science centers for processing into scientifically useful measurements and for further distribution and analysis (see details for each instrument in their respective sections of this document). The SSC also transfers all Level-0 data from the MOC electronically for archival storage.

A block diagram showing significant components of the data flow is included in *Figure 6*. Here we present some of the details of data processing provided by each subsystem and instrument team. Where necessary, modifications from the plans stated in the individual Phase A reports have been incorporated into this document. All of the instrument teams have existing data processing sites available to the public, and those sites are referred to by specific Internet address where appropriate.

All STEREO instrument teams have adopted an open policy for access to all data, software, and documentation. The STEREO investigators have also built on the existing SolarSoft infrastructure that enables data access, display, and analysis for similar data from SOHO, ACE, and TRACE.

As part of the Level-0 product from the MOC, all of the spacecraft subsystem housekeeping parameters that are downlinked in the STEREO telemetry are archived in the SSC. These data, along with descriptions of parameter locations and decoding algorithms, form an integral part of the complete set of mission data.

The MOC also generates tables of agreed upon spacecraft housekeeping parameters decoded into engineering units. These data are generated on a daily basis covering a 24-hour period. The engineering unit product are available within 24 hours of receipt of the data in the MOC.

6.2 Data Handling and Timeline

Real-time telemetry from each STEREO spacecraft flows from the spacecraft into the DSN and be routed through the Restricted IONet to APL on a low-latency delivery path with complete data delivery not guaranteed. These data are flowed to the Ops DMZ network where they can be viewed in real-time by the spacecraft engineering team or the POCs either locally or remotely. The data are stored for several days on the data servers where they can be played back via instant replay in the MOC or across the Internet at the request of the POCs. The SSR playback data are recorded at the Central Data Recorder (CDR) at JPL where they are sent to the MOC in half-hour segment Intermediate Data Record (IDR) files over the Internet. These data are guaranteed complete and are the data that will be used to populate the raw archive and generate level 0 data. Daily, and upon complete playback of the SSR and MOC receipt of all the IDR files from the CDR, level 0 data are processed for each of the instrument POCs and the spacecraft housekeeping data. Level 0 data are time ordered with duplicates removed. Each day level 0 files are produced for the previous day, the preceding day, the day before that, and for 30 days earlier. This allows for the delivery of data that may have resided on the SSR for a few days and it is expected that the file from 30 days ago will be the final delivery with the complete data for that day. Due to the volume of data in the SECCHI POC partitions, each of these level 0 files are produced in 4-hour segments where all the other level 0 files are produced for a 24-hour period. Once generated, the level 0 files are placed on the STEREO Data Server (within 24 hours from receipt of the IDR files from the DSN) where they can be retrieved by the POCs and SSC. These files are maintained on the SDS for 30 days when they can be removed after receipt of the Archive Products List from the SSC indicating that they have retrieved the data. Table 22 shows how the data flow through the system.

Table 22. Data Flow from Spacecraft

Flow	Data Product	Timeline	Transfer Method
DSN to MOC	X-band data Primary Science Ancillary Data Instrument HK	1 day of downlink	TCP/IP over Internet
DSN to MOC	X-band data Realtime telemetry Playback telemetry	<10 seconds of downlink	TCP/IP via RIONet
MOC to POC, SSC	Instrument telemetry files	1 day of downlink	TCP/IP over Internet

MOC to POC, SSC	X-band data Realtime telemetry Playback telemetry	<10 seconds of downlink	TCP/IP over Internet

7.0 ARCHIVING AND DATA ACCESS

7.1 Current Archive Locations

The STEREO Science Center (SSC), located at NASA Goddard, serves as the main archive for all STEREO data. The primary source of ancillary data products for the STEREO mission is the STEREO Data Server (SDS) maintained as part of the Mission Operations Center at the Johns Hopkins University Applied Physics Laboratory. These data, which include all operational and engineering data and reports shared between the operations and instrument teams, are mirrored over to the SSC several times per day for archiving. All the ancillary data products are made available online except for the telemetry dictionaries which are archived separately for security reasons, and the DSN Schedule Change reports which are not made public because they include email addresses; the information in them is included in the subsequent DSN schedule files. Event lists maintained by the PI teams and others are available at the SSC Website.

Telemetry, Ephemerides, and Attitude History. Final level-0 telemetry files are archived by the SSC for each of the instruments and spacecraft subsystems. All STEREO ephemerides and attitude history files are provided as SPICE kernels. SPICE is a standard ephemeris package provided by the Jet Propulsion Laboratory's Navigation and Ancillary Information Facility (NAIF), and used by many interplanetary and heliospheric missions. Information about SPICE and the SPICE software package can be obtained from the NAIF Website. The SPICE kernels archived by the SSC are in ASCII transfer format, which can then be compiled into machine-readable form for any supported platform.

7.2 Data Access and Processing Tools

SolarSoft. Data analysis software is distributed as part of the Solar Software Library, also known as SolarSoft. This multi-mission software library is used extensively within the solar physics community, and enables cross-mission data analysis. The primary emphasis is on Interactive Data Language (IDL) software, but source code for other languages is also distributed using the SolarSoft mechanism. Together with the large generic library supplied with SolarSoft, each instrument team provides software for analyzing their own data. Also provided are the most current ephemeris and attitude history files for the entire mission, and software to manipulate them in a large variety of standard coordinate systems.

Data Distribution. The SSC resides within the Solar Data Analysis Center (SDAC) at the Goddard Space Flight Center. The SDAC is a multi-mission Resident Archive with extensive experience distributing data for a number of missions, including SOHO, TRACE, RHESSI, Hinode, SDO, and others, as well as archiving data for older missions such as the Solar Maximum Mission. The SDAC will act as the active Resident Archive for the lifetime of the mission and beyond. Ultimately, the data will be delivered to the Permanent Archive designated by NASA Heliophysics MO&DA management.

The remote sensing and in situ data being actively delivered to the SSC form the major core of what will become the STEREO long term archive, and many of the in situ data products are also being actively delivered to the Space Physics Data Facility (SPDF). SECCHI Level 1 and Level 2 products are generated from the current Level 0.5 files using already existing software, after final validation of the calibration. The various levels of data from the IMPACT and PLASTIC instruments are already in archivable format, as are the CDF versions of the S/WAVES data in the SPDF, and only require revalidation of the calibration and completion of the most recent data. At the end of the STEREO mission, an additional year of work will be needed from the instrument teams to perform a last validation of the calibrations, and to complete any remaining data processing.

The Virtual Solar Observatory (VSO) acts as the primary access point for all STEREO data, with the SSC as the data provider. This maximizes the use of existing resources without duplication, and enables collaborative data analysis with other solar observatories. An extensive list of all access sites, including those at the individual PI and Co-I institutions, is maintained on the SSC Website.

The Heliophysics Data Portal (HDP) provides access to STEREO data from many different sources, including the VSO. SPASE descriptions for almost all STEREO science data products have been registered within the Space Physics Data Facility, as well as many of the browse data products for the in situ instruments. The instrument teams are in the process of reviewing the SPASE descriptions for accuracy and completeness. In addition, the SSC and SECCHI instrument teams have begun putting together SPASE descriptions for the various browse products and tools that are on their respective websites, and expect to have this process completed within the next few months.

7.2.1 IMPACT

The IMPACT data sets are available through the main IMPACT UC-Berkeley instrument resource web site listed above. In addition, all data are mirrored by the SSC and available there. Data are also mirrored and available through CDAWeb. IMPACT data are being included in the HDP interface. Space Physics Archive Search and Extract (SPASE) descriptions of the IMPACT Level 1 data products have been written.

Together with the above, Caltech hosts a site specific to the Solar Energetic Particle (SEP) suite. This site provides SEP and some ancillary data (notably, orbit and attitude information) in ASCII format. A site hosted by the IRAP includes additional data products and analysis tools for the SWEA instrument.

The IMPACT team reviews the data listings in the Heliophysics Data Portal for completeness and accuracy. The team makes changes to the SPASE descriptions of its data products as necessary and works to include additional data products as they come online.

7.3 Documentation and Metadata

Instrument resources. Resource pages are available for each of the STEREO instruments, using a standardized format first developed for the SOHO mission, and are accessible from the SSC Website.

Mission Documentation. A special issue (2008, Volume 136) of Space Science Reviews (SSR) is devoted to the STEREO mission. In that issue are extensive descriptions of the spacecraft, instruments, and ground systems. See Appendix A for specific references.

7.4 Final Archive/Mission Archive Plan

7.4.1 Data Products

7.4.1.1 IMPACT

The IMPACT investigation provides several levels of science data products. The primary, "Level 1" science products include all science data at highest time resolution and in scientific units and coordinates. These products are produced at UC-Berkeley upon transfer of the Level 0 telemetry files from the SSC and validated by the IMPACT Co-Investigators within one month of generation. Once validated, these files are made publicly available (see below). Level 1 data files are in ISTP-compliant CDF format and intended to be self-documenting. The full complement of ISTP-required metadata are included within these files. All IMPACT Level 1 files are archived within the SSC. Appropriate metadata have been developed for each Level 1 data product, and incorporated into the HDP. In addition, a Level 1-like data product has been produced using the Solar Weather Beacon data for the period surrounding solar occultation. These data, for MAG and the SEP suite, are, for MAG, at a reduced cadence and, for SEP, include a subset of the data parameters available in the true SEP Level 1 data products due to the inherently compressed nature of the Solar Weather Beacon data. These data are intended to fill in data gaps during the period when true Level 0 and Level 1 IMPACT data was produced by APL and UC Berkeley only during periods of spacecraft contact.

Level 2 data are a merged data set, including data from the IMPACT and PLASTIC investigations, and averaged to ensure identical time cadences (1-minute, 1-hour and 1-day). These data are intended for quick browsing and are integrated with an online plotting and ASCII listing service hosted at UCLA. The same data in CDF format are also available through UC-Berkeley, the SSC and the SPDF. Level 3 data are list-type data such as event lists compiled by the IMPACT team. They are in PDF and Excel formats. Appropriate metadata have been incorporated into the HDP to enable searching on the data.

Currently, the IMPACT investigation provides Level 1 data for all instruments. Level 2 data including MAG and PLASTIC moments are being served at UCLA in ASCII format, and are archived within the SSC as CDF files. Level 2 data in ASCII format are also available for the SEP suite instruments through the Caltech and Kiel sites, with links for the latter on the UCLA site. CDF versions of these data are under active development. Level 3 event lists are served by UCLA, and archived within the SSC.

The STEREO Level 3 (ASCII) event lists of ICMEs, SIRs, shocks, and SEP events represent an unparalleled resource for the study of solar cycle evolution of space weather from a multipoint perspective. They include basic characteristics in addition to time interval, such as peak B field magnitude and peak pressure. STEREO A continues to provide a basis for comparisons to ACE and WIND near-Earth observations. For STEREO A, these lists have been updated to August 2014, or July 2018 for the SEP events; for STEREO B, the lists are updated to the time when STEREO B became lost in contact in September 2014.

During the periods surrounding solar conjunction, very little Level 1 and 2 data is available because the spacecraft SSR was reallocated to record only Space Weather Beacon data. Therefore, the IMPACT Beacon data, processed and archived at the STEREO Science Center, should be used for studies requiring continuous data coverage. The IMPACT/MAG group has produced a MAG data product, newly calibrated, based on these Beacon data which are being served at UC Berkeley, UCLA, the STEREO Science Center and CDAWeb. This MAG product provides the highest quality continuous MAG data available for this period.

7.4.1.2 PLASTIC

Level 1 data are the highest-resolution, complete data set. They have the epoch time and instrument section decommutated, counts decompressed, and entries separated into meaningful products (solar wind proton moment array, reduced proton and alpha distributions, heavy ion species count rate arrays, pulse height data, housekeeping, etc.), but are not fully converted into physical units (such as flux) that require the incorporation of detection efficiencies which may change over the life of the mission (due to gain changes in the detectors). Level 1 data products are produced at UNH within 24 hours of receipt of Level 0 telemetry files. Software and calibration/efficiency files to convert the data into physical units, along with appropriate documentation, are delivered electronically to the SSC archive. Level 1 data products are in ISTP-compliant CDF files.

Level 2 data products include the most frequently used quantities from PLASTIC in physical units. These data products are accessible on the PLASTIC Website (menu link to "Data Portal") and include both browse quality (typically available within 1 day of Level 1) and validated (updated monthly) products. Validated Level 2 products currently available on the UNH site as ASCII files include solar wind protons, alphas, and selected minor ions. Selected key parameters (such as solar wind bulk parameters, ion charge state distributions, and He+ intensities) are also provided on the UNH-hosted PLASTIC online browser as daily and/or monthly time series plots. Verified and validated products undergo both automatic and science personnel quality checks. These archival quality data are added to ISTP-compliant Level 2 CDFs and mirrored at the SSC. The validated PLASTIC proton moments are also included as a merged plasma plus magnetic field product courtesy of the IMPACT/MAG site at UCLA.

Level 3 data products typically result from directed scientific analysis, and include specific intervals (such as identified ICMEs) and other value-added products. He+ phase space densities are available for STA in 10 min, 1 hr and 24 hr cadences, and He+ relative fluxes are available in a 24 hr cadence. He+ solar wind frame velocity count distributions are available at a 5 min cadence. Early mission He++ phase space densities are available at a 1 hr cadence. All He+ and He++ products are available in CDF and ASCII format through UNH, and also mirrored at the SSC website. In addition, three event lists are available through UNH and the SSC website in ASCII format: a Suprathermal Event List, an Alfven Wave List, and a Small Transients List.

7.4.1.3 SECCHI

The primary distributed data is the Level-0.5 FITS file (See Section 4.3). The Level-0.5 FITS images may be converted to calibrated Level-1 by the user using a SolarSoft IDL procedure, SECCHI_PREP, which performs all of the calibration functions using the latest calibrations. All Level-0.5 FITS files are archived at the SSC, along with processed Level-2 HI files from the

Rutherford Appleton Lab and from the Southwest Research Institute. Additional data, described below, are available from the SECCHI team and other websites. Some of these data sources are primarily intended as quick-look browse tools. The SSC is considering which of these additional data should also be incorporated into the official NASA archive.

The same image header metadata that appear in the FITS headers are also stored in a database at NRL. The NRL SECCHI Website uses this database to query and download specific Level-0.5 FITS files. In addition, the top SECCHI Website serves Level-2+ data products for scientific and public use, including weekly browse movies, and auto-generated CACTus CME lists for SECCHI. A second SECCHI website is deployed at APL that mirrors all SECCHI data (except EUVI FITS files). It also provides access to a range of Level-2+ products, including but not limited to: a COR2 CME list with simultaneous identifications in STEREO-A & B and properties of the events; EUVI and EUVI-AIA synchronic 360^0 maps in Carrington coordinates (19.5 nm, 28.4 nm, 30.4 nm); browse movies for user-defined intervals, for all SECCHI and LASCO telescopes and and preprocessed EUVI wavelet-enhanced images, FITS and PNGs, for the duration of the mission. Additional products are under active development (e.g. Carrington and COR2-HI1/2 Plate Carrée maps).

A CME list with 3D properties is available from the University of Göttingen. Several events catalogs (CME, CIRs) with an emphasis to the HI data are available through the HELCATS project. The SECCHI/HI site in the UK hosts a variety of L2+ products, including HI-1/2 Time-elongation plots ("J-maps").

Housekeeping. Selected SECCHI instrument housekeeping telemetry is available via web interface to a database at NRL. Plots may be extracted from this database of various engineering parameters such as temperatures, currents, voltages, door position, guide telescope pointing and HK events. Table definitions and table structure are described on the NRL SECCHI web site.

7.4.1.4 S/WAVES

The S/WAVES investigation provides several levels of science data products. Access to the Level 0 data is achieved through a processing system called TMlib, based on a similar system (WindLib) successfully used since the early 1990s for the Wind/WAVES (W/WAVES) data. The TMlib can be downloaded from the University of Minnesota (send request to goetz@umn.edu).

Daily summary plots showing all frequency-domain receivers and summaries of the time domain receivers are available from the SSC and S/WAVES Webpage. Both of these sources also serve 1-minute averages in both ASCII and IDL save format of all frequency-domain receivers. These 1-minute averages are also served by the CDAWeb in CDF format. The CDAWeb site includes customized plotting capabilities. Both the daily summary plots and the 1-minute averages are produced automatically upon receipt of the data, so are available usually within 24-hours of real-time.

The French IRAP Plasma Physics Data Center (CDPP) also serves daily summary plots of the frequency domain receivers in a different format than those from the U.S sites. CDPP also serves the higher level S/WAVES products associated with direction finding and wave polarization capability. This site requires a password (due to French security regulations), but this is freely given upon request.

Additional higher level data includes the Type II/IV catalog maintained by the Wind/WAVES team and now including S/WAVES data. This site has been in existence since the late 1990s and is a valuable resource for solar researchers. The years covering the STEREO mission are archived on the SSC website.

7.4.2 Analysis Tools

7.4.2.1 IMPACT

The IMPACT investigation provides data products in ISTP-compliant CDF and ASCII formats to ensure easy integration with users' native analysis environments. In addition, the IMPACT team provides custom software through the instrument resource page based on the UC-Berkeley SPEDAS library. This is an IDL-based set of analysis routines designed specifically for in situ measurements.

Online browsers and plotters hosted by UCLA, UC-Berkeley, the University of Kiel, and the Institut de Recherche en Astrophysique et Planétologie (IRAP) provide tools on the web. At UC-Berkeley, a traditional browse-type, static plot tool is available. This tool links IMPACT and ACE plots and data with images and models. A real-time space weather page has also been developed at UC-Berkeley which integrates STEREO Beacon, SDO and ACE plots.

7.4.2.2 PLASTIC

PLASTIC data are available in ISTP-compliant CDFs such that they can be easily integrated into existing analysis and search tools, such as the HDP and SolarSoft. In addition, the PLASTIC team has extended the UC-Berkeley TPLOT library, (see IMPACT section, above), into the IDL-based SPLAT (Stereo PLastic Analysis Tool) that further enables integration of data sets. SPLAT and other IDL programs, including those that support composition analysis and those that create specialized ASCII files from the CDF files, are distributed through the SolarSoft library.

7.4.2.3 SECCHI

SECCHI analysis tools, and most of the pipeline software, are freely available through SolarSoft. The following tools are currently available via SolarSoft: data browsers, data calibration, movie generation and display, image enhancement and visualization, polarized image processing, star-removal, height-time plots, ray-tracing, CME detection, tomography. As these tools are improved and future tools developed, they will be added to the SolarSoft library. In addition, there are some stereographic visualization tools that currently require specialized hardware. At NRL all software is under Concurrent Versions System management.

7.4.2.4 S/WAVES

The customized plotting capability available at the CDAWeb is based on the same program used by the S/WAVES team. This original IDL program is available from the instrument resource site at the SSC.

7.4.3 Documentation

7.4.3.1 IMPACT

The SSR special issue includes complete information regarding the IMPACT instruments and data products. In addition, documentation is served online through the IMPACT instrument resource page. Information about calibrations and software versions used in the production of Level 1 data products are listed on this website and included in the internal documentation of the CDF files themselves.

7.4.3.2 PLASTIC

A full descriptions of the PLASTIC instrument can be found through the Instrument Resource page of the UNH website. Full descriptions of the Level 1, Level 2, and Level 3 data products can be accessed through the Data Portal webpage at the UNH website and through SolarSoft. Metadata relevant to particular data products are also available within the CDF files. ASCII products either have the product information contained within the file header, or else a Readme file is provided. The instrument and data products are fully described in the PLASTIC instrument paper in the SSR special issue. This paper is available online, open-access.

7.4.3.3 SECCHI

The NRL SECCHI Website serves the SECCHI documentation: Science (FSW) Operations Manual, FSW documentation, image telemetry completeness data, instrument status, image scheduling details, various instrument and operations event logs, software user's guides, SECCHI FITS Keyword Definition, and the SECCHI Data Management Plan. There is a complete user guide for the SolarSoft IDL SECCHI_PREP procedure, as well as other analysis tools. A description of the instrument is given in the SSR special issue. SECCHI operations and data documentation are maintained on the NRL site; many of these documents are also included in the SolarSoft distribution. The pages are updated as information becomes available.

7.4.3.4 S/WAVES

Three papers of importance to S/WAVES data processing are in the SSR special issue, one providing a complete description of the S/WAVES instrument (Bougeret et al, 2008), another discussing the antennas (Bale et al., 2008), and a third describing the direction finding technique used by S/WAVES (Cecconi et al., 2008). Pointers to these articles as well as to a description of the 1-minute average data are on the S/WAVES instrument resource page referenced by the SSC. The direction finding and wave polarization parameters, are documented on the CDPP Web site mentioned above. The S/WAVES datasets have SPASE descriptions.

7.4.3.5 IMPACT

The IMPACT Level 1, 2 and 3 data sets are the "final" data products and are already being produced and archived at the STEREO Science Center. However, it is possible that instrument calibrations may be updated prior to the end of the mission necessitating reprocessing of some data products. Such reproduction will take place as soon as the new calibration factors are determined and incorporated in the data set archived at the STEREO Science Center.

7.4.3.6 PLASTIC

Data Distribution. PLASTIC Levels 1 and validated Level 2 and Level 3 data are available both via the UNH-hosted Website (via the Data Portal page) and at the mirrored SSC instrument data site. PLASTIC archival data is also available at the CDAWeb, the VSO, and the Heliophysics Data Portal (HDP). In order to address comments from the last review, all SPASE descriptions in the HDP have been checked, and SPASE descriptions for the event lists have been added.

Final Data Set. Final PLASTIC data are created and mirrored by the archive on an on-going basis. There is the possibility that, with further scientific analysis, a product might be updated. If this happens, the data will be reprocessed and the new files distributed with an updated version number.

7.4.3.7 SECCHI

Final Data Set. The SECCHI Level-0.5 data is "final" after the FITS files have been updated with any additional telemetry received in the final (+30-day) Level-0 telemetry from APL. Currently, the Level-1 (calibrated) product is the combination of the Level-0.5 FITS images and the SECCHI_PREP IDL routine and data files available in SolarSoft. This allows the user to take advantage of the evolving calibration of the various telescopes. At the end of the mission, the calibration files and parameters that are used in this package will be revalidated to ensure that they are up to date and able to generate Level-1 FITS files of calibrated images, polarized brightness, and brightness images. Calibration will include corrections for instrumental artifacts such as stray light, vignetting, shutterless readout, and conversion to physical units. (Geometric distortion is described by header keywords together with the World Coordinate System standard algorithms.) Complete documentation, transparent software code, and non-proprietary data formats ensure that calibration can be properly applied to Level-0.5 data into the foreseeable future. The final archive will contain both the calibrated Level-1 files and the final Level-0.5 files.

Data availability. The primary site for storage of Level-0.5 FITS image data is the NRL Solar Physics Branch (PI home institution). The primary means of querying data for analysis is by utilizing summary flat-files which are read by SolarSoft tools. Besides being available on-site, the data is freely available (in relatively small quantities) from NRL via database query at the SECCHI website. All of the data are also synchronized several times per day to the SSC. In addition, other partner institutions – LMSAL (California), APL (Maryland), RAL (UK), IAS (France), MPS (Germany) – mirror STEREO data. These all serve as backups for the complete data set.

Virtual Observatory Access. The SSC is serving SECCHI data through the VSO at GSFC/SDAC, which is intended to be the gateway to other Virtual Observatories. The SECCHI data are fully accessible to the wider VO community. VSO is committed to community interoperability efforts, such as the SPASE data model. The SECCHI team is working with representatives of the Heliophysics Data Portal to ensure proper descriptions of SECCHI data products.

7.4.3.8 S/WAVES

Data Distribution. S/WAVES data, as mentioned above, are available directly from the team's US Web site, from the SSC, from CDAWeb, and from the CDPP. The S/WAVES event lists can be obtained from the Type II/IV catalog Web site, and from the SSC website.

Final Data Set. The S/WAVES data are "final" when they appear at https://stereo-ssc.nascom.nasa.gov/data/ins_data/swaves/, given that updates occur for any additional telemetry received in the final (+30-day) Level-0 telemetry from APL. This FTP site provides the Level-1 (calibrated) products, which are ASCII and IDL saveset files for the HFR, LFR, and TDS. Plots of these data as dynamic spectra in Postscript, PDF, and PNG formats are also available on this FTP site.

Appendix A – References

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Appendix B - Acronym List

ACE - Advanced Composition Explorer
amu - atomic mass unit
ApID - Application Identification
APL - Applied Physics Laboratory
ASCII - American Standard Code for Information Interchange
AU - Astronomical Unit
CACTus - Computer Aided CME Tracking
CCSDS - Consultative Committee for Space Data Systems
CDF - Common Data Format
CDPP - French Plasma Physics Data Center
CDR - Central Data Recorder
CME - Coronal Mass Ejection
COR1 - Coronagraph 1
COR2 - Coronagraph 2
DAC - Digital to Analog Converter
DSMS - Deep Space Mission Services
DSN - Deep Space Network
EDT - Eastern Daylight Time
EEPROM - Electrically Erasable Programmable Read-Only Memory
ESA - Electrostatic Analyzer
ESA - European Space agency
EUV - Extreme Untraviolet
EUVI - Extreme Ultraviolet Imager
FDF - Flight Dynamics Facility
FITS - Flexible Image Transport System
FOV - Field of view
FPGA - Field Programmable Gate Array
FSW - Flight Software
Gb - Gigabit
GB - Gigabyte
Gbyte - Gigabyte
GF - Geometrical Factor
GIF - Graphics Interchange Format
GSFC - Goddard Space Flight Center
GOES - Geostationary Operational Environmental Satellite
HDP - Heliophysics Data Portal
HET - High Energy Telescope
HFR - High Frequency Receiver
HGRTN - Heliographic Radial-Tangential-Normal coordinate system
HI - Heliospheric Imager
HI1 - Heliospheric Imager 1
HI2 - Heliospheric Imager 2
ICD - Interface Control Document

ICER - Progressive Wavelet Image Compressor
ICME - Interplanetary Coronal Mass Ejection
IDL - Interactive Data Language
IDPU - Instrument Data Processing Unit
IDR - Intermediate Data Record
IMAGE - Imager for Magnetopause-to-Aurora Global Exploration
IMPACT - In-situ Measurements of Particles and CME Transients
IRAP - Institut de Recherche en Astrophysique et Planétologie
ISTP - International Solar-Terrestrial Physics
JHU - Johns Hopkins University
JPEG - Joint Photographic Experts Group file format
JPL - Jet Propulsion Laboratory
kbps - Kilobits per second
LET - Low Energy Telescope
LFR - Low Frequency Receiver
LOS - Line of Sight
MAG - Magnetometer
MCP - Microchannel Plate
MHD - Magnetohydrodynamic
MIL-STD - Military Standard
MO&DA - Mission Operations and Data Analysis
MOC - Mission Operations Center
MOT - Mission Operations Team
MPAe - Max-Planck-Institut fur Aeronomie
MPEG - Motion Picture Experts Group file format
MSB - Mean Solar Brightness
NASA - National Aeronautics and Space Administration
NOAA - National Oceanic and Atmospheric Administration
NRL - Naval Research Laboratory
nuc - Nucleon
ODM - Operations/Data Manager
OSO - Orbiting Solar Observatory
PDF - Portable Data Format
PI - Principal Investigator
PDMP - Project Data Management Plan
PLASTIC - PLasma And SupraThermal Ion Composition
PNG - Portable Network Graphics
POC - Payload Operations Center
RAM - Random Access Memory
RHESSI - Reuven Ramaty High Energy Solar Spectroscopic Imager
Rs - Solar Radii
S/WAVES - STEREO/WAVES
SDAC - Solar Data Analysis Center
SDO - Solar Dynamic Observatory
SDS - STEREO Data Server
SEC - Space Environment Center

SECCHI	- Sun-Earth Connection Coronal and Heliospheric Investigation
SEP	- Solar Energetic Particle
SEPT	- Solar Electron Proton Telescope
SEPT-E	- SEPT-East
SEPT-N/S	- SEPT-North/South
SIR	- Stream Interaction Region
SIT	- Suprathermal Ion Telescope
SOHO	- Solar and Heliospheric Observatory
SPASE	- Space Physics Archive Search and Extract
SPDF	- Space Physics Data Facility
SSC	- STEREO Science Center
SSD	- Silicon Semiconductor Device
SSR	- Solid State Recorder
SSW	- Solar SoftWare
STA	- STEREO-A
STB	- STEREO-B
STE	- Suprathermal Electron Telescope
STE-D	- STE-Downstream
STE-U	- STE-Upstream
STEREO	- Solar TErrestrial RElations Observatory
STEREO-A	- STEREO observatory ahead of the Sun-Earth line
STEREO-B	- STEREO observatory behind the Sun-Earth line
STP	- Solar Terrestrial Probes
SW	- Solar Wind
SWEA	- Solar Wind Electron Analyzer
SWS	- Solar Wind Sector
TBD	- To Be Determined
TDS	- Time Domain Sampler
TOF	- Time of Flight
TRACE	- Transition Region and Coronal Explorer
TS	- Thomson-scattered
UCB	- University of California at Berkeley
UCLA	- University of California at Los Angeles
UNH	- University of New Hampshire
USAF	- United States Air Force
UV	- Ultraviolet
VSO	- Virtual Solar Observatory
WAP	- Wide-Angle Partition Sector
WWW	- World Wide Web