NAVAL RESEARCH LABORATORY

E.O. HULBURT CENTER FOR SPACE RESEARCH

Data Management Plan
for the
Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI)

7906-PLN-9-0-0010 **28 January 2008**

Revision 2 draft 2

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RECORD OF CHANGES

Revision Letter	Date	Title Or Brief Description	Entered By
0.0	October 8, 2002	Draft for internal review	R. Howard; S. Plunkett; N. Rich
0.1	October 17, 2002	Comments and additions	R. Howard; S. Plunkett
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2 d 1	June 30, 2004	Minor changes, mostly to real-time telemetry description	N. Rich
2 d 2	January 28, 2008	Updated to reflect current practice	N. Rich

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1 INTRODUCTION

1.1 Purpose and Scope of Document

This Data Management Plan:

- Contains a detailed description of data products suitable for data users.
- Describes how data from the Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) instruments on the Solar TErrestrial RElations Observatory (STEREO) spacecraft are obtained, processed, archived and distributed.
- Describes various team responsibilities.
- Describes the development plan for the SECCHI Data Processing System (DPS).

2 APPLICABLE DOCUMENTS

This section identifies documents that are referenced in this Data Management Plan or that provide information useful to understanding the SECCHI Project. The following documents of the exact issue shown form a part of this document to the extent referenced herein.

2.1 Government Documents

2.1.1 Military Standards and Specifications

No military standards or specification documents are applicable for the SECCHI Data Management Plan.

2.1.2 Other Publications

Table 2-1 Non-Military Government Publications

Number	Title
NOST 100-2.0, 1999/03/29	NASA Science Office of Standards and Technology (NOST), *Definition of the Flexible Image Transport System (FITS)*, http://archive.stsci.edu/fits/fits_standard/
2000/07/12	Thompson, William, *Coordinate Systems for Solar Image Data*, 2000/07/12, http://orpheus.nascom.nasa.gov/~thompson/papers/coordinates.ps

NASA National Aeronautics and Space Administration

2.1.3 Project-Specific Documents

Table 2-2 Project-Specific Documents

Number	Title
(APL) 7381-9045a	STEREO Missions Operations Center (MOC) to Payload Operations Center (POC) and to STEREO Science Center (SSC) Interface Control Document (ICD) (MOC-POC ICD)
	SECCHI Ground Data System Requirements
	SolarSoft, http://www.lmsal.com/solarsoft/sswdoc/index_menu.html
(NRL) 7906-PLN-9-0-0006	SECCHI Ground Data System Development Plan
SECCHI 7906-RPT-9-0-0020, NRL	SECCHI Ground Data System Requirements
NASA 460-PLAN-0039, GSFC,	STEREO Project Data Management Plan--A Solar-Terrestrial Probes Mission, http://gdms.gsfc.nasa.gov/gdms/plsql/frontdoor
2000/08/18	SECCHI Phase A Concept Study Report
(NRL) 7906-SPC-9-0-0003	SECCHI Science Requirements and Instrument Performance Specification

GSFC Goddard Space Flight Center
NRL U.S. Naval Research Laboratory
APL The Johns Hopkins University Applied Physics Laboratory
LMSAL Lockheed Martin Solar and Astrophysics Laboratory

2.2 Order of Precedence

In the event of a conflict between the text of this plan and the reference cited herein, the text of this document takes precedence, except for STEREO documents. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3 DATA PRODUCTS

3.1 Instrument Overview

SECCHI is a suite of remote sensing instruments consisting of two (2) white light coronagraphs (COR1 and COR2), an Extreme Ultraviolet (EUV) Imager (EUVI), and a Heliospheric Imager (HI). SECCHI will observe Coronal Mass Ejections (CMEs) from their birth at the sun, through the corona to their impact at earth. SECCHI includes a coordinated effort to provide magnetohydrodynamic (MHD) models and visualization tools to interpret the images that will be obtained from two (2) viewpoints and to extrapolate that imagery to in-situ and radio emission measurements obtained from other instruments on STEREO.

The SECCHI Instrument Suite consists of the (2) two optical packages, the Sun-Centered Imaging Package (SCIP) and the HI package, and an electronics package, the SECCHI Electronics Box (SEB).

The SCIP is a rigid optical bench, the function of which is to hold the EUVI, COR1, COR2 and Guide Telescope (GT) in co-alignment. The EUVI images the solar corona in four (4) wavelengths out to about 1.4 solar radii. The COR1 images the white light corona from 1.5 to 4 solar radii using an internally occulted coronagraph. The COR2 images the corona from 2 to 15 solar radii using an externally occulted coronagraph. The SCIP also contains the GT that provides fine pointing information for the spacecraft (S/C) attitude control system and for the EUVI Fine Pointing System (FPS).

All three (3) SCIP scientific telescopes have recloseable doors to protect the instruments during ground operations and during possible contamination events in flight. The EUVI contains a sector wheel to select the wavelength, a filter wheel to put in various aluminum filters of different thicknesses, and a shutter to time the exposures. The COR1 and COR2 have a rotating polarizer with 144 positions, and a shutter to time the exposure.

The HI package contains two (2) simple coronagraphic telescopes to directly view the Sun-Earth line. These two (2) telescopes are sheltered within a protective baffle structure to obtain the necessary rejection of bright objects outside the field, including the solar disk, and S/C glints. A small triangular baffle shields the HI-1 from the Earth-Moon system early in the mission, when they are large and bright. The HI telescopes do not have any shutters or filter/polarizer wheels.

All five (5) telescopes use the same type of Charge-Coupled Device (CCD): backside illuminated, 2k x 2k 13.5 micron pixel. The only difference is that the EUVI CCD has an uncoated backside rather than the anti-reflective (AR) coating that the other four (4) have. The CCDs are read out using the same camera design. A 14-bit analog-to-digital converter (ADC) converts the doubly sampled video signal at the pixel readout rate of 1 millionpixels/sec.

The SEB is a common electronics unit for both the SCIP and HI. It provides command and data handling, observation sequencing, mechanism drive, housekeeping, power distribution, heater control, camera interface, and S/C interface.

3.2 Data Product Overview

SECCHI science data consist of 2048 x 2048-pixel images of the following types:

1. Emission line intensity images from EUVI at one (1) of four (4) wavelengths and through aluminum (Al) filters of varying thicknesses;
2. Total brightness images (B) from HI1 and HI2, and
3. Total brightness images (B), and polarized component images, from COR1 and COR2.

Additional calibration images will be available such as darks, calibration lamps, door-closed, etc. for each telescope.

All of the data are measurements of brightness or luminescence, in digital counts (DN). The science data product will be stored and distributed as uncalibrated, uncompressed 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 (Appendix A), and will 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. Interactive Data Language (IDL) procedures will be

available to convert the FITS image files into a calibrated data product. Calibration images, including pre-flight images taken for calibration or test purposes, will also be stored as FITS files.

The routine processing flow will produce the FITS images in addition to several other types of products. These additional products include browse images and movies for the World Wide Web (WWW), higher resolution movies for research, Carrington maps, and ancillary data (housekeeping tables and plots, attitude and orbit files). Lists of various events (such as CMEs, comets, etc) will be generated. Table 3-1 gives an overview of SECCHI data products and their formats, along with bytes per pixel to give an indication of data volume.

Table 3-1 SECCHI Data Product Formats

Data Product	Format	Bytes/pix
Science images (COR, EUVI)	FITS	2
Science images (HI)	FITS	4
Calibration images	FITS	2 - 4
Pre-flight images	FITS	4
Browse images	JPEG or GIF	~ 0.1 or ~ 0.8
Browse movies	MPEG or JavaMovie or animated GIF (512x512)	~ 0.05
Science movies	MVI (512x512)	1
Ancillary data	JPEG, GIF, Interactive Java Display, ASCII Text, or FITS	varied
CME Lists	ASCII/DBMS	varied
Comet Lists	ASCII/DBMS	varied

JPEG Joint Photographic Experts Group
GIF Graphics Interchange Format
MVI NRL-developed IDL movie format
MPEG Motion Picture Exports Group
DBMS Database Management System

3.3 Roles and Responsibilities

Routine processing of SECCHI data will take place at the SECCHI POC and at the SECCHI Data Processing Facility (DPF). NRL is responsible for the POC and the DPF; software for Level 1 processing; providing software to the SSC for beacon data processing; and distribution of Level 0.5 data to the SSC. NRL will also provide the calibration data for the COR2 telescope, and the pre-flight calibration information for all the CCD camera subsystems.

The Co-Investigator institutions will be responsible for providing calibration data and any special algorithms for routine processing of data from their respective telescopes to NRL. The Co-Investigators will be responsible for performing detailed analyses of their respective subsystems and for submitting updated calibration data to NRL as necessary. The Co-Investigators will be in residence at the POC during special observing campaigns requiring real-time or near-real-time commanding.

NASA/GSFC is responsible for the COR1 telescope. LMSAL is responsible for the EUVI telescope and for the GT. The Rutherford Appleton Laboratory (RAL) is responsible for the HI-1 and HI-2 telescopes.

The SSC will have four (4) key functions:

(1) it will be the focal point for archiving STEREO data;

(2) it will be the processing center for the space weather beacon data;

(3) it will be the central point for science coordination between the instruments and other space-based and ground-based campaigns; and

(4) it will be the focal point for mission-related education, public outreach, and public affairs.

3.4 Data Processing

The requirements for the SECCHI DPS are found in the SECCHI Ground Data System Requirements document (SECCHI 7906-RPT-9-0-0020).

3.4.1 Data Acquisition

The JHU/APL MOC will provide socket and File Transfer Protocol (FTP) interfaces for all STEREO data. The interfaces are governed by the MOC-POC ICD (APL 7381-9045).

The SECCHI POC will connect to the MOC over a non-secure Internet socket during real-time contact with the spacecraft to receive housekeeping and science telemetry. During normal operations, only house-keeping and beacon data will be available in real-time to the POC.

Playback data may be retrieved from the MOC in the same way as the real-time data. The playback data are available at the MOC beginning approximately three (3) hours after reception by the MOC until 30 days after reception. The MOC also will prepare a preliminary cleaned and merged playback data (Level-0) for downloading via FTP by the POC 24 hours after the end of a pass. A second, final set of Level-0 files will be produced 30 days after reception.

3.4.2 Data Processing Level

Definitions of SECCHI data processing levels are summarized in Table 3-2.

Table 3-2 Data Processing Level Definition

Level	Source	Description
Packets	Spacecraft, MOC	Consultative Committee for Space Data Systems (CCSDS) Packets as transmitted by the spacecraft to the Deep Space Mission System (DSMS) and then the MOC
Level-0	MOC	CCSDS Packet files sorted and duplicates removed; final after 30 days
Level-0.5	POC or DPF	FITS files containing uncompressed (16-bit) images. Values are raw counts (DN). Header contains • only telemetry information that came with the image (quick-look) **OR** • all information in telemetry plus any ancillary information necessary to interpret the data (pre-final or final).
Level-1	User Workstation using SolarSoft	FITS files with calibration applied ”on the fly”. Values are physical units (COR, HI) or calibrated DN (EUVI).
Level-2	User Workstation using SolarSoft or DPF	Data products which are a result of combining 2 or more (non-calibration) images. Includes movies, polarized Brightness images, Carrington maps, etc. May or may not be calibrated.
Level-3	User Workstation using SolarSoft	Derived quantities: Electron density, temperature ratios, emission measures, etc.

”Quick-look” data may be produced from the real-time channel wherever the POC is located (JHU/APL or NRL). Quick-look data will be produced only during commissioning or other times with high real-time allocation. The data product will be FITS files with raw counts (“Level-0.5”); the quick-look Level-0.5 FITS files are differentiated from the final data product by the completeness of the header. The FITS files produced from the real-time channel will be kept indefinitely.

Final SECCHI data will be produced at the NRL DPF. The six (6) time-sorted Level-0 packet files prepared by the MOC will be retrieved and processed daily.Level-0.5 (FITS) images, with all relevant ancillary data in the header, will be produced along with any other SECCHI ancillary data products. After 30 days, these Level-0.5 files will be “Final.”

The "Level-1" data product will be a combination of FITS files and SolarSoft IDL procedures that are executed when reading the file in.

3.4.3 Data Flow and Data Product Generation

3.4.3.1 Pre-Flight

During instrument development, images will be generated for test and/or calibration purposes. Depending on the stage of development, these files will be produced by the Telescope Development System (TDS) or the integrated SECCHI instrument. The image files will be in Level-0.5 format with header keywords that are relevant to pre-flight. The pre-flight images for all telescopes will be part of the SECCHI data archive at NRL.

3.4.3.2 Flight Operations

Figure 3-1 provides an overview of the different components of the DPS. Data originates at the POC, which in this diagram represents a workstation receiving telemetry from the MOC. This workstation may be located at either JHU/APL or NRL. When at JHU/APL, science and housekeeping data files will be transmitted to NRL via rsync. The three (3) types of data available through the SECCHI POC are the Level-0 (MOC-processed) packet files, real-time or unprocessed packet files, andsocket playback telemetry. The POC will parse the incoming raw telemetry data and will sort the data into image and housekeeeping files. All processed data are archived at NRL.

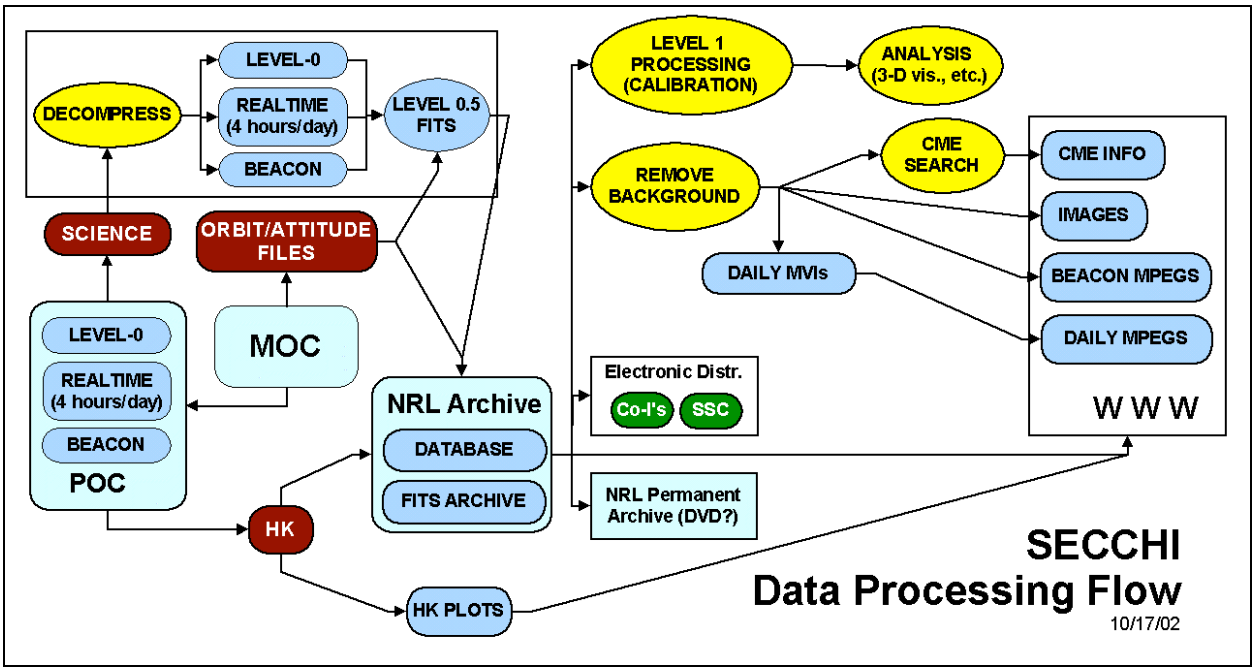

Figure 3-1 SECCHI Data Processing Flow

3.4.3.3 Beacon Data

The beacon data will follow the same process outlined above up to the Level-0.5 product. The data will be saved as FITS files, with images for display and browsing (byte-scaled) created with the best available background; these display images may be replaced if an the background model is updated. The beacon data will be processed by the STEREO Science Center using the same pipeline as the SECCHI data processing center.

3.4.4 Data Calibration and Evaluation

The flight science data, including the beacon data, will be compressed using one (1) or more of the onboard compression algorithms. Following the restoration of the original uncompressed image (perhaps with loss of some information), the images will be characterized statistically in the following way:

- Noise and standard deviation
- Histogram of pixel values
- Minimum and maximum pixel values
- Average pixel values

The images will also be evaluated to determine the effectiveness of the compression algorithm that was used.

Software procedures will be developed in the IDL to perform the following calibration tasks:

- Remove geometric distortion
- Locate stars, determine roll angle, and absolute pointing
- Remove CCD fixed-pattern noise

- Perform photometric calibration
- Remove vignetting, stray light, and instrumental polarization
- Remove background F-corona from total brightness images to reveal the K-coronal structures
- Sharpen resolution using modulation transfer function (TBC)

A variety of on-orbit calibration checks will be performed, using techniques that have been developed and used successfully on data from the Solar and Heliospheric Observatory (SOHO) and Trace missions. Stars and planets will transit through the fields of view of each of the optical systems. Their positions are well known and provide roll angle, absolute pointing, and geometric distortion determinations. Similarly, photometric measurements of stars and planets in transit through the field of view will yield vignetting and photometric calibrations. Instrumental stray light observations can be obtained for the EUVI when a planet transits the field.

Periodic spacecraft rolls will be conducted to permit polarization and stray light calibrations, and periodic offpoints of the spacecraft will permit flat-field calibrations for the EUVI instrument.

Instrument calibration sources (Light-Emitting Diodes [LEDs]) will also be used in flight to check the optical performance of each telescope, and to check the sensitivity of the CCDs.

3.4.5 Data Distribution and Accessibility

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 images will be available as soon as the routine processing steps have been completed. This is estimated to be within 30 minutes of receipt of the data packets necessary to form an image. After the images are released as Final, the Level 0.5 FITS files will be delivered electronically to the SSC from NRL as available. A Digital Video Disk (DVD) media archive (or whatever medium is the best choice, to be determined closer to launch) will be maintained at NRL. Data will also be delivered electronically to other sites in the U.S. and in Europe. No data will be distributed routinely on hard-copy such as CDROM or DVD.

Browse/display images will be created from the pre-final FITS files using the best available background and will be available on the SECCHI Web server. One (1) copy of each image will be kept as part of the SECCHI archive until replaced by a superior version (if any). The same procedure will be followed for browse movies.The image data will be accessible through the Internet using a searchable database. It will be possible to generate queries using most header keywords as parameters. Temperatures, voltages and other housekeeping parameters can also be obtained through database queries.

IDL procedures and auxiliary data will apply calibration and processing steps as specified by the user. These procedures, calibration files and auxiliary data will be updated as necessary throughout the mission and will be freely available via Internet access as part of the SolarSoft software library (SSW) and database (SSWDB). Community analysis of STEREO observations will be from a virtual center, in that data will be requested from the SSC and/or the NRL DPF and automatically delivered to investigators via the open Internet.

3.5 Data Volume

The decompressed science data is estimated to be about 12 GB per day for both observatories during the prime (two-year) science phase of the mission. Table 3-3 outlines the estimated data volume for all data products, which comes to 12.9 TB for the two-year primary mission.

Table 3-3 SECCHI Data Volume

Data Product	Bytes/pix	1kx1k/day/SC	2-yr Vol. (GB)
Science images (COR, EUVI)	2	2700	8267
Science images (HI)	4	40	245
Calibration images	2 - 4	?	10
Pre-flight images	2	NA	250
Browse images (GIF and JPG)	~ 0.1 or ~ 0.8	2000	3062
Browse movies (512x512)	~ 0.05	500	38
Science movies (512x512)	1	500	766
Ancillary data	varied	?	10

Data Product	Bytes/pix	1kx1k/day/SC	2-yr Vol. (GB)
3-D daily model	2	64	196

3.6 Labeling and Identification

In general, data product files will be named using date and time of observation. Additional characters in the file name will indicate spacecraft, telescope, and level of processing, including whether the data are quick-look data. The file format will be indicated by the suffix. The file format will conform to the following:

yyyymmdd_hhmmssTTSL.typ

S = [a,b,c] for Spacecraft A or B or non-specific

TT = camera: [eu, c1, c2, h1, h2, tk, d[1,2…]] for EUVI, COR1, COR2, HI1, HI2, Talktronics, SECCHI camera development model [1,2,…] or other characters TBD to represent other (preflight) cameras

L = p for pre-flight images

L = r for Level 0.5 real-time (Quick-look) flight images

L = 0 for Level 0.5 Middle or Final flight images

L = [1, 2, …] for flight images at level 1, 2 etc.

Yyyymmdd_hhmmss = year, month, day and hour, minute and second of the observation time

Typ = suffix indicating format, such as fts, gif, jpg, txt, ….

3.7 Standards Used in Generating Data Products

3.7.1 FITS Standard

The SECCHI image files will conform to the FITS standard as specified in Table 2-1 and clarifications may apply.

3.7.2 Time Standard

Time is Universal Time (UTC) unless otherwise stated. According the Flight Software Requirements document, “The exposure start time of all pictures shall be derivable by ground processing to Universal Time with an accuracy of 0.5 second.”

3.7.3 Coordinate Systems

The proposed coordinate system for SECCHI data is Helioprojective Cartesian using Gnomic projection. “Helioprojective Cartesian” indicates heliocentric coordinates where physical distances are replaced with angles, in recognition that observations are projected against the celestial sphere. It is an observer-centric system. The gnomic projection, or TAN, comes into play because the image is focused onto a flat focal plane, in this case a CCD detector (See Thompson, 2000, in Appendix A, Section A.2.).

4 DATA ANALYSIS

All Co-investigators may contribute to any aspect of the data analysis effort. Various groups have been established with bulletin boards to facilitate the communication between the groups. Each group has a leader or moderator. While cross-institutional collaborations are encouraged, most efforts at this time are based within a single institution.

At this time the various analysis groups and their moderators are:

- 3-D Reconstruction and Visualization: John Cook <cook@louis14.nrl.navy.mil>
- CME Science: Ken Dere <dere@halcyon.nrl.navy.mil>
- Space Weather: David Webb <David.Webb@hanscom.af.mil>
- MHD Modeling Jim Klimchuk <jklimchuk@ssd5.nrl.navy.mil>

5 DATA PROCESSING SYSTEM DEVELOPMENT PLAN

5.1 Timeline

- Image Decompression 3/19/04
- Processing Pipeline from TLM to FITS 6/24/04
- Database 8/1/05
- Website 8/1/05
- Data Archive 10/1/05
  - Order Archive Systems 5/15/05
- STEREO Analysis 11/15/05
- CME Search and Characterization 11/15/05
- Generate Movies 11/15/05
- Geometric & Photometric Calibration 11/15/05
- Process to Level 1 11/15/05

5.2 Software Reuse Strategy

Much of the image processing (decompression, FITS format, movies, etc.) is similar if not identical to that done for the Large Angle Spectrometric COronagraph (LASCO) and the Extreme-ultraviolet Imaging Telescope (EIT) on SOHO. The basic SECCHI image processing software will use the same IDL procedures as LASCO with slight modifications. For the TDS freely available C libraries exist to read/write FITS files (CFITSIO).

5.3 Testing

The DPS will be tested during STEREO Integration and Test (I&T). Observing plans for post-launch verification of instrument calibration will be developed before launch.

5.4 Configuration Management and Backup Plan

5.4.1 Software

Configuration management (CM) of data processing procedures will be done with the Concurrent Versions System (CVS). Calibration data will also be under CM. Information on calibration revision level will be contained in image headers, which are the output of calibration software.

Besides the ability to restore previous versions of software using SCCS, backups of software will exist as multiple copies in the SSW and on regular tape backups. The SECCHI library of data processing procedures will be on a shared disk, so processing may be done on any computer in the network.

5.4.2 Data

There will be at least three (3) copies of the processed level 0.5 FITS images and ancillary data products:

1. The primary archive online at NRL

[2. On removable media (such as DVD) at NRL]??

3. At the SSC

There will be one (1) complete set of all SECCHI raw telemetry (science and housekeeping) in the SSC archive. This archive is replicated at NRL.

5.5 Equipment and Space Requirements

Table 5-1 Equipment and Space Requirements

Use	Equipment	Need Date
Dedicated Web server	1 Sparc	Aug. 2005
Data Processing (mission sims)	2 Sparc	April. 2004
Data Processing (flight ops)	2 Sparc	Aug. 2005
Database	1 Sparc	Aug. 2005
Archive	2 DVD writers and 13 TB of storage for 2 years: DVDRAM jukeboxes or SAN solution	Aug. 2005
Data Distribution	2 Sparc	Sept. 2005
Generate movies	3 Sparc	Nov. 2005
Displays	Two 22”CRT, 8 17” LCD, plus servers	Jan. 2006

DVDRAM	Digital Video Disk Random Access Memory	SAN	Storage Area Network
CRT	Cathode Ray Tube	LCD	Liquid Crystal Display

6 ACRONYM LIST

Acronym	Definition
ADC	Analog to digital converter
Al	Aluminum
ApID	Application Identifier
APL	The Johns Hopkins University Applied Physics Laboratory
AR	Anti-Reflective
B	Brightness
CCD	Charge Coupled Device ((detector)
CCSDS	Consultative Committee for Space Data Systems
CDROM	Compact Disk Read-Only Memory
CEB	((SECCHI) Camera Electronics Box
CFITSIO	A FITS File Subroutine Library
CM	Configuration Management
CME	Coronal Mass Ejection
COR	SECCHI Coronagraph
CRT	Cathode Ray Tube ((monitor)
DBMS	Database Management System
DN	Digital Number ((photon counts)
DPF	Data Processing Facility
DPS	Data Processing System
DSMS	Deep Space Mission System ((= DSN)
DSN	Deep Space Network
DVD	Digital Video Disk
DVDRAM	Digital Video Disk Random Access Memory
EIT	Extreme-ultraviolet Imaging Telescope on SOHO
EUV	Extreme-UltraViolet
EUVI	Extreme-UltraViolet Imager
FITS	Flexible Image Transport System
FPS	EUVI Fine Pointing System
FSW	((SECCHI) Flight Software
FTP	File Transfer Protocol
GB	Gigabyte ((1 billion bytes)
GIF	Graphics Interchange Format
GSFC	Goddard Space Flight Center
GT	((SECCHI) Guide Telescope
HI	((SECCHI) Heliospheric Imager ((also refers to the HI package CEB)
I&T	Integration and Test
ICD	Interface Control Document
IDL	Interactive Data Language
JHU/APL	The Johns Hopkins University Applied Physics Laboratory
JPEG, JPG	Joint Photographic Experts Group ((glossy image compression)
LASCO	Large Angle Spectrometric COronagraph on SOHO
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LMSAL	Lockheed Martin Solar and Astrophysics Laboratory
LZ	Level 0 ((data)
MHD	Magnetohydrodynamic
MOC	((STEREO) Mission Operations Center
MPEG, MPG	Motion Picture Exports Group
MVI	NRL-developed IDL movie format
NA	Not Applicable
NASA	National Aeronautics and Space Administration
NOST	NASA Office of Standards and Technology

Acronym	Definition
NRL	U.S. Naval Research Laboratory
PB	Polarized Brightness
POC	Payload Operations Center
RAL	Rutherford Appleton Laboratory
S/C or SC	Spacecraft
SAN	Storage Area Network
SCCS	Source Code Control System
SCIP	Sun Centered Imaging Package ((includes SECCHI COR1, COR2, EUVI)
SEB	SECCHI Electronics Box
SECCHI	Sun Earth Connection Coronal and Heliospheric Investigation
SOHO	Solar and Heliospheric Observatory
SSC	STEREO Science Center
SSC	STEREO Science Center
SSW	SolarSoft IDL Libraries
SSWDB	SolarSoft Databases
STEREO	Solar TErrestrial RElations Observatory
TAN	Tangent
TB	Terabyte ((1 trillion bytes)
TBC	To be confirmed
TBD	To be determined
TDS	Telescope Development System
TLM	Telemetry
UNIX	X/Open operating system
UTC	Universal Time
WWW	World Wide Web

APPENDIX A DEFINITION OF SECCHI LEVEL 0.5 FITS HEADER

As of **October 22, 2002**.

This appendix exists as a separate document which may be updated separately.

A.1 Overview

A.1.1 Main Header

The items in the box are part of the pre-flight image header. Each group of keywords is to be added as they become applicable.

1. **Minimum Header:** All images taken with SECCHI cameras should have this header information, from camera level testing onward.
2. **Preflight Only:** Only images taken before launch will have these keywords.
3. **Misc. Camera/CCD values:** Values specific to CCD and camera characteristics. Should be in all images from camera level testing onward.
4. **Used from telescope level testing onward:** These keywords are applicable only if mechanisms apart from the camera are used in taking an exposure.
5. **Housekeeping Parameters:** Ancillary information indirectly related to an image.
6. **Software-Dependent Values:** These values are dependent on on-board image processing, nominally the SECCHI Flight Software (FSW).
7. **Computed from information external to the image, on the ground:** These values have ancillary information about spacecraft position, attitude, etc. This includes coordinate system definition.
8. **Computed from image values, on the ground:** Values computed from the image but not in the FSW are included here.
9. **History:** Examples of history field values.

A.1.2 SECCHI FITS Extension

Information about individual exposures used to compute a single image from a sequence is contained in an ASCII table extension to the FITS header.

1. **Extension Table Column (Field) Definitions:** These are the values that will be recorded for each exposure.
2. **Keywords for FITS Extension:** Each column in a FITS extension has its own set of keywords to define the type of value.

A.1.3 Table Description

The following tables have four (4) columns: KEYWORD, TYPE, VALUES, and DESCRIPTION.

KEYWORD gives the name of the FITS keyword and may be up to eight (8) characters.

TYPE refers to the data type of the header value:

- S String
- I Integer
- R Real
- L Logical

The size of the data depends upon the data type. For example S*2 is a two (2) character string, whereas I*2 is a two (2) byte integer (16 bits).

VALUES shows the range of values that the KEYWORD can take.

DESCRIPTION gives a short description of the keyword. At the end of the description is a reference to a FSW requirement, if any. (NOTE: FSW requirement numbers not up-to-date as of 9/10/02.)

A.2 References

1. "Coordinate Systems for Solar Image Data", http://orpheus.nascom.nasa.gov/~thompson/papers/coordinates.ps
2. "Definition of the Flexible Image Transport System (FITS)", http://archive.stsci.edu/fits/fits_standard/
3. "Definition of LASCO Level 1 FITS Header Keywords", http://lasco-www.nrl.navy.mil/level_1/level_1_keywords.html
4. "SSW Keyword/Tag Definitions", http://www.lmsal.com/solarsoft/ssw_standards.html
5. "A User's Guide for the Flexible Image Transport System (FITS)", http://fits.gsfc.nasa.gov/documents.html#Uguide
6. Detailed proposal for representing world coordinates in FITS (http://www.aoc.nrao.edu/~egreisen/inFITS.html):
7. *Representations of world coordinates in FITS* by Greisen and Calabretta, 31-December-2001.
8. *Representations of celestial coordinates in FITS* by Calabretta and Greisen, 12-December-2001.
9. *Representations of spectral coordinates in FITS* by Greisen and Valdes, 31-December-2001
10. SOHO object list http://Orpheus.nascom.nasa.gov/object.dat