C.5 Mission Operations Support

C.5.1 Operational Constraints

C.5.1.1 Commissioning Phase

During the commissioning phase we will have 3-4 people present at the SSC at any time, including the IDPU specialist (the Project Manager), an instrument engineer and scientist for each instrument checkout in process, the boom engineer for the boom deployment, and the integrated SEP package specialist for each SEP instrument checkout. Two workstations will be necessary to monitor housekeeping and commanding on one, and diagnostic science data on the other. This assumes one spacecraft is commissioned at a time (if both are undergoing commissioning during the same period, we will require two set-ups as described here). It also assumes internet connections will be available so that additional support can be given from other locations.

C.5.1.2 Regular Mission Operations

There are no operational constraints on the instrument package occasioned by the pointing of the spacecraft except for thermal or light exposure constraints. STE must operate in shadow, but that is accomplished by its location on the spacecraft boom. The MAG experiment requires periodic rolls of the spacecraft around the solar direction, as described in the STEREO Mission Requirements Document. If possible, some IMPACT instruments including SWEA and MAG are very interested in taking data during any yaw or pitch maneuvers also. Two workstations are expected to be used to display the housekeeping and commanding, and science data diagnostics, for monitoring at the SSC. The IMPACT team will provide the setup software for the necessary displays, and instructions for their use by SSC personnel. It is assumed this information will also be available via the internet to the IMPACT team sites on a continuous basis.

C.5.2 Mission Operations Plan

The IMPACT investigation mission operations support plan minimizes risk and cost with a central point of contact at UCB, the Operations/Data Manager (ODM). The ODM sequences commands and monitors instrument health for the entire investigation. The ODM is the sole point of contact with NASA on the operations for the investigation and he/she or their appointed assistant is on call 24 hours a day, 7 days a week (via pager) during the prime mission. The ODM collects and integrates the commands and software from all of the IMPACT team experimenters, and provides updates to the flight software for the IDPU or instruments. This task is a combination of management and programming that utilizes software developed by the instrument providers specifically for their contribution to IMPACT. The ODM checks all commands and changes to the flight software on a high fidelity pre-integration breadboard IDPU testbed maintained at UCB prior to transmitting them to the STEREO SSC for uplink at the MOC.

Each instrument also has a cognizant CoI, who provides high level guidance, develops the command sequence, and makes any needed changes to the instrument-specific flight software. These are transmitted to the ODM who in turn assembles the weekly sequences, tests them and then forwards them to the SSC over the project-provided internet link. The IMPACT team has minimized operational modes and commanding of the instruments and returns a standard set of observations throughout the course of the investigation. The IMPACT integration and test phase GSE will be left with the SSC for the purpose of providing a monitor for IMPACT operation. The PM will develop an IMPACT housekeeping data display that allows SSC personnel to determine at a glance if there is an IMPACT problem. The ODM is always available for contact in the event of an IMPACT anomaly, and immediately reports any variances to the cognizant CoI for that subsystem. The ODM maintains an IMPACT investigation database of voltages and temperatures for all instruments and subsystems critical to the success of the investigation.

C.5.3 Uplink Data Volume

IMPACT does not require a significant volume of commanding. We require some limited near-realtime commanding during early operations to get the instruments powered on and tuned up, on the order of 100 commands over the first week. After that, occasional adjustments and operational mode changes requires only a few commands per month. IMPACT also requires occasional time-tagged commands. These can be included in the spacecraft time-tagged command memory, or if that is not possible, a similar mechanism can be included in the IDPU.

C.5.4 Data Processing, Validation, Analysis and Archiving

C.5.4.1 Data Processing Plan

The data processing plan is designed to minimize cost, optimize data quality and enable efficient dissemination with the same point of contact, the ODM. Both Operations Manager and Data Manager roles have been successfully filled by a single person during UCB's WIND mission participation, suggesting the same approach for IMPACT. The IMPACT summary data dissemination and display system that provides STEREO in situ data in forms most used by the community is based on a pre-existing system at UCLA currently widely used for IMP-8, ISEE, and GGS mission data access (http://www-

ssc.igpp.ucla.edu). This system is available to the UNH-PLASTIC and SWAVES investigations for comparable access to their complementary key parameters.

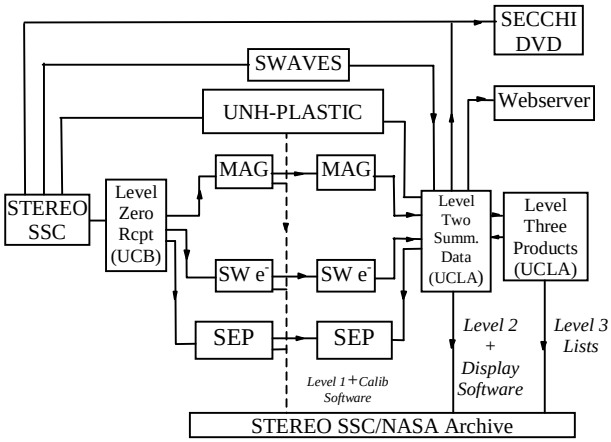

Figure C.5.1. IMPACT Data Flow

Figure C.5.1. shows the data flow from receipt from the STEREO SSC through to the data archive. We assume that the Level zero data are unpacked, time sorted, and distributed to the STEREO teams by the SSC. The IMPACT Level zero data made available to UCB are provided by the ODM to the individual IMPACT instrument teams. The instrument provider, who is intimately familiar with the performance of their instrument, is responsible for quality checking their data and informing the ODM of any irregularities. The ODM analyzes and reports any such irregularities in either the instrument or IDPU level zero data and records them in a database to be archived with Level 1 data.

Level 1 data are obtained by running the Level zero 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. Both the Level zero and Level 1 data, together with calibration and basic processing software for the full investigation, are next submitted to the designated project archives by the IMPACT ODM at UCB. The in-situ data set is modest, and can be delivered electronically, avoiding media and mailing costs. The Level zero archive includes the space weather beacon data. If desired, UNH-PLASTIC and SWAVES Level 1 data can be included with the IMPACT Level 1 data sent to the archive. These Level 1 data are also referred to as high (time) resolution data, and contain all of the measurements made by the IMPACT instruments in physical units.

The second stage of data processing, at our IMPACT summary data access site at UCLA, provides Level 2 and 3 products and archiving. Our Level 2 or key parameter data consist of synchronized one-minute summary data sets containing the most often used quantities from IMPACT, PLASTIC and SWAVES, such as plasma moments. Level 3 products result from basic analyses of the IMPACT data, for example shock identifications and characterizations. The timeline for data processing is summarized in Table C.5.1.

Table C.5.1. Data Timeline

Process Time Required from Release of Data (location)	
Check and verify Level 0, catalogue	< 3 hours (UCB)
Run Calibration on Level 0 --> Level 1	24 hours (UCB)
Level 0 and 1 data+software to Archive	2 months(UCB)
Process Level 2 (summary database)	2.5 months (UCLA)
Level 2 Products to SOC and Archive	2.5 months (UCLA)
Create Level 3 Value-added Products	3 months (UCLA)
Level 3 Products to SOC and Archive	3 months (UCLA)

The Level 2 processing creates the combined, averaged set of data that will be the workhorse for most research using the IMPACT investigation data. Anticipated summary data include: solar wind density, velocity, electron and ion temperatures, electron and ion anisotropy referenced to the magnetic field, major ion species densities, suprathermal electron fluxes and anisotropies in several energy ranges, magnetic field vector components in GSE and GSM coordinate systems, standard deviation of the field, solar wind convection electric field (E = -V X B), a provisional Dst index computed from the solar wind measurements, SEP fluxes as a whole and in several energy ranges, SEP anisotropy in the chosen energy ranges, and all of the directly transmitted Beacon data for comparisons with the calibrated and cleaned final values of the same quantities. Open Web access is provided to the Level 2 summary data through the existing UCLA data display and dissemination system (http://www-ssc.igpp.ucla.edu), while specialized data products and displays are accessed through hyperlinked instrument contributor Web sites.

The IMPACT team applies their expertise to provide value-added Level 3 products that enhance access to and use of the data. For example, team members review the database to identify the start and stop times of all ICMEs on both spacecraft; they invert all ICME flux ropes and provide the scale size and axis orientation using codes developed at UCLA. The team identifies all interplanetary shock encounters, and determines the shock speed, Mach number, and shock normal orientation. They provide the onset times, spectral parameters, peak fluxes, and rise and decay times of all energetic particle events. The Level 3 data are also made available for the STEREO project database. UNH-PLASTIC and SWAVES investigation data are absorbed into this system in a mutually agreed upon way that best utilizes the combined data. The UCLA in-situ STEREO data access site is maintained in addition to any access provided by the instrument teams or the SSC. The SECCHI investigation will similarly use the SDAC for public access to STEREO images and engage IMPACT, UNH-PLASTIC and SWAVES in creating a useful DVD archive of the combined STEREO remote sensing and in-situ data.

While the routine processing steps are centralized to minimize costs, we emphasize that each cognizant CoI develops the calibration factors and software for the individual data sets, performs quality checks, calculates moments as appropriate and compares these with the real-time space weather data that are transmitted separately. This critical validation process is placed under cognizant CoI control, both to minimize the possibility of errors, and to maximize the utilization of experience and existing software. As soon as the data have passed the data quality checks, the ODM is notified and the data are documented and submitted to the archive. Software is included with any level of archived IMPACT data for access and display, making the IMPACT data readily usable by the scientific community.

Some minor Level 1 processing is desirable for the space weather Beacon data from IMPACT, for example the calculation of the magnetic field in various coordinate systems such as GSM and GSE, or the calculation of SEP fluxes using improved geometric factors and updated efficiencies. For this purpose, the IMPACT team will supply the necessary software to the SSC which will be the distributor of the STEREO Beacon data.

C.5.4.2 Data Validation

IMPACT data validation includes the high time resolution, Level zero, and its calibrated counterpart Level 1, data and the low resolution space weather beacon data. The Level zero and Level 1 data are quality checked with proven techniques used in prior programs, and the content compared against their expected values, by the instrument scientist for each instrument. For example, the zero levels of the magnetometer are continually checked using the fact that in the solar wind the strength of the magnetic field is not correlated with the direction of the field. After the data are validated, the algorithms are updated and a set of Level 2 data produced for the summary database. These best values are compared with the space weather beacon data, and any needed adjustments are made and transmitted to the ODM for uplink at the next available opportunity.

C.5.4.3 Data Analysis Plan

The IMPACT team plans a working group approach to scientific problem solving under team member leaders. These working groups will have representatives from the appropriate measurement and modeling groups. The problems to be solved will vary as the STEREO spacecraft move apart, at first involving the local ejecta features and later the entire ICME and the complementary quadrature imaging. Each of the instrument CoIs already has software inherited from previous missions for the analysis of data from their sensors. The most useful of these routines are made available to the community at large for use over the Web on the IMPACT investigation summary database access site.

C.5.4.4 Archiving and Public Access Plans

The IMPACT team archives its Level zero and Level 1 data and Level 1 processing and calibration software, with Level 2 and 3 data as project options, and sends them to the appropriate archive center according to the schedule in Figure C.5.1. The anticipated data volume is summarized below in Table C.5.2. This archival data follows agreed upon standards and includes the software used to produce the data, and documentation and software needed to access the data. While these data and routines are sufficient for complete public access to the data, the IMPACT team provides web access to the investigation Level 2 summary data for easy previewing of the in situ observations, event identification and context, and for statistical and case studies.

The IMPACT data access site at UCLA (http://www-ssc.igpp.ucla.edu) will tailor a user interface for the two-spacecraft STEREO configuration. Down-loadable files will be in selectable ascii or flat file (binary) forms. Web displays containing user-selected measured quantities will allow simultaneous viewing of the data from both STEREO spacecraft, with the option to invoke such features as corotation lag. Spacecraft position information is also supplied. Hyperlinks to IMPACT instrument, UNH-PLASTIC and SWAVES sites, and to associated imaging data sites, will be included should the user desire additional information on an instrument or more specialized data products.

Table C.5.2. Archivable Data Volume

Data Source	**Rate** (bps)	**Level 0** (GB/2yr)	**Level 1** (GB/2yr)	**Level 2** (GB/2yr)	**Level 3** (GB/2yr)
Solar Wind	458	3.7	14.6	1.5	0.1
Magn. Field	154	1.3	6.5	1.5	0.1
SEP	800	6.3	25.2	1.5	0.1
Beacon	32	0.2	1.0	0.1	0.1
Burst Mode	524	4.2	16.5	4.0	-
Models	-	-	-	-	20.0
Total	1968	15.7	63.8	8.6	20.4