SECTION 2. INTERFACE OVERVIEW

2.1 DATA EXCHANGED

The subsections below provide a description of the various data items exchanged over the interface between the ECS and the instrumenters. Several modes of data transfer will be used:

1) Data stream: transfer data in real-time over sockets.
2) File transfer: transfer large and less time-sensitive data using File Transfer Protocol (FTP).
3) Remote graphic displays: graphical interface to interactive ECS processes via X.11.
4) Mail services: address text messages to a specific user to be read later using Simple Mail Transfer Protocol (SMTP).

Table 2.1 provides a list of the main types of data exchanged between the ECS and the instrumenters and, for each type, it identifies the mode of data transfer used.

Table 2.1. Data exchanged over the ECS/instrumenters interface

DATA TRANSFERRED:	DIRECTION	TRANSFER MODE
Session Control messages	Bidirectional ECS/IWSs	Data stream
Near-real-time commanding data	IWSs to ECS	Data stream
Commanding status messages	ECS to IWSs	Data stream
Informational messages	Bidirectional ECS/IWSs	Data stream/Mail services
Commanding and telemetry status windows	ECS to IWSs	X.11 remote graphic display
Delayed commanding data	Instrumenters to ECS	File transfer
Background-queue commanding data	Instrumenters to ECS	File transfer
Delayed command validation reports	ECS to Instrumenters	File transfer
Background-queue cmd validation reports	ECS to Instrumenters	File transfer
Real-time telemetry data	ECS to IWSs	Data stream
Real-time TLM distribution control messages	ECS to IWSs	Data stream
Quicklook / Archived TLM data	ECS to Instrumenters	File transfer
Activity plan	ECS to Instrumenters	File transfer
Instrumenter input to activity plan	Instrumenters to ECS	File transfer
Summary data	ECS to Instrumenters	File transfer
Instrumenters input to the Summary Data	Instrumenters to ECS	File transfer
Orbit and attitude data	ECS to Instrumenters	File transfer
Command history data	ECS to Instrumenters	File transfer
Time correlation log	ECS to Instrumenters	File transfer
SOHO Daily Report	ECS to Instrumenters	File transfer
As-Run Database	Instrumenters to ECS	File transfer
Synoptic data	ECS to Instrumenters	File transfer
Project data base	ECS to Instrumenters	File transfer
Project data base update requests	Instrumenters to ECS	Mail services
Time services	ECS to Instrumenters	Data stream

2.2 COMMANDING PROCESS OVERVIEW

There are two primary commanding modes differentiated by the delay between the time the commands are transmitted by the instrumenters and the time they are uplinked: the near-real-time commanding mode and the delayed commanding mode. In both modes, all instrument commands are routed to the instruments as soon as they are received by the spacecraft, since the instrumenters may not use the spacecraft time-tagged buffer. The actual execution of a command once it is received by an instrument processor is not relevant to this classification.

A third commanding mode is defined to accommodate the case where instrumenters need to utilize spacecraft commands or critical commands: the FOT-coordinated commanding mode. The instrumenters must coordinate the issuance of these commands with the FOT operator who will send the commands requested by the instrumenters. This commanding mode may also be utilized in case of contingency. A particular case of this commanding mode will be used to command the VIRGO instrument.

The commands are submitted either in binary or in mnemonic format by the instrumenters who have the basic responsibility of command validation. The role of the ECS is limited to verifying that the commands originate from an authorized source, and does not include a check against the command definitions in the PDB. This check is done by the CMS. However, commands that will be submitted in the binary format will not be checked against the PDB. In particular, critical commands cannot be flagged. The instrumenters have the choice of disallowing commanding in binary format and they may do so by contacting the SOC. From then on and until the request is revoked by the originating instrumenter, ECS will reject commands in binary format for that instrument.

2.2.1 NEAR-REAL-TIME COMMANDING

The near-real-time commanding data is submitted by the IWS to the ECS as a series of "messages", the functional protocol being, as much as possible, similar to the protocol used with the Central Checkout System (CCS) in the Assembly, Integration and Validation (AIV) environment. Modifications have been necessary to support the operational environment.

2.2.1.1 Throughput Mode

The overall ground system requirement for this mode is that commands generated by an instrumenter in the EOF will be received by the spacecraft within 60 seconds. More specifically, ECS shall make a single near-real-time command available for transmission to the SMOCC within 10 seconds of reception from an IWS. This mode is only available to the instrumenters who are resident in the EOF. Its primary goal is science monitoring and control of experiments as dictated by changes in solar activities. Thus, full processor reloads would normally not be done in this mode, although the uplink of large loads might be negotiated among the experiment teams resident at the EOF.

The throughput mode may be interrupted or ended in three different ways:

1) Pause: In order to allow POCC or FOT activities to take place, the throughput mode is temporarily interrupted. At that time, ECS stops accepting near-real-time commands from the instrumenters but all near-real-time command queues in ECS and in the SMOCC are maintained. When the throughput mode resumes, near-real-time commanding resumes without any data loss.

2) Stop gracefully. This is the normal ending for the throughput mode. SMOCC sends a warning that the throughput mode will be ended shortly. All the near-real-time commanding data in the ECS queues and in the SMOCC queues are processed, uplinked and acknowledged before the throughput mode is ended.

3) Stop immediate. In cases of emergency, SMOCC will terminate the throughput mode without a warning. In this case, all the near-real-time commanding queues in the SMOCC and in the ECS will be flushed.

If an error is detected in a near-real-time command group, both the ECS and SMOCC will reject all near-real-time command groups addressed to the same instrument following the group where the error was found. The originating IWS must submit an Instrument Reset message. Commanding will resume after proper reception by ECS and SMOCC of the Instrument Reset message. All near-real-time command groups for the same instrument between the group in error and the reset message will be discarded by ECS and the CMS. The operation of the throughput mode for the other instruments is not affected by this process.

2.2.1.2 Reserved-time Commanding

This mode allows one or more instrumenter teams to have exclusive use of the throughput mode during a reserved period of time. At least one operational day in advance, an instrumenter requests a reserved time slot, and indicates the command volume expected. The request may be included in the planning process, it is negotiated among the EOF instrument teams, and if accepted, the requested time window is reserved for that instrument. The SOC will manually control the start and end of a reserved-time session. This mode can be used when an instrument requires a larger amount of commands or when the command uplink needs to be timed in a very precise manner.

2.2.2 DELAYED COMMANDING

In this mode, the commanding data will be uplinked to the spacecraft by the FOT within a time window specified by the instrumenter. The delayed commanding mode applies to individual command groups which need to be uplinked during a rather precise time window. It is available to all instrumenters, EOF resident or not.

A command group is submitted in a file, the header of which specifies the desired uplink window. Under normal operational conditions, the file should be submitted to the EOF at least 8 hours be fore the start of the operational day during which the commands will be uplinked. When received by ECS, the command group is submitted to the CMS for validation. CMS will return a command validation report which will be transmitted back to the originating instrumenter. If the group is valid and the requested uplink time does not create any scheduling conflict, it will be uplinked by the FOT during the specified window.

The width of the requested uplink window should be on the order of one hour. This would avoid scheduling conflicts and too frequent interruptions of the throughput mode since the uplink of delayed commands necessitates pausing the throughput mode for near-real-time commands. There also will be times outside of the throughput mode reserved for payload-related activities by the FOT; these time windows will be specified in the ECS activity plan and should be used as much as possible for the uplink of delayed commands. CMS cannot ensure the ordering of individual command groups that would have the same or overlapping uplink windows. In order to avoid

sequencing problems, the following is suggested: for a given instrument, all delayed command groups should have non-overlapping uplink windows. As long as the maximum number of commands contained in a single file does not exceed the allowed limit, a single larger group should be used instead of several smaller groups with the same requested uplink window.
ECS is informed of a successful uplink via an informational message generated in the POCC. This informational message is forwarded to the IWS commanding this instrument if a NRT session is open at that time. In order to accommodate remote instrumenters, ECS will also send the same message via E-mail to two addresses agreed upon between the instrument team and the ECS.

2.2.3 BACKGROUND-QUEUE COMMANDING

This mode is primarily intended to deal with large command groups which do not need to be uplinked in a time-critical manner. In particular, this mode will be used for large amounts of commanding data (e.g., large table loads) which could block the commanding link for a long period of time. To avoid this, the instrumenters must package the commanding data into "chunks" no larger than 0.5 Kbytes. Just like for delayed commanding, ECS submits the command groups to the CMS which returns a command validation report that will be transmitted back to the originating instrumenter. If no errors were found, the command groups are put in the SMOCC "background queue". The individual groups are uplinked in the order submitted by the instrumenter, by interleaving them into the real-time command stream as soon as some space becomes available. However, ECS and SMOCC understand that there is no need to uplink the individual chunks in any specific order. Background-queue commands have the lowest priority among all commanding data. The originating instrumenter may optionally specify an uplink window. If not specified, the chunks are uplinked whenever possible without a time limit. If specified, CMS would reject all the chunks that could not be uplinked during the requested uplink window. It is recommended that the width of the requested uplink window be at least on the order of one week.

Note that for both delayed and background-queue commands, once the validation report has been received and until uplink confirmation, there is no electronic method for an instrumenter to determine the status of the submitted file. This information may be requested from the FOT through the SOC.

2.2.4 FOT-COORDINATED COMMANDING MODE

This mode allows the instrumenters to request the execution of spacecraft commands or critical commands. This is implemented using either a Remote Command Request (RCR) or a Remote Procedure Request (RPR). When originating from an IWS, these requests are received by the ECS and forwarded to the FOT via the SMOCC in a format similar to the NRT command messages. These requests identify the originating instrumenter and contain the name of a Predefined Command Sequence (PCS) in the case of an RCR, or the name of a STOL procedure in the case of an RPR. The PCSs and STOL procedures are defined directly between the instrumenters and the FOT. The FOT maintains a list of PCSs and STOL procedures that have been approved and can be invoked in RCRs or RPRs respectively. The throughput mode can be set to either allow RCRs or not. If RCRs are disallowed, ECS will reject them. If RCRs are allowed, ECS forwards them to the CMS/POCC. If an instrumenter's RCR is valid, the PCS will be automatically executed in the POCC and incorporated into the uplink transmission. Critical commands are not allowed via RCRs. If an instrumenters' RPR is valid, the FOT operator will initiate its execution. The throughput mode will have to be paused during the execution of an RPR. ECS will always acknowledge the receipt of an RCR or RPR via a NRT response message. For RPRs, the originating IWS will receive an informational message containing text defined in conjunction with the FOT as part of the procedure itself (last line of the procedure).

This mode of commanding may only be used by EOF-resident instrumenters while the near-real-time throughput mode is enabled. For remote instrumenters, it will require communication with the SOC (E-mail or fax) to request the intervention the FOT operator.

2.2.5 COMMANDING PRIORITY SCHEME

The ECS has a requirement to prioritize the commanding data it receives from the instrumenters. To that effect, different levels of priority are implemented at the instrument level.

Near-Real-Time Commanding
Two priority levels apply:

> **1) High Priority.** This level is intended for emergency situations. It may only be granted by the SOC for near-real-time commands originating from a given instrument or a given set of instruments. It may even be a single-user mode where all commanding activities for all other instruments are stopped.
>
> **2) Normal Priority**. This is the normal level of priority for near-real-time commanding. However, ECS provides several levels within the normal priority (instruments can be prioritized on an individual basis). These levels will be negotiated by the instrument teams during the daily planning meeting, but they can be changed at any time by the SOC. This will allow the instrumenters to control, and modify when needed, the allocation of relative priorities regarding near-real-time commanding.

Delayed and Background-Queue Commanding
All delayed commanding data is assigned a lower priority for transmission to the SMOCC. Within the SMOCC, delayed commands are guaranteed an uplink time. Background-queue commands are assigned the lowest priority level and are only transmitted when the uplink channel is free.

2.3 TELEMETRY DISTRIBUTION

ECS receives, archives and distributes real-time telemetry data (house-keeping, science and MDI-M data) to the resident instrumenters. ECS receives and archives tape recorder playback data.

2.3.1 REAL-TIME TELEMETRY DISTRIBUTION

The real-time telemetry data is comprised of housekeeping and science data (VC0 and VC1), as well as MDI-M data (VC2). ECS receives that data from the Information Processing Division (IPD) Packet Processor (PACOR) as a stream of packets identified by an Application Process Identifier (APID). ECS distributes these packets in real-time to the IWSs.

During a given real-time pass, the IWSs request the APIDs they wish to receive, each APID being requested individually. An IWS may request more than one APID for simultaneous distribution (for example, housekeeping and science from different sources). A given IWS is not limited to telemetry from the instrument it primarily controls, and it may request telemetry from other instruments. The maximum number of APIDs that may be requested simultaneously depends on the system capacity and utilization: if during the pass, the requests for telemetry distribution exceed the system capacity, the instrumenters will have to negotiate and modify the distribution scheme.

The IWSs receive the telemetry packets they requested in individual messages, one packet per message. PACOR provides quality and accounting information associated with each packet. The instrumenters may select to either receive or not receive this information on a session basis. Under normal conditions, ECS will stop distributing the telemetry to a given IWS either following an interrupt-packet-transfer message from that IWS, or at the end of the real-time pass.

2.3.2 ARCHIVED TELEMETRY DATA

The telemetry data archived within ECS consists of all VC0, VC1 and VC2 packets received either as real-time telemetry or as quicklook data, including the tape recorder dumps and retransmissions of real-time telemetry in the case of a transmission loss. The archived telemetry data are sorted by APID and by time: each file contains approximately 2 hours worth of data for a single APID. The tape recorder dump data are available to the instrumenters at ECS within approximately 2 hours of downlink. The telemetry data are kept on-line for 7 days and off-line for 21 days.

The archived telemetry data are organized among several system directories and specific naming conventions are used. That data may be retrieved by the instrumenters via file transfer. To access the data, the instrumenters utilize the telemetry file naming conventions and search the system directory. They may also submit to the SOC a request to receive the telemetry data for a given set of APIDs and ECS will automatically send the requested data via FTP as soon as the files are available.

2.4 MISSION SUPPORT DATA

2.4.1 SUMMARY DATA

These data provide a synopsis of solar conditions and SOHO science programs. They include three classes of data: images from the imaging instruments, parameters from non-imaging instruments, and a list of observation programs which is information extracted from the As-run database. Table 2.2 describes the various components of the summary data.

Table 2.2. SOHO Summary Data.

Instrument	Images	Key Parameters	Observation Program
GOLF		X	X
VIRGO		X	X
MDI	X		X
SUMER	X		X
CDS	X		X
EIT	X		X
UVCS	X		X
LASCO	X		X
SWAN		X	X
CELIAS		X (CDHF)	X
CEPAC		X (CDHF)	X

MDI, EIT, UVCS and LASCO are expected to provide ECS with daily images. SUMER and CDS are also expected to provide images, but possibly not on a daily basis. Key parameters will be calculated for CELIAS and CEPAC by CDHF, and will be kept on-line in that facility. Parameters are expected to be provided to the SOC in the ECS by GOLF, VIRGO, and SWAN. A daily observation program report will be compiled by the SOC based on input from the instrumenters (see As-run database).

The average size of the instrumenter input to the summary data is 20 Mbytes per day. ECS stores these data (images, instrumenter-generated parameters, and observation program report) for on-line access by the instrumenters for 28 days. Input to the summary data is submitted to ECS by the individual instrumenters. Under the control of the SOC, it is merged and stored in the ECS where the instrumenters can access it. Once all the instrumenter input has been received and approved, the SOC transmits the daily summary data to CDHF.

2.4.2 PREDICTIVE AND DEFINITIVE ORBIT DATA

The orbit data describes the translational motion of the spacecraft relative to an inertial reference system. Definitive orbit refers to the measured past translational motion of the spacecraft; predictive orbit refers to the calculated future translational motion of the spacecraft. That data consists of a series of state vectors describing the position and velocity of the spacecraft at 10-minute intervals. The orbital data is generated weekly or biweekly by FDF, sent electronically to CDHF and forwarded to EOF. The definitive data describes the previous week (7 days), and the predicted data refers to the upcoming 5 weeks (42 days). ECS stores 5 weeks of predictive and 28 days of definitive orbit data on-line. With 10-minute intervals between data points, the average daily volume of orbit data is on the order of 1.0 MB.

2.4.3 DEFINITIVE ATTITUDE DATA

Definitive attitude data describes the past rotational motion and pointing stability of the spacecraft relative to an inertial reference system. It contains pitch and yaw offsets from Sun-center, and roll angle offset from the projection of the Sun north pole.

Two attitude products are available in the EOF:

- the "full-time resolution" data contains pitch and yaw values at 10 samples per seconds and roll values at one sample per second.
- the "definitive attitude" data contains pitch, yaw and roll values averaged over 10-minute intervals.

The attitude data is generated by CDHF and forwarded to the EOF. ECS stores 28 days of attitude data.

2.4.4 COMMAND HISTORY

This data is provided by the SMOCC and contains a time-ordered list of POCC activities and all the command groups uplinked to the spacecraft during a given operational day. This is a fixed-format report, where each entry contains a time field and a description of the activity. Instrument commanding activities are keyed by instrument name and command group ID uniquely identifying each command group. CMS will append to that report activities that are specific to the CMS, such as the background queue processing.

2.4.5 SYNOPTIC DATA

This data is comprised of images and science reports obtained from other missions and other observatories. It is presently estimated that ECS would receive approximately 50 Mbytes per day of solar-related data for planning purpose. It is obtained by the SOC, and stored for 7 days within the ECS, for access by the instrumenters.

2.4.6 TIME CORRELATION LOG

This information describes the on-board clock drift rates and resets. This data is created from information received from the SMOCC in the command history report. It will be kept within the ECS in a data set containing the times and description of procedures run in the POCC affecting the spacecraft clock.

2.4.7 PROJECT DATA BASE

The PDB is maintained by the POCC. ECS will obtain the original version of the PDB from the POCC. Later on, when new versions of the PDB are issued, the POCC distributes the entire updated PDB to the interested entities.

The POCC provides the PDB to the ECS via tape or possibly electronically, as a series of ASCII files. ECS will make these files available for the instrumenters to retrieve them via file transfer. These files are in the format provided by the POCC, that is the format defined in the Data Format Control Document (DFCD) which is produced by the POCC (reference 14). ECS does not modify or reformat them. An E-mail message will inform the instrumenters of the reception of a new PDB.

2.4.8 PROJECT DATA BASE UPDATE REQUESTS

When instrumenters need to request an update to the existing PDB (for example modification of command or telemetry parameter definitions), they must send an E-mail message to the FOT operator describing the desired change. FOT will approve or reject this request. If accepted, it will be incorporated into the operational data base which is the POCC working copy of the PDB. Recreating an operational data base is usually a cumbersome process and is done infrequently. Changes to the PDB require approval by the Configuration Control Board and there may be a rather long delay between the time a PDB update is requested by an instrumenter and the time it is actually implemented.

2.4.9 SOHO DAILY REPORT

FOT sends this report to ECS via E-mail, typically within 24 hours of the operational day being reported. It gives a high level status of the spacecraft and each instrument (ON/OFF) for that day. The report provides descriptions and times of anomalies or contingencies in the spacecraft or any instrument. The SOHO Daily Report contains the times of any unrecoverable data gaps. It will be stored in one file per operational day, each file being uniquely named for that calendar day. It will remain available on-line in the EOF for the most recent 30 days. It is also transmitted electronically to CDHF where it is stored on-line for 30 days for access by remote instrumenters and other interested researchers. The SOHO Daily Report will be included by DDF in the distribution data on hard media.

2.4.10 TIME SERVICES

The ECS will obtain the Universal Time using the Network Time Protocol (NTP). The ECS system clocks will be synchronized to that time to allow for uniform time tagging. Using the appropriate utilities on their own systems, the instrumenters will be able to access that time service and synchronize their own system clocks.

2.4.11 DISPLAYS

Two main types of displays are made available to the instrumenters:

1) Commanding Status and Telemetry Distribution Monitoring displays. These displays are primarily designed and implemented to support the SOC with ECS monitoring functions. They are made available to the EOF-resident instrument teams that have X.11 capabilities. ECS will make available to the instrumenters ANSI C code to support these displays on their workstations. The format and general content of these displays are provided in Appendix B.

2) POCC Telemetry Displays. Two POCC terminals will be located in the EOF. POCC telemetry pages will be displayed on these terminals for viewing by the instrumenters within the EOF.

2.5 PLANNING PROCESS OVERVIEW

The planning process enables the instrumenters to incorporate their science activities with pre-existing constraints such as DSN contacts or commanding time slots reserved by the FOT for special spacecraft activities. Planning can be done on a quarterly, monthly, weekly or daily basis. The long term planning is mainly based on science programs, whereas the shorter term planning is more detailed and incorporates DSN schedules and FOT planned activities.

In order to initially set-up the planning process, a set of activities needs to be defined. The definition of activities also includes specifying associated priorities and scheduling strategies. For the shorter term planning (monthly or less), the instrumenters are expected to submit their activity requests to ECS who merges them. ECS identifies and resolves conflicts when possible. If conflicts remain, the instrumenters are notified, and they should modify and resubmit their requests. This process is repeated until all conflicts are solved. The final conflict-free plan is referred to as the schedule.

2.5.1 ECS ACTIVITY PLAN

The ECS Activity Plan (EAP) consists of a list of activity requests or notifications. The following is provided to the instrumenters as part of the activity plan:

1) DSN Contacts. This provides DSN contact start and end times, and the associated ground station. This information is incorporated into the activity plan as soon as the ECS receives it from the SMOCC. Each transmission covers one week of confirmed schedule and up to 3 weeks of forecast and FDF predicts schedule. Long-term predictions may be incorporated if and when available. This information is transmitted by the SMOCC every week on a fixed day, 3 days before the start of the confirmed week.

2) FOT-controlled Events. This indicates the start and end times of events and activities controlled by the FOT. For instance, it includes time windows for planned near-real-time commanding and time windows reserved by the FOT for special activities such as spacecraft commanding, maneuvers and instrument maintenance. It also provides start and end times for events such as tape recorder dumps, MDI-M transmission to the EOF and planned telemetry modes.

3) Reserved Times for Activities Coordinated with Other Observatories. This indicates the start and stop times of science programs and special campaign activities.

2.5.2 INSTRUMENTERS INPUT TO THE ACTIVITY PLAN

The Instrumenters Input to the Activity Plan (IAP) consists of a list of statements, each statement defining a specific activity request or notification. These statements may be classified as follows.

1) Science Plan and Program Notifications. The Science Plan entries describe the planned science plans, their goals and objectives. They specify the first level of science planning information, i.e. the overall plan as developed during the monthly or weekly science planning meetings and refined during the daily meetings. The Science Program entries describe the specific programs that each instrument team would run to satisfy the scientific objectives of the corresponding Science Plan: for each Plan entry, there will be a sequence of Program entries that represent the details of the Science Plan.

2) Notification for Special Activities. This is used to indicate when an instrument will perform an activity that may affect the operation of other instruments. This will include requests for near-real-time commanding for a specified period of time, requests for a reserved time slot for near-real-time commanding for a given instrument, or uplink window for a group of delayed commands. It may also include notifications of planned execution of STOL procedures and maneuvers that may cause vibrations and affect the overall pointing stability of the spacecraft.

3) Instrument Mode Change Notifications. Examples of possible requests are:

- Change in telemetry sub-modes
- Change in the inter-instrument flag configuration
- Change in instrument mode of operation (specific to each instrument).

Specific requests may be defined by the instrument teams for activities which are of interest to or affect the operation of other instruments.

2.5.3 AS-RUN DATABASE

This information is provided by the instrumenters to the ECS. It describes the science programs that were actually executed on the previous day. It is electronically transferred to the ECS as ASCII files and the SOC is responsible for incorporating it into the Summary Data that will be sent to the CDHF for later distribution to the instrument teams. The design and implementation of the As-run database are not the responsibility of the ECS development task and further details on the nature and format of that data are not included in this ICD.