6.0 MISSION OPERATIONS

Overview. Figure 6-1 shows the STEREO Mission Operations System (MOS) which consists of the two STEREO spacecraft, DSN ground stations, Mission Operations Center (MOC), the Science Operations Center (SOC) and their respective operational teams. The STEREO spacecraft will be operated by APL utilizing the DSN for communications with the spacecraft after launch. The spacecraft bus and the instrument suite will be operated in a decoupled fashion. The MOC will support all spacecraft bus operations and the SOC will operate all instruments on both spacecraft, although communication between the SOC and the spacecraft will necessarily flow through the MOC. All spacecraft servicing, including commanding and data recovery will occur during a single (nominal) ground contact, or track, each day. This track will extend over a two to eight hour window, depending on the spacecraft's range from Earth. Spacecraft command messages will be uploaded and real-time engineering data will be downloaded and evaluated to assess spacecraft health. The Solid State Recorder (SSR) will be played back on each contact and all science data will flow to the SOC in near real-time.

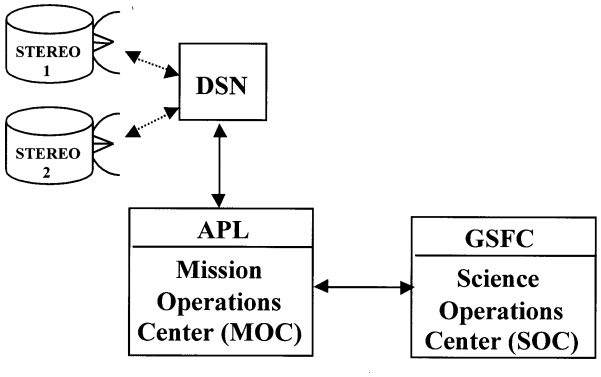

Figure 6-1 STEREO Mission Operations System

6.2 Mission Operations Center

The MOC has primary responsibility for management of the spacecraft bus including the development of operational timelines with associated command sequences and the uplink to the spacecraft by way of the DSN. Recovery of spacecraft bus engineering telemetry and the analysis of this telemetry is also performed at the MOC. The MOC receives instrument command sequences (packets) from the SOC and, after verification, queues them for uplink to the spacecraft based on start and expiration times appended to the command messages by the SOC. The MOC also distributes the downlinked science data and necessary operational data products to the SOC. The MOC is operated by the Mission Operations Team (MOT) and is located at JHU/APL in Laurel, MD.

6.2.1 Mission Operations Team

The MOC is staffed and operated principally by the Mission Operations Team (MOT). Staffing of the MOT will begin during the development phase of the program. Every MOT staff member will have a detailed knowledge of the operation and constraints of both STEREO spacecraft and MOS. The MOT will be assigned functional responsibilities necessary to provide both an education and essential tasks in support of the Spacecraft Bus Engineering Team (SBET) as well as the Integration and Test (I&T) Team. The MOT will support the SBET during the testing of the subsystems prior to delivery to the I&T Team. Components of the actual MOC will be employed to support subsystem testing and the I&T phase of the program. These components will be used to develop of databases, display formats and command sequences which are necessary to support subsystem tests. These items may be brought forward to the spacecraft system level support effort.

During the I&T phase, the MOT will be part of the I&T Team. They will define and produce the necessary system level tests to support the conduct of mission simulation tests. The spacecraft will be tested in the same manner as it will eventually be operated on-orbit. During test, the MOT Spacecraft Specialists will provide direct support to the Test Conductor as members of I&T Team. During this time, the function of the MOT will be to provide an assessment of the performance of the spacecraft subsystem under test. The MOT will assume the role of the Test Conductor during certain times within the I&T phase.

On-orbit mission simulations, where the spacecraft is operated as if it were on-orbit, will be conducted during the I&T phase. These tests will be conducted by the MOT just as they will during the actual on-orbit phase of the mission. All external operations supporting organizations and facilities (DSN and SOC) will be invited to support these tests. These tests will become the rehearsals of the MOT and the entire MOS.

Once on-orbit, the MOT is responsible for all spacecraft commanding, recovery of spacecraft telemetry, assessment of the telemetry, and the control, monitoring and performance assessment of all ground components necessary to support these functions. The MOT is also responsible for supporting SOC mission planning activities. During the Normal Operations mission phase, the MOT staff will be comprised of the following:

- Flight Operations Manager
- Spacecraft Specialists (two/vehicle)
- DSN Scheduler
- System Maintenance Engineer

During the Early Operations mission phase, the MOC will be staffed 24 hours/day and seven days/week. As a goal, during Normal Operations the MOT will work business hours, five days/ week. This will require validation of many automated MOC procedures and autonomy rules on the spacecraft. Occasional off-business hours scheduling is likely to occur during some special operations including contingency activities.

6.2.2 Mission Operations Team Activities

Operations planning will consist of the following activities necessary to support a scheduled track:

- Track scheduling
- Maintenance activity scheduling
- Managing the uplinking of instrument commands
- SSR management
- Timekeeping management
- Navigation management
- Track Plan Generation

The STEREO operations' planning consists of planning a week of tracks in advance. The MOT will determine the operational requirements of the spacecraft bus over the next week and will prepare the necessary command packets to satisfy these requirements. Operations planning and assessment activities for all instruments will be conducted by the SOC.

6.3 Operations Control and Assessment Activities

6.3.1 Data Flow

Figure 6-2, illustrates the flow of command and telemetry data between the ground-based spacecraft bus elements, instrument operations elements and the on-orbit STEREO spacecraft. The 'outer-loop' depicts instrument operations. Using a decoupled instrument operations approach, all instruments will be operated by the instrument operations team at the SOC. In Figure 6-2, SOC Planning begins on the far right, where instrument commands are produced. These command messages, which will be packetized along with some additional information needed by the MOC, are transmitted

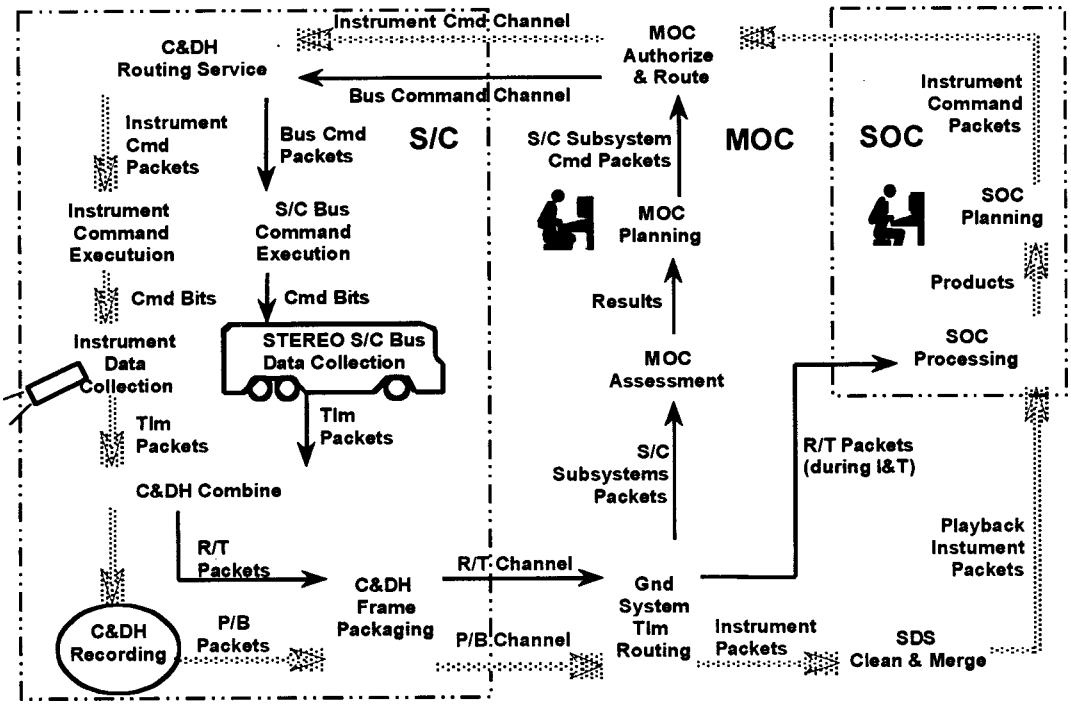

Figure 6-2 STEREO Mission Data Flow

to the MOC via the Internet. At the MOC (MOC Authorize and Route) authorization and checking is performed, then these commands are queued for uplink to the instrument. Along with the command packets, the SOC appends timing information which indicates the time span (earliest and latest times) over which the command packet may be uplinked to the instrument. Real-time command packets, when uplinked to the spacecraft, are immediately routed by the spacecraft bus Command and Data Handling (C&DH) processor (the C&DH Routing Service) to the appropriate instrument. They are time tagged and macro command packets are stored in the instrument's allocated storage locations in the C&DH processor. Conceptually, the command packet goes 'directly' from the SOC to the instrument, since the MOC, ground station and spacecraft bus are merely the delivery system. This delivery system notifies the SOC of the delivery status of the command message.

Whereas the SOC produces instrument commands, the MOC produces spacecraft bus commands. This is depicted in the 'inner-loop' on the Data Flow diagram. Starting at the MOC Planning process, the MOT prepares command messages which operate spacecraft bus during the next day. These command messages are queued for uplink (MOC Authorize and Route) just like the instrument commands, only they go to a different destination (via the C&DH Routing Service). The C&DH processor immediately routs real-time commands, to the appropriate spacecraft subsystem and time tagged and macro commands are stored in the C&DH processor. The MOC receives delivery status of the command packets just as the SOC does.

Once these commands have been executed (Instrument Command Execution and Spacecraft Bus Command Execution) on the spacecraft, the operations become integrated. The instruments

produce science and engineering data (Instrument Data Collection) in response to the uplinked command messages. The data produced by the instruments is sent to the spacecraft data system in the form of CCSDS telemetry packets. Similarly, engineering data produced by the spacecraft bus, is also formatted into CCSDS packets. These packets, produced by the instruments and the spacecraft bus, are stored on the SSR within the spacecraft data system (C&DH Recording). During a track with the spacecraft, the contents of the SSR are transmitted to the MOC (C&DH Frame Packaging).

On the ground (Ground System Telemetry Routing), real-time data is forwarded to the MOC and to the STEREO Data Server (SDS), while all recorded data is sent to the server facility (SDS Clean and Merge). All instrument data will be sent to the SOC for processing and analysis. The cycle repeats, with the SOC preparing instrument commands for the next time period. Spacecraft bus data is routed to the MOC (MOC Assessment) where an assessment function is performed. The MOC spacecraft bus planning process then repeats.

Of significance is that the instruments and spacecraft bus are operated (almost) entirely independent of each other. The same can be said about the ground elements (the SOC and the MOC). This decoupling of instrument operations concept greatly simplifies the operations process, which traditionally requires these functions to be merged in a complicated manner. For additional information on Mission Operations, see the Concept of Operations in Appendix H.

6.4 STEREO Ground System forMission Operations, Integration and Test, and Field Operations

The STEREO Ground System (GS) supports the sending of commands to the STEREO spacecraft and the display/distribution of telemetry data. The baseline for the STEREO Ground System is to use a modified TIMED MOC at APL. This system is capable of operating the TIMED mission while the STEREO Mission is

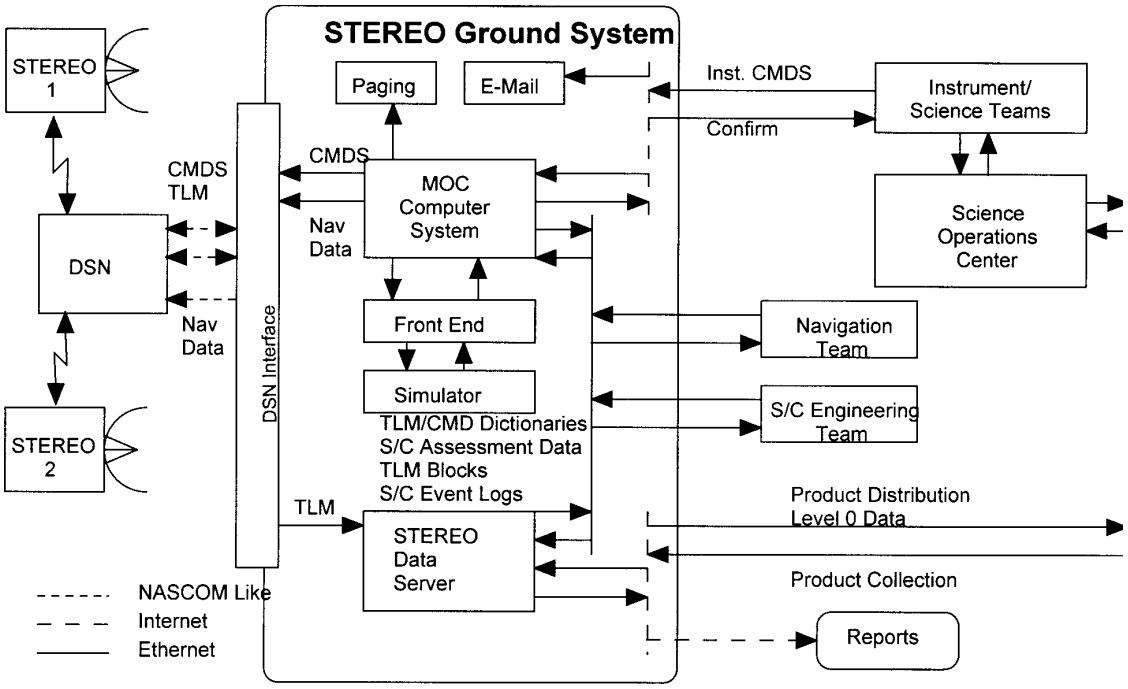

Figure 6-3 STEREO Ground System Normal Operations Functional Block Diagram

performing Integration and Test, Launch, and Normal Operations. The TIMED GS will be compatible with the STEREO Spacecraft due to the similarities of the TIMED and STEREO spacecraft bus. The STEREO Ground System, as configured for Normal Operations, Integration & Test, and Field Operations, is described in the following subsections.

6.4.1 Normal Operations

The STEREO Ground System includes all hardware, software, data links, and facilities used to plan tests and operations; generate and uplink commands; and receive, process, analyze, and disseminate telemetry and test data. The majority of the STEREO GS design is inherited from the TIMED program. The STEREO GS will be capable of performing unattended spacecraft contacts and uplink commands, downlink science and housekeeping telemetry, and perform basic state of health verification from the housekeeping telemetry. The GS will have the capability to detect anomalous conditions, page STEREO spacecraft specialists and send basic information from the anomalous contact to the spacecraft specialist via the Internet. The GS will be capable of sending telemetry data and MOT data products to the SOC and receiving STEREO Instrument commands from the SOC via the Internet. Commands and telemetry will flow to and from the Deep Space Network (DSN) via a DSN.

The transfer of telemetry data and mission operations data products to the Science Data Center will be accomplished by the STEREO Data Server (SDS). For the purpose of trending and assessment, the SDS will archive all STEREO Bus telemetry for the duration of the mission. The Spacecraft Engineering Teams and the Navigation Team will be able to access the STEREO Bus telemetry via the SDS and the MOC Computer System. The MOC Computer System will consist of several workstations and X-Terminals and/or Intel based PCs which will use a COTS based command and telemetry system as well as several custom software packages. Custom software packages will handle the following tasks:

- contact planning and scheduling
- command load generation (including merging the Instrument commands from the Science Teams and sending acknowledgement back to the Science Teams)
- Solid State Recorder Management
- Engineering dump data display
- processor dump data display, analysis and trending
- Spacecraft Timekeeping,
- Ground System and Spacecraft autonomy management.

6.4.2 Integration and Test (I&T)

During the I&T phase, the MOC depicted in Figure 6-3 will be supplemented with Ground Support Equipment (GSE) to enable testing and simulation of the STEREO mission. During this phase, the DSN Interface will be replaced with a Front End which will provide an interface and serve data to the STEREO Ground System and record all raw telemetry. The Instrument Teams will be able to accomplish commanding and telemetry analysis either remotely as they will during the Operations phase or locally at the MOC. The dashed lines indicating how the Instrument Team's data flows during I&T is still being traded. It is expected that the SOC will be on-line and flowing products during I&T on a trial basis. Figure 6-4 depicts the STEREO GS during the I&T phase of the program.

The STEREO GS will be used extensively during this phase of the mission for all STEREO commanding, telemetry displays, analysis, and distribution of spacecraft data. During this phase, the GS will connect to the STEREO GSE via an Ethernet interface. The GSE will consist of Instrument GSE, Guidance & Control GSE,

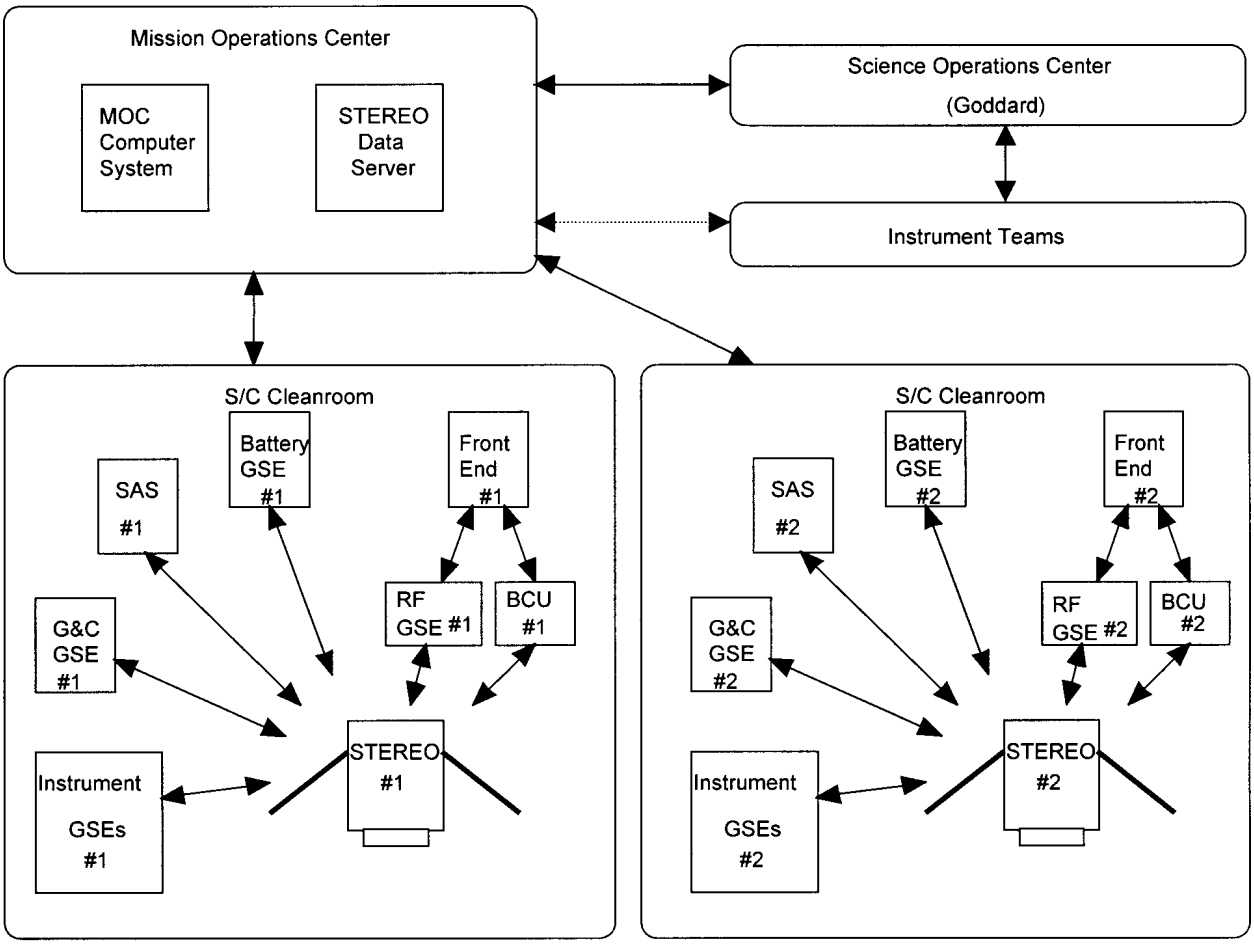

Figure 6-4 STEREO Ground System Block Diagram for Integration and Test

Solar Array Simulator, Battery GSE, RF GSE, Blockhouse Control Unit (BCU), and a Front End Processor for each of the STEREO Spacecraft. The STEREO GS will be able to command and receive telemetry from both Spacecraft simultaneously. All I&T commanding will be possible using the STEREO GS.

6.4.3 Field Operations

Figure 6-5 is a block diagram of the STEREO GS configuration during field operations. This phase of the mission includes environmental testing at the Goddard Space Flight Center (GSFC) and Launch Operations at the Kennedy Space Center (KSC). The testing and operations will be performed like Integration and Test in that the commands will be sent from the STEREO GS at APL and telemetry will be received and analyzed at the MOC. All instrument teams will now be interfacing directly with the SOC. The MOC connection to the STEREO Spacecraft will be through a NASCOM-like interface via the GSFC. The link must support the flow of telemetry and commands for both spacecraft simultaneously. This interface will most likely be a TCP protocol interface. This interface will also require several voice circuits for communication between the STEREO MOC and the field operations personnel.

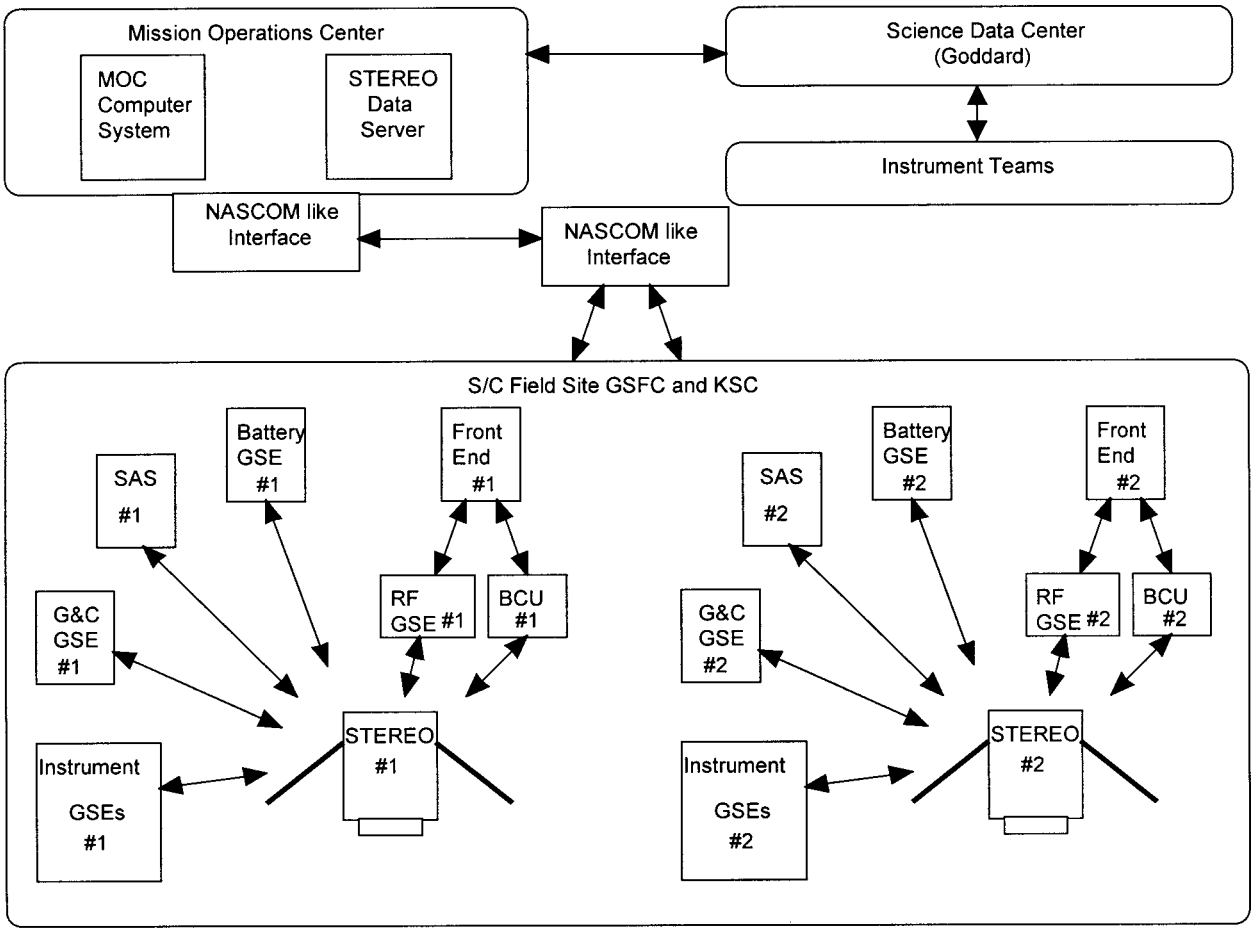

Figure 6-5 STEREO Ground System Block Diagram for Field Operations