DRAFT IN PROGRESS

Solar Oscillation Investigation
Michelson Doppler Imager
Experiment Operations Manual

DRAFT Version 2.6
SOI-RD-019
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1.0 GENERAL DESCRIPTION and SCIENTIFIC OBJECTIVES

1.1 General

This document describes the operational modes, operational scenario, ground segment support requirements and experiment database for the MDI instrument. It is the SOI-MDI input to the SOHO Spacecraft User's Manual which will be used by the SOHO flight operations team to operate the MDI experiment as a subsystem of the SOHO spacecraft. The scientific objectives and instrument performance requirements are detailed in the SOI-MDI Instrument Performance Specification and the SOI-MDI section of the EID. Mission products are specified in the SOI-MDI Data Management Plan. This section provides a brief summary of these subjects, for more detail please see the above documents, portions of which are included in the appendices.

1.2 Scientific Objectives

The primary scientific objective of the Solar Oscillation Investigation (SOI) is to investigate the solar interior using helioseismology techniques. To fulfill the potential of helioseismology, observations free of distortions from the Earth's atmosphere and free of diurnal data gaps must be obtained. The primary data set consists of precision measurements of the line-of-sight surface velocity field from which the oscillation modes of the solar interior can be deduced.

Observations made by the Michelson Doppler Imager (MDI) instrument will measure wave velocities on the surface of the sun which are caused by global oscillations. The physics of the solar interior can be deduced in part from the modal frequencies of these global oscillations. MDI will yield data on the temperature, density and composition of the interior of the sun. In addition, data will be used to determine interior rotation rates as a function of latitude and longitude. Local properties such as convection cells, sun spots and active regions can also be investigated.

In order to resolve the individual modes it is necessary to observe as much of the sun as possible for as long as possible. To preserve information about individual mode amplitudes the velocity detector must be linear and free of systematic errors.

The overall SOI program is organized to address a set of science objectives to measure the internal structure and dynamics of the sun by the techniques of helioseismology and to study observable solar phenomena using traditional techniques. These objectives will be achieved by combining observations of line-of-sight doppler velocity, transverse velocity (observed as advection of solar features), line-of-sight magnetic field, line and continuum brightness, and the limb figure.

1.3 Description of the Instrument

The MDI instrument has the capability to obtain solar images of line-of-sight velocity, line intensity, continuum intensity, longitudinal magnetic field components, and limb position. The instrument uses two wide-field, temperature compensated Michelson interferometers as tunable elements which operate behind a series of fixed bandpass filters. High-accuracy linear doppler shift measurements are made by multi-point measurements of the line profile. To eliminate cross coupling of spatial and temporal oscillations, the image is held steady to a few hundredths of an arcsecond using an internal image stabilization system. The primary observable is the line-of-sight velocity determined from the doppler shift of the Ni I 6768 Angstrom solar absorption line.

Physically, MDI consists of an Optics Package, an Electronics Package and the interconnecting cables.

1.3.1 Instrument Performance

The MDI instrument will have access to a mode domain with mode temporal frequencies between 0.03 and 16 mHz and spatial mode degree between 3 and 5000. The mode frequency domain is determined by the one-minute cadence of velocity measurements which is required in order to adequately sample solar oscillations with periods of 3 to 5 minutes. The maximum measurable mode degree is determined by the detector resolution and the area of the sun being observed. The image detector is a 1024x1024 pixel CCD camera with two imaging modes, full disk and high-resolution. The full disk mode has a 4 arcsecond resolution to achieve sensitivity to oscillation modes with degree up to 1500 and the high-resolution mode a 1.25 arcsecond resolution over a fixed 635 arcsecond square region of the sun to measure modes with degree up to 5000.

1.3.2 Optics Package

The MDI Optics Package (OP) is a single unit that contains the optical and filter subsystems of the instrument, all of the instrument mechanisms, and small subset of the electronics. These electronics include a CCD Camera, active Thermal Control Systems for both the Filter Oven and the overall OP, and a portion of the Image Stabilization System (ISS). Section B1.4 of the EID-B provides an expanded description of the OP as do various sections of the MDI Instrument Performance Specification (IPS).

1.3.3 Electronics Package

The MDI Electronics Package (EP) contains the majority of the MDI electronics. These can be roughly divided into the Power System, the Dedicated Experiment Computer (DEP) which controls and monitors the functioning of the instrument, the Image Processor (IP), and Application Electronics which drive mechanisms and provide for control of the active thermal systems and the ISS. Section B1.4 of the EID-B provides an expanded description of the EP as do various sections of the IPS.

1.4 Mission Products

The MDI instrument will acquire solar images of line-of-sight velocity, line intensity, continuum intensity, longitudinal magnetic field components, and limb position. The primary data set will consist of precision measurements of the line-of-sight surface velocity field from which the oscillation modes of the solar interior can be deduced. The medium rate science channel will provide medium-l resampled velocity, continuum intensity and limb figure. In addition, a magnetic proxy will be provided for the GOLF investigation and LOI mask velocity and intensity images will be provided for the VIRGO investigation. The high rate science channel will be delivered on tape to the SOI Science Support Center at Stanford for pipeline processing and archival. At least three times per day the high rate science channel will be routed into the SOHO Experiment Operations Facility (EOF) to provide a magnetogram, line-of-sight velocity map and continuum intensity image in real time. These real-time images from the high rate science will be combined with the medium rate science data products and provided as mission support summary data in the EOF. A summary of the data products expected is presented in Figure 1.4.1.

For further detail please see SOI-MDI Data Management Plan.

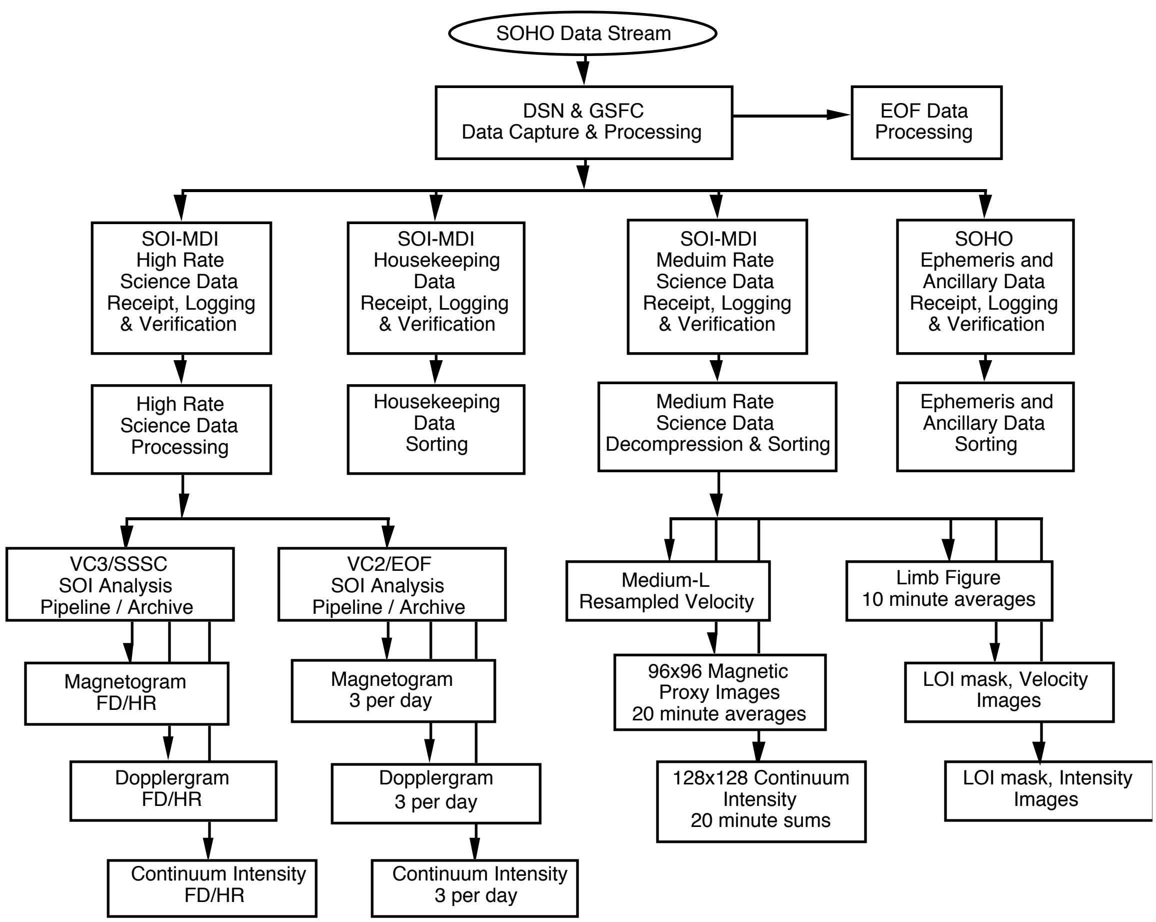

Figure 1.4.1 Data Products

2.0 EXPERIMENT CONFIGURATION and MODES

2.1 General

The SOHO mission is divided into three distinct phases: Launch and Early Operations (LEOP), Transfer Trajectory (TTP), and Halo Orbit (HOP). The timeline for these phases is documented in the SOHO SIRD. The nominal mission is approximately 40 minutes in LEOP, 4 months in TTP and the remainder in HOP.

2.1.1 Experiment Configuration in LEOP

During LEOP MDI will have no internal power and all of its subsystems will be inactive. No measurements or processing of any kind will take place.

To avoid damage to its elements, the MDI optics package must be always kept at a temperature above 0° C. If the spacecraft thermal roll cannot keep MDI above that temperature during the parking orbit, its non-operational heaters should be enabled to provide the necessary heat input to do so.

2.1.2 Experiment Configuration in TTP

During the first month of the orbital transfer phase of the mission the MDI instrument will be powered-up and commissioned. To minimize CCD contamination, the operational CCD heater will be turned on as soon as practical. Initial power up will be immediately after the solar array deployment, with commissioning tests with the front door closed taking about 2 weeks. This will provide adequate time for outgassing to avoid contamination of the CCD and to load the IP tables prior to opening the front door. The high rate telemetry link for MDI should be operational as soon as is practical in order to begin calibration and checkout. As part of the checkout, all normal procedures will be verified, the command link will be exercised, and data will be taken in every nominal operating mode. No testing of redundant or contingency modes is planned. After the high rate telemetry link has been verified, the MDI front door will be opened, a preliminary alignment will be performed and calibration and sequence verification will begin. This will include running the dynamics, structure, and a variety of campaign observing sequences, as well as telecommand calibration tests. As verification is completed, the instrument will be used for measurements that cannot be made in conjunction with the background structure program. This phase will also be the best time to roll the spacecraft to allow for calibration of the instrument for absolute limb figure and doppler measurements and to perform detailed assessment of spacecraft and other payload induced jitter. Following the checkout of the instrument and operational sequences, TTP operations and MDI configurations and modes are the same as in Halo Orbit Phase. As spacecraft resources permit, the instrument will be operated in the same fashion as it will after reaching final halo orbit. Approximately a month before the 2 month continuous MDI high rate telemetry period, a 72 hour period of continuous MDI high rate telemetry will be used to test the dynamics program. This initial dynamics program will be considered the start of MDI nominal observing.

2.1.3 Experiment Configuration in HOP

Nominal MDI operations should have begun well before the Halo orbit insertion maneuver, and the MDI observations will concentrate on maintaining continuity of the Structure Program when SOHO is on-station during HOP. The basic cadence of observations for the MDI instrument is to complete two separate measurements in one minute. The one minute period of observation is required to observe solar signals having an oscillation period of around 5 minutes.

There are several observing programs for the MDI instrument, each of which requires a series of filtergrams. A filtergram is one exposure and readout of the CCD camera, with a particular wavelength setting of the Michelson filters, orientation of the polarization wheel, and magnification.

Imaging can be performed at two resolutions, Full Disk (FD) and High Resolution (HR). Approximately 20 images can be taken per minute. The standard measurements are the velocity dopplergram, continuum intensity, and magnetograms. A dopplergram is generated from 8 or 16 filtergram images and represents a map of the line of sight velocity. The continuum intensity is computed from the same filtergrams used for the doppler measurement with the addition of filtergrams taken at the instrument "continuum" wavelength. A magnetogram is produced from the difference of a right and left circularly polarized dopplergram pair, each of which is derived from 4 or 8 filtergrams. The image data is downlinked via one or both of the medium rate and the high rate science telemetry channels.

2.2 Telemetry Formats

There are three spacecraft telemetry format data rates (not including Reed-Solomon encoding): a low rate of 1.18 kbps, a medium rate of 47.35 kbps and a high rate of 211.2 kbps. The spacecraft low rate telemetry format is transmitted to ground from launch until the deployment of the high gain antennae, and in contingency operations when the high gain antenna is not available. The spacecraft medium rate telemetry format is transmitted to ground for the period between the high gain antenna deployment and the first midcourse correction, and during orbit correction maneuvers. In addition, the medium rate telemetry format is recorded on the SOHO tape recorders when the spacecraft is not in DSN contact. The spacecraft high rate telemetry format can only be used during real time contacts, and cannot be recorded on board.

The low and medium rate telemetry data are transmitted as a stream of packets that are identified and sorted on the ground. The high rate telemetry consists of the medium rate telemetry packets plus a 160 kbps data stream that can be used by only the tape recorder for dumping recorded data or by MDI for a high data rate channel available during real-time contacts. By combining real-time transmission and tape recorder operations, the goal is to have complete continuity of the medium rate telemetry.

The nominal telemetry coverage schedule is shown in Figure 2.4.1.1. For a 2 month period each year, the 160 kbps telemetry channel will be available to MDI 24 hours/day, and there will be no data saved to the tape recorder. During the remaining 10 months per year, the 160 kbps telemetry channel will be available to MDI about 8 hours per day, and the tape recorder playback will use the 160 kbps telemetry channel about 5 hours per day.

The MDI instrument has been allocated portions of all the spacecraft telemetry formats, and the data have been separated into housekeeping (or engineering) information and science measurements. A small number of MDI voltages, temperatures, and digital status indicators are monitored by the spacecraft and transmitted in spacecraft telemetry packets, and. These are available whether or not MDI is powered on. The majority of the MDI housekeeping information is collected by the MDI DEP (when it is powered on), and transmitted in separate MDI housekeeping packets. The MDI instrument has two science data channels which can operate simultaneously, one with a data rate of 5 kbps (MDI low rate science) and the second with a data rate of 160 kbps (MDI high rate science). The MDI 5 kbps science data are observables computed by the Image Processor, transferred to the DEP and sent on to the spacecraft data handling system in packet format. The MDI 160 kbps science data stream is sent directly from the Image Processor through a dedicated MDI/tape recorder data channel.

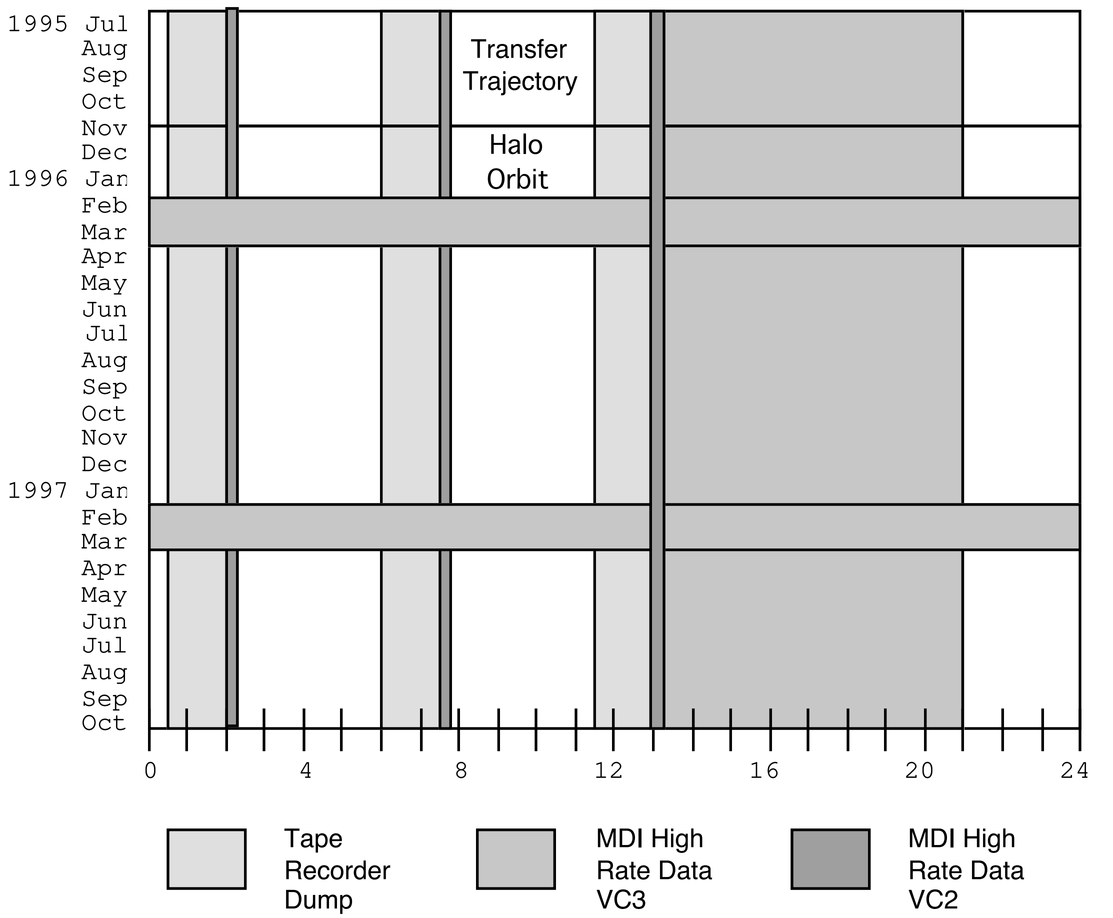

Figure 2.4.1.1 Telemetry Coverage

2.2.1 Low Rate

A limited number of MDI housekeeping parameters are included in the telemetry stream when the spacecraft is configured for low rate telemetry mode. Only the housekeeping packets are requested from the MDI instrument, and of the two MDI housekeeping packets per major frame, the first 50 bytes of the first packet are stripped off and inserted in a combined science instruments housekeeping packet. The MDI parameters in this combined packet are primarily the internally monitored voltages, temperatures and power status. The MDI parameters monitored by the spacecraft continue to be sampled and are transmitted in the spacecraft housekeeping packets.

2.2.2 Medium Rate

MDI is in Medium Rate Format when the spacecraft is configured for medium rate telemetry. Two MDI housekeeping and 24 MDI science packets are acquired every major frame resulting in an effective downlink data rate of 360 bps of housekeeping data and 5.0 kbps of science data. The MDI parameters monitored by the spacecraft continue to be sampled and are transmitted in the spacecraft housekeeping packets. Continuity of the MDI housekeeping and 5 kbps science data stream will be maintained by saving the spacecraft medium rate channel to tape during periods when real-time telemetry contact is unavailable.

2.2.3 High Rate / VC2

The MDI instrument has use of the 160 kbps telemetry channel when the spacecraft is in real-time contact, and tape recorded data has been successfully downlinked. The MDI 160 kbps data can be labeled with one of two virtual channel identifiers by the spacecraft telemetry formatter. Transition to and from the high rate virtual channel will be controlled by ground command. MDI is in High Rate / VC2 Format when the 160 kbps high rate data is available on Virtual Channel 2 for data transfer direct to the EOF in real time.

2.2.4 High Rate / VC3

The majority of the high rate data is received in virtual channel VC3 and written to tape for later delivery to the SOI Science Support Center (SSSC). When the 160 kbps telemetry channel is continuously available for a two month period to support the Dynamics Program, MDI will be in Extended High Rate Format.

2.3 Nominal Observing Modes

The imaging programs for science data collection will be performed by onboard DEP sequences. These sequences will be loaded into the DEP and will manage the configuration of the mechanisms, acquisition of images, and IP image processing for downlink. When an imaging program is active MDI will be in DEP Sequence Observing Mode. During some instances, ground commanded observing sequences may be used. While operating imaging sequences via telecommand, MDI will be in Telecommand Observing Mode.

2.3.1 Telecommand Observing Mode

During some instances, ground commanded observing sequences may be used. These sequences will be limited by the uplink telecommand rate and will not run as efficiently as the onboard DEP sequence programs. Telecommand sequences may be used for some of the calibration image acquisition during TTP.

2.3.2 DEP Sequence Observing Mode

The observing programs that have been defined are the Structure, Dynamics, Campaign, Magnetic Field, and Calibration Programs. The telemetry coverage determines which observing programs are used. During nominal operations, the first thirty seconds of every minute will be dedicated to generating a FD Dopplergram to support the Structure program. All other programs normally run in the remaining 30 seconds. The Structure Program may occasionally be interrupted for Calibrations and Magnetic Field measurements. Each observing program is described below.

2.4 Nominal Non-observing Modes

The nominal non-observing modes consist of five specific instrument states and a sixth system test mode where the actual state varies depending on the type of test being performed.

2.4.1 Power Off

The MDI is initially in powered off mode during the LEOP and initial phases of

TTP. During this unpowered phase the spacecraft will manage the thermal state of MDI using the non-operational heaters for thermal maintenance as described in Section 2.6.2.

2.4.2 Sleep

The MDI can be placed in sleep mode with minimum activity and power consumption but still provide full housekeeping telemetry. In this configuration only the power converters, the DEP, the application electronics and any required heaters are powered on. Sleep mode is entered during a normal activation sequence to allow the configuration of heaters for the flight environment. It is also briefly entered during power down. It can also be used as a minimal power draw contingency mode.

2.4.3 Safe

To avoid contaminants during orbit adjust thruster firings and excessive inputs to the ISS, MDI will be placed into a Safe Mode in which the front door is closed, the limb tracker placed in open loop and any DEP imaging sequence terminated. The transition from safe to standby mode is achieved by opening the front door.

2.4.4 Standby

Following the opening of the MDI front door, the instrument is configured for imaging either via DEP sequence or telecommand procedure. However, in standby mode the limb tracker is not yet placed into closed loop operation so the stability of the images can not be guaranteed.

2.4.5 Ready

The transition from standby to ready mode is achieved by commanding closed loop operation for the limb tracker and successfully achieving a stabilized image. The termination of a nominal imaging sequence or telecommand imaging period will also leave MDI in ready mode. Successful operation of the limb tracker in closed loop requires stable and accurate pointing by the spacecraft.

2.4.6 Systems Test

There are a variety of subsystem tests the MDI can perform. Subsystems can be tested by running test programs stored in the DEP or IP and initiated by ground command, or by interactively exercising the subsystem elements through spacecraft commands and verifying the effect on housekeeping data. MDI is in systems test mode during the initial commissioning. The actual state of the MDI subsystems will depend on the type of test being run. Systems test mode can also be entered as a contingency mode to support anomaly resolution.

2.5 Degraded Observing Modes

MDI has several degraded observing modes and two Degraded Operation Capabilities (DOC) modes. The latter consist of the Degraded Science Operations System (DSOS) and the Degraded Motor Controller (DMC) modes.

2.5.1 Degraded Science Operations System

The Degraded Science Operations System (DSOS) is an alternate microprocessor system which can control the MDI CCD camera and operate the mechanisms using the Degraded Motor Controller in the event of catastrophic failure of the DEP. The DSOS is capable of obtaining CCD images and transmitting them through the high-rate telemetry interface, but will not be able to control the Image Processor or use the 5 kbps telemetry. The DSOS is operated on the redundant telemetry and command channels

2.5.2 Degraded Motor Controller

The Degraded Motor Controller (DMC) is capable of operating any of the MDI mechanisms in the event of a failure of the primary operational capability of the Applications Electronics, but will result in a degraded performance because it operates the mechanisms as simple stepper motors. The DMC is capable of being operated by either the DEP or the DSOS.

2.5.3 Observing Without Image Stabilization

Once the front door is open and MDI has entered standby mode solar images may be acquired without closing the loop in the limb tracker. The initial images taken during the transfer phase commissioning will be acquired in this fashion.

2.5.4 Direct Camera to Telemetry Interface

The camera data can be routed directly to the high rate telemetry system in the event of a total failure of the image processor.

2.6 Survival Modes

Beyond nominal standby mode and sleep mode, MDI has two survival modes which should be used in parallel. MDI is powered off for both these modes and so internal MDI housekeeping data is not available. Five spacecraft powered temperature monitors for MDI are available, four on the OP and 1 on the EP. In addition, several instrument state parameters are monitored by the spacecraft including the MDI front door status.

2.6.1 Keep Alive Power

MDI has a keep alive power mode. Two spacecraft provided keep alive power busses are automatically activated when main power from the spacecraft is lost. They supply power to four IP memory pages containing tables and programs necessary for on-board science processing. Maintaining such information intact on board will considerably decrease MDI reactivation time after a power loss.

2.6.2 Thermal Maintenance

To avoid damage to its elements, the MDI optics package must always be kept at a temperature above 0°C. If put in prolonged survival mode, the spacecraft non-operational heaters should provide the heating necessary to keep the MDI OP always above such temperatures. Under sun pointing conditions, the optics package has a cooling rate approaching 5°C/hour. This mode will used during LEOP and TTP as necessary until the initial activation of MDI is performed. It can also be augmented by brief power up to sleep mode where full housekeeping telemetry of the instrument temperatures can be obtained.

2.7 Redundant Configurations

MDI has several redundant subsystems capable of replacing their nominal ones including power converters, high rate telemetry interface and serial command interface. The optics oven thermal control system has a backup mode. Transitions from nominal to redundant subsystem are initiated by spacecraft Pulse Commands.

2.7.1 Redundant Power Converter Configurations

Either one or both of the primary power converters can be disconnected from the spacecraft bus and replaced by the redundant unit resulting in three additional backup modes. If connection to a different spacecraft power bus defines a different mode as well, then four additional modes will exist based upon which spacecraft bus (A or B) is operational.

Table 2.6.1.1 MDI Power System Configurations

Mode	Pri 1	Pri 2	Red 1	Red 2	S/C Bus	Description
PCSCA	on	on			A	Nominal
P1R2A	on			on	A	
P2R1A		on	on		A	
RCSCA			on	on	A	Cross-strap Redundant
PCSCB	on	on			B	Cross-strap Prime
P1R2B	on			on	B	
P2R1B		on	on		B	
RCSCB			on	on	B	Redundant

2.7.2 Redundant Serial Commands Interface

A redundant serial command interface can be selected via pulse command. The nominal and redundant spacecraft telecommand channels are cross-strapped to the MDI prime and redundant telecommand interfaces. If the redundant telecommand interface has been selected, the primary configuration can only be recovered via MDI power cycle.

2.7.3 Redundant Packet Telemetry

The spacecraft clock, sampling and data lines for the MDI packet data acquisition are fully redundant. These interfaces are cross-strapped to the spacecraft prime and redundant on board data handling system. The MDI 360 bps housekeeping and 5 kbps science telemetry operate in a hot redundant manner because both the prime and redundant MDI telemetry interfaces are fed from the same DEP buffer.

2.7.4 Redundant 160 kbps Science Telemetry

The 160 kbps science telemetry interface can be switched via pulse command or DEP command from the prime interface (designated as TLM1) to the redundant interface (designated as TLM2). The IP must be re-configured to use TLM2 if selected. The 160 kbps science telemetry interface is redundant at the level of the spacecraft, MDI telemetry board and IP memory, none of which can be cross-strapped.

2.7.5 Backup Oven Controller

The backup oven controller (HRO) is capable of operating heaters on the oven. This is a software controlled system that can substituted for the closed loop prime oven controller.

2.8 Contingency Modes

MDI also has a contingency sleep mode which provides full housekeeping telemetry at minimum power consumption. This mode is entered during the initial instrument power up. This mode can also be entered in contingencies to preserve power. It is recovered from with a partial activation procedure refered to as wakeup. The systems test mode can also be used in support of anomaly resolution and testing of redundant systems as required. Both of these modes are described in section 2.4.

2.9 Mode Transitions

The procedures to transition among the nominal non-imaging modes are listed here and are included in the appendices.

Table 2.8.1 Nominal Mode Transitions

From	To	Procedure
OFF	SLEEP	M_PCONPRI
SLEEP	SAFE	M_WAKE
SAFE	STANDBY	M_FDOPEN1
STANDBY	READY	MBLTCLSL (LT closed loop)
OFF	SAFE	M_ON
SAFE	SLEEP	M_SLEEP
STANDBY	SAFE	M_SAFE
READY	SAFE	M_SAFE
READY	STANDBY	MBLTOPNL (LT open loop)
STANDBY	SLEEP	M_SLEEP
READY	SLEEP	M_SLEEP
ALL	OFF	M_OFFSCA
ALL	OFF	M_EMOFF

3.0 OPERATIONAL SCENARIO

3.1 General

MDI will initiate science operations as soon as initial power up, checkout and calibration can be completed and as early as possible during TTP. It is desired that sufficient experience with operation of the instrument is gained during the later half of TTP to be prepared for the initiation of the Dynamics Program, 24 hour/day telemetry schedule as soon as possible after Halo Orbit is attained.

3.2 Activation, Commissioning and Calibrations

Following the initiation of the transfer trajectory and SOHO sun pointing attitude the spacecraft heaters will be required to stabilize the MDI instrument temperature. As early as possible in the TTP, the MDI instrument will be powered-up, initialized, verified operational and calibrated. As resources permit, all nominal procedures will be verified, the command link will be exercised, and data will be taken in every nominal operating mode. As commanding requirements permit, the IP tables will be uploaded. A special science campaign that can only be done before beginning the Primary Structure Program (the 5 kbps continuous science) will be accomplished during the transfer phase if spacecraft requirements permit and the high data rate telemetry is available for a long enough period. This phase will also be the best time to roll the spacecraft to allow for calibration of the instrument for velocity and absolute limb figure measurements. Participation in spacecraft systems tests (e. g. medium term pointing stability and jitter) is also possible. During the remainder of TTP, the instrument will be operated in the same fashion as it will after halo orbit insertion.

3.2.1 Description of the Operations

MDI procedures which involve or impact on the spacecraft will be performed by the flight operations team via TSTOL procedures. These activities include non-operational heater activation, MDI activation, opening the front door, and the spacecraft roll test. Other activation and commissioning procedures will be performed via near real time commanding from the MDI command workstation in the EOF.

After the initial power up is complete the Dedicated Experiment Processor (DEP) is activated. The default is for the DEP to be activated using the primary OBDH lines. If the redundant OBDH lines are to be used an On/Off pulse command must be issued. After the DEP is powered up the remaining subsystems are systematically powered up and verified. At this point the procedure is the same whether the primary or redundant OBDH lines and power are being used.

The commissioning of the MDI subsystems consists of moving each mechanism, insuring basic camera functionality, verifying thermal control systems operations, and checking the health of the DEP and the IP computers. These detailed checkouts are followed by an extensive set of imaging exercises designed to provide sufficient data to calibrate the instrument.

3.2.2 Operational Constraints

The MDI optics package should never be colder than 0 C nor warmer than 40 C in order to avoid damage to the optics and/or filters during non-operational periods. It should not be colder than 10 C nor warmer than 30 C during operations. If too many heaters were turned on the MDI could become overheated and damage would occur to the optics. Damage may also occur to the optics if insufficient heaters are commanded and the temperature falls below minimum. Detail precautions are TBD.

The CCD operational heater should be enabled as soon as possible to minimize contamination of the CCD. A two week bakeout period will be required after initial power on to further minimize contamination.

MDI should be activated as early as possible during TTP to begin the checkout process and initiate the IP memory load in which 2 Mbytes of memory necessary for MDI operation must be uploaded via the command link. Assuming MDI can receive at most 1 command/sec and each command can transmit thirty 2-byte words, the upload would take approximately 10 hours if done without interruptions. If contact with the spacecraft is made for only 8 hours a day, and if a command link use factor of 25 percent is added in, full upload should take approximately two week.

The low rate science, 5 kbps, and housekeeping telemetry are necessary for initial power on and checkout. The high rate, 160 kbps, data channel will be required for functional checkout and calibration of the CCD camera imaging system. Ideally, the activation, commissioning and calibration will be performed with continuous high rate and Near Real Time command support.

Improper use of the DMC configuration could possibly damage the front door or the alignment system. Detailed precautions are TBD.

The spacecraft should maintain sun center pointing beginning with the opening of the MDI outer door and initial alignment.

Jitter producing activities by other payloads and the spacecraft must be coordinated to avoid degradation of the calibration and science data and to allow for calibration of these disturbances during ISS testing.

A spacecraft roll will be required to support calibration of absolute limb figure and doppler measurements.

3.2.3 Detailed Timeline

An decriptive timeline for the activation and checkout is included below. A detailed timeline is included in Appendix ??. The MDI IP Memory load will be effected via the background command queue following the initial commissioning but preceding calibration and sequence tests. The duration times listed below are working calendar days, and the majority of the activities will take place during real-time contacts limiting working time to about 8 hours per day.

Table 3.2.3.1 Activation and Commissioning Timeline

Description	Duration
Activation to Sleep Mode	1 day
Establish power up configuration	
Power up MDI subsystems to Sleep Mode	
Configure for CCD decontamination	
Configure for thermal environment	
Activation to Safe Mode	1 day
Power up MDI subsystems to Safe Mode	
Configure for Safe Mode	
Configure for thermal environment	
Commissioning	3 days
Mechanisms	
CCD Camera	
Image Processor	
Dedicated Experiment Processor	
Thermal control systems	
Shutter performance tests	
Bakeout	2 weeks
IP Table Load	
Configure for Standby Mode	1 days
Open Front Door	
Configure for Ready Mode	1 days
Close loop in ISS	
Initial alignment	
ISS test	
Calibration	11 days
Picture Series	
Light Transfer Curve	
Focus Series	
MTM Rotation Distortion Series	
PAW Rotation Distortion Series	
PAW Distortion Series	
Flat Field	
Scattered light	
MTM Tuning	
Observing Program Checkout	4 weeks
Calibration Program	
Structure Program	
Magnetic Program	
Dynamics Program	
Typical Campaign Program	

High Frequency Campaign Program

Special Tests 15 days

Alignment Mechanism Test
S/C Roll Test
ISS Calibration and Jitter Test
Intra-Instrument Flag Test

3.2.4 Instrument Activation

This procedure defines the initial power-up at the beginning of TTP. Ground commands will connect the power converters to the spacecraft power bus, and will turn the DEP power on. The remainder of MDI will be powered on in a controlled fashion with subsystem health verified at each step. The activation is completed with the instrument configured for nominal observing and several images acquired and downlinked. The activation sequence begins with MDI in power off mode and completes with MDI in safe mode. The activation will be performed via TSTOL procedures.

The instrument is activated to sleep mode by the power-up sequence, M_PCONPRI, which is listed in Appendix D. The M_PCONPRI sequence uses primary command and telemetry channels, spacecraft bus A and primary MDI power converters. The MDI is powered on in a controlled fashion with subsystem health verified at each step. The procedure configures and verifies the initial state of the instrument, selects the appropriate telecommand interface, connects power converter 2 to the spacecraft power bus, and turns on DEP, application electronics and configures the relay for H/R telemetry select for the primary interface. Finally, power converter 1 is connected to the spacecraft bus and all internal power system monitors are re-checked. At this point MDI has entered into sleep mode and, with all housekeeping monitors available, instrument health and status is evaluated, thermal environment assessed and heaters configured as necessary.

Next, the IP, CCD camera and internal mechanisms are powered and initialized and the limb tracker turned on. Once again the thermal environment assessed and heaters configured as necessary. The activation is completed with the instrument configured for nominal observing except that the door is closed and the limb tracker is in open loop. At this point several images are acquired and downlinked. The activation sequence completes with MDI in safe mode.

Table 3.2.4.1 Instrument Activation Procedure - M_PCONPRI

Establish Power Up Configuration
- Primary converters to non-active S/C bus B
- S/C Bus A power on

Power Up MDI Subsystems to Sleep Mode
- Primary converter 2 to active S/C bus A
- DEP, Application Electronics, H/R TLM select board 1
- Verify front door closed
- Primary converter 1 to active S/C bus A

Power system limits enabled

MDI in Sleep mode

Table 3.2.4.2 Thermal Configuration for CCD Decontamination

Configure for Thermal Environment
- Check Temperatures
- Optics Package Thermal Controller on - M_HTRON
- CCD Heater on - M_HCMON
- Prime Oven Controller on - M_OVENON
- Activation thermal limits enabled

Table 3.2.4.3 Activation to Safe Mode

Power Up MDI Subsystems to Safe Mode
- Image Processor (IP) on - M_IPON
- CCD Camera on - M_CMON
- MDI Internal Mechanisms on - M_MCHSON
  - Shutter
  - Michelson Tuning Motors (MTM1 and MTM2)
  - Calibration Wheels (CAL1 and CAL2)
  - Polarization Analyzer Wheel (PAW)
- Image Stabilization System (ISS) open loop - M_LTON

Configure for Thermal Environment
- Check Temperatures
- Optics Package Thermal Controller set point - M_HOPSPT
- CCD Heater set point - M_CCDSPT
- Prime Oven Controller set point - M_OVENSPT

Configure for Standby Mode
- Put the mechanisms into observation positions - M_OBSMODE
- Configure IP/Camera for images and take a picture - M_TAP

MDI in Safe Mode

3.2.5 Instrument Commissioning

A detailed commissioning will be performed following the initial power up. This will involve exercising each subsystem individually to assure nominal performance including camera, internal mechanisms, ISS, alignment mechanism, heaters, DEP, and IP. While being commissioned, MDI will be in the systems test mode. At the beginning and completion of commissioning MDI will be in safe mode. This instrument subsystem commissioning is accomplished by the sequence MDICOM as listed in Appendix E.

Table 3.2.5.1 Instrument Commissioning Procedure - MDICOM

CCD Camera

Mechanisms
- Shutter
- Michelson Tuning Motors 1

Michelson Tuning Motors 2
Polarization Analyzer Wheel
Calibration Wheel 1
Calibration Wheel 2
Alignment Mechanism
Image Stabilization System
Thermal Control Systems
Prime Heater Oven Controller
Optics Package Thermal Controller
CCD Heater
Image Processor
Dedicated Experiment Processor

3.2.6 IP Memory Load

To run its Structure Program, MDI will need to have approximately 2 Mbytes of IP tables stored in its memory. Those data will first be uploaded during TTP. The IP memory load will be performed via the background command queue with MDI in safe mode during the initial bakeout period. The procedure is MDIIPLD and is found in Appendix E.

3.2.7 Front Door Open

The front door will be opened using the TSTOL procedure M_FDOPEN1 once the initial bakeout period is completed. This will be followed by the initial alignment and ISS test.

3.2.8 Initial Alignment

The MDI contains an external alignment mechanism. This system will be checked out during TTP. Following the initial opening of the front door, the alignment mechanism will be powered up and an initial alignment of the solar disk image on the CCD will be performed. Images will be acquired during a period of high rate telemetry format with the spacecraft quiescent and while the alignment mechanism offset and initial MDI alignment is achieved. The Alignment Mechanism test procedure is included in Appendix E as MDIALIGN.

3.2.9 ISS Test

The MDI contains an internal Image Stabilization System (ISS) which is used to eliminate cross coupling of spatial and temporal oscillations, by stabilizing the image on the CCD to a few hundredths of an arcsecond. This system will be checked out in TTP during a period of high rate telemetry format . At the completion of the ISS test, the front door will be open and the ISS in closed loop, thereby placing MDI into standby mode for the first time. The ISS test procedure is included in Appendix E as MDIISS.

3.2.10 Instrument Calibration

A detailed instrument calibration will be performed as soon as the high rate telemetry is available and instrument bakeout is complete. Calibration is performed with a mix of DEP sequence observing and telecommand observing modes. This calibration will include the procedures: MDIPICT, MDILTC, MDIFOCUS, MDIMROT, MDIPROT and MDIPDIST are found in Appendix E.

Table 3.2.6.1 Instrument Calibration Procedures

MDIPICT	Picture Series
MDILTC	Light Transfer Curve
MDIFOCUS	Focus Series
MDIMROT	MTM Rotation Distortion Series
MDIPROT	PAW Rotation Distortion Series
MDIPDIST	PAW Distortion Series
MDIEXP	Shutter Test

3.2.11 Observing Sequences Checkout

The checkout of the observing sequences will be performed during periods of Near Real Time command link and with virtual channel 2 enabled for the high rate telemetry to allow receipt of initial images the in the EOF in real time. Control of the DEP sequences will nominally be performed by DEP and IP register configuration commands. Examples of such command seqeunces are the procedures MDICAL, MDICMP, MDIDYN, MDISTR and MDIMAG as found in Appendix E.

Table 3.2.11.1 Instrument Imaging Program Checkout Procedures

MDICAL	Calibration Program Checkout
MDISTR	Structure Program Checkout
MDIMAG	Magnetic Program Checkout
MDIDYN	Dynamics Program Checkout
MDICMP	Typical Campaign Program Checkout

3.2.12 Alignment Mechanism Offset Test

The Alignment Mechanism will be used to do an offset scattered light test,a flat field test and other performance tests. The Alignment Mechanism test procedure is included in Appendix E as MDIAMTST.

3.2.13 Spacecraft Roll Test

Following the initial MDI alignment, the spacecraft will be rolled around the line of sight to the sun to allow for calibration of the absolute limb figure and doppler measurements. The limb figure calibration test procedure is included in Appendix E as MDILFTST. The doppler test will be performed by MDICAL.

3.2.14 Spacecraft Jitter Test

The ISS will be assessed for performance limitations due to the higher than expected spacecraft and instrument jitter sources. This test will be performed in TTP during a period of high rate telemetry format support. A special format for the MDI medium rate science channel will be used to downlink higher resolution measurements from the ISS. This 5 kbps data and images in the high rate channel will be acquired with the spacecraft quiescent and while various possible jitter sources are exercised. The test procedure is MDIJITT

3.2.15 Intra-Instrument Flag Test

The DEP will configure for receiving intra-instrument flags. The test procedure is MDIIIC

3.3 Routine Operations

3.3.1 Description of the Operations

SOHO will be operated during each year in one of two telemetry schedules. For ten months each year high rate data will be provided for eight hours per day during the Campaign Program. For two months in every year high rate data will be provided continuously during the Dynamics Program. The actual DSN contact schedule will be made available on a weekly basis and may vary from these plans due to other requirements on its use. Lack of or constrained support will likely be forecast with up to several weeks of notice.

During nominal operations minimal commanding will be required to operate MDI. The MDI instrument is designed to be self-sufficient; daily commanding requirements will be minimal, perhaps requiring only signals to indicate data rate and consequent operating mode changes and changes from one preset campaign mode to another. The principal mode of MDI operations will be delayed commands via an established command plan. The command plan will consist of a set of files containing a combination of direct instrument commands, DEP sequence initiation commands, DEP campaign and frame list loads, or IP macro queue loads.

There are several observing programs for the MDI instrument, each of which requires a series of frames. A frame is one exposure and readout of the CCD camera, with a particular wavelength setting of the Michelson filters, orientation of the polarization wheel, and magnification. The basic cadence of observation for the MDI instrument is to complete two separate measurements in one minute. The one minute period of observation is required to observe solar signals having an oscillation period of around 5 minutes.

The observing programs that have been defined are the Structure, Dynamics, Campaign, Magnetic Field, and Calibration Programs. The Structure Program proceeds at all times and collects data in the first 30 seconds of each minute. All other programs normally run in the remaining 30 seconds. The Structure Program may occasionally be interrupted for Calibrations and Magnetic Field measurements. The imaging programs for science data collection will be performed by the onboard DEP sequenceer. These observation lists will be loaded into the DEP and will manage the configuration of the mechanisms, acquisition of images, and IP image processing for downlink. The procedures to initiate and terminate different observing sequences and the sequences to be performed are summarized in Appendix G. The imaging programs are described below.

3.3.2 Operational Constraints

The MDI optics package should never be colder than 10 C nor warmer than 30 C so as to not damage the optics and/or filters during nominal operations. If too many heaters were turned on the MDI could become overheated and damage would occur to the optics. Detail precautions are TBD.

Improper use of the DMC configuration could possibly damage the front door or the alignment system. Detailed precautions are TBD.

The spacecraft should maintain sun center pointing.

Jitter producing activities by other payloads and the spacecraft must be coordinated to avoid degradation of science data.

3.3.3 Detailed Timeline

Two different timelines will be run, 10 months of campaign and 2 months of dynamics, every year.

The Campaign Program will run for ten months of every year with eight hours of

MDI high rate data scheduled during daylight hours at GSFC. The nominal telemetry schedule for the Campaign Program is as shown in Figure 3.3.3.1.

1 Three 3.6 hour periods per day of no telemetry (LOS) with tape storage of low rate VC0 housekeeping and VC1 science onboard the spacecraft.

2 Three 1.6 hour real-time periods per day of low rate VC0, VC1 and high rate tape dump on VC4 of VC0 and VC1 as stored during preceding 3.6 hour LOS period.

3 Three 0.1 hour real-time periods per day Magnetic Field / Synoptic Program data on VC2 following each VC4 tape dump in addition to low rate data.

4 One 8 hour real-time period per day of high rate Campaign / Structure Program on VC3 in addition to low rate data on VC0 and VC1.

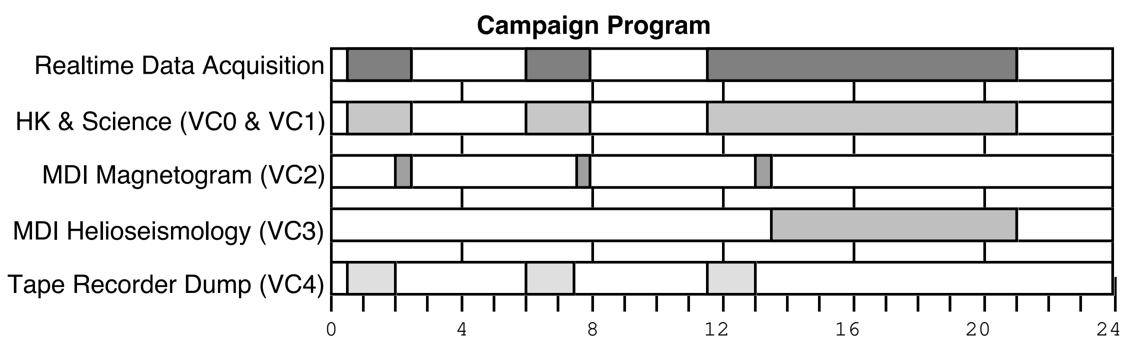

Figure 3.3.3.1 Campaign Program Schedule

For two months of each year the Dynamics Program provides continuous high rate telemetry, 24 hours per day on VC3. This will be interrupted occasionally to provide magnetograms on the high rate VC2 channel for use in developing summary data at the EOF. This schedule is shown in Figure 3.3.3.2.

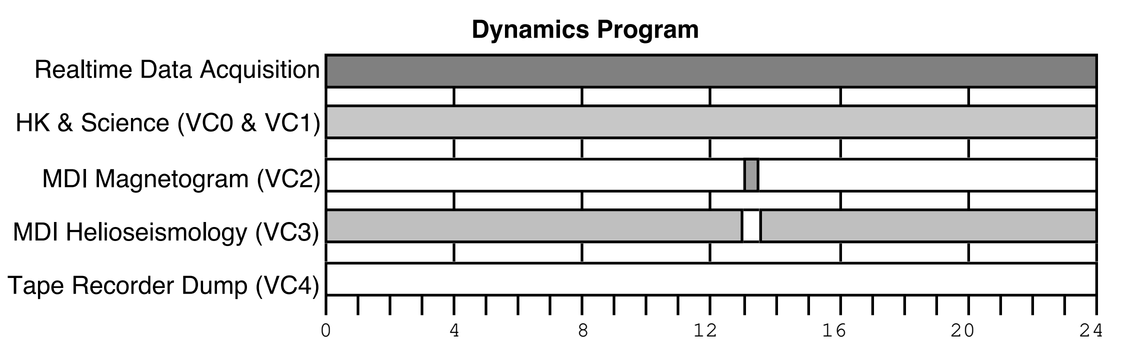

Figure 3.3.3.2 Dynamics Program Schedule

3.3.4 Structure Program

MDI runs the Structure Program of scientific observations almost continuously during HOP. This involves nearly continuous operation of the instrument to measure full disk solar velocities, process them on-board to extract an interesting subset of parameters, and downlink an unbroken time series of these data in the 5 kbps medium rate science channel. The Structure Program requires eight filtergrams to make two 4 point dopplergrams which are then averaged, and a continuum observation. The series of 9 filtergrams should take no longer than 30 seconds. Dopplergrams are computed and then processed on board to determine about 20,000 binned medium-l velocity averages which are then downlinked. Limb data will be processed to determine centering information and the limb figure. The limb information, a magnetic proxy average, compressed intensity sum and LOI mask velocity and intensity images will also be included in the medium rate science downlink .

The structure program can be initiated from standby mode by the MDISTR procedure.

3.3.5 Dynamics Program

The Dynamics Program runs each year during the 2-month period of extended high rate telemetry format. The Dynamics Program uses the same data obtained for the structure program analysis. Both 1024 x 1024 dopplergrams and intensity images are compressed and transmitted. When the 160 kbps channel is available continuously, the Dynamics Program is initiated. The Structure Program will continue as usual, but the same full disk images will also be compressed (by encoding) and downlinked in the 160 kbps channel. Occasionally, one or more cycles will be devoted to magnetic field measurements or calibrations, but these will be scheduled carefully to ensure the minimum disruption of the long time series.

The dynamics program can be initiated from standby mode by the MDIDYN procedure.

3.3.6 Campaign Program

The Campaign Programs run during the high rate telemetry intervals when the Dynamics Program is not being run. The Campaign Programs will be a mixture of other observing modes, with the accent on high resolution observing. One program might consist of continuous high resolution magnetograms. Another program might consist of continuous high resolution line and continuum intensities. When the 160 kbps telemetry channel is available for any period between a few hours and a few days (high rate telemetry format), MDI will run Campaign Programs. The Structure Program will continue, occupying the instrument for about 50% of its duty cycle and filling the 5 kbps channel as usual, and other observations will use the remainder of the duty cycle and fill the 160 kbps channel. The other observations will often involve images in high magnification mode, images at different wavelength settings in the line or continuum, and/or magnetograms, depending on the scientific program selected.

A campaign program can be initiated from standby mode by the MDICMP procedure. The program must be previously loaded into the DEP and any tables or macros required loaded into the IP as described in section 3.3.11. A Campaign program can also be run without interrupting the structure program by setting the appropriate DEP register as described in appendix G.

3.3.7 Magnetic Field Program

The Magnetic Field Program will run a few times each day. It is an interleaved set of right and left circularly polarized dopplergrams, averaged over several minutes. It will be telemetered in the five minutes following each scheduled 160 kbps tape dump. The magnetograms will be telemetered on Virtual Channel 2 (VC2) which will enable the direct receipt at the Experiment Operations Facility (EOF). The magnetic field program interrupts the structure program for the period of time the magnetogram is acquired.

The magnetic program can be initiated from standby mode by the MDIMAG procedure. The magnetic program can also be run in parallel with the structure program using procedure by setting the appropriate DEP register as described in Appendigx G..

3.3.8 Calibration Program

The Calibration Program runs during the high telemetry rate intervals, and uses calibration lenses to provide defocused sunlight through the optics system. The Calibration Program should be run every few hours (as possible) early in mission and perhaps once to several times per day later on after instrument time constants are shown to be very long; some random variation in scheduling is probably desirable. The sun-source provides calibration of the intensity flat field at each magnification, velocity flat field in low magnification, and of the Lyot filter in high magnification mode. The sun-source calibration does not interrupt the structure program.

The calibration program can be initiated from standby mode by the MDICAL procedure.

3.3.9 Terminate Imaging Program

Any DEP sequence imaging program can be terminated and MDI placed into standby mode by the MBSQSTP command. Any calibration program running in parallel with the primary structure program can be terminated by setting the appropriate DEP register as described in Appendix G. This will leave the structure program active.

3.3.10 Configure for Orbital Maneuver Safe Mode

MDI can be placed in a mode safe for orbit adjust thruster firings using the M_SAFE procedure which is found in Appendix E.

3.3.11 Recover From Orbital Maneuver Safe Mode

MDI can be recovered from safe mode to standby mode using the M_FDOPEN1 procedure which is found in Appendix E, and from standby to ready by the MBLTCLSL command to close the loop in the limb tracker.

3.3.12 DEP/IP Memory Loads

On occasion, updates to the onboard data tables and imaging sequences may be required. Examples of these updates could be changes to the Campaign Program, updates to DEP data tables or changes to DEP imaging sequences. These updates will be developed with sufficient lead time prior to needed use to allow for review, uplink and operational test. Uplink and operational test of new or significantly modified sequences will typically be performed during periods of high rate data support. The data will be routed to the EOF by switching to VC2 for a short period to support the sequence testing and performance evaluation. This data support period will be scheduled to coincide with a period of reserved, Near Real Time commanding to allow for instrument commanding in the advent of anomalies.

3.4 Coordinated Operations with Other Experiments

3.4.1 Description of the Operations

Coordinated observations will be performed via timelines generated during the planning meetings in the weeks prior to the observations.

3.4.2 Operational Constraints

See section 3.3.2.

3.4.3 Detailed Timeline

To be defined by planning process.

3.4.4 Detailed Operational Procedures

To be defined by planning process.

3.5 Special Operations

No special operations have been identified at this time.

3.6 Contingency Operations

Contingency operations procedures are listed in Appendix F. Some of the procedures may be executed for verification during the initial MDI checkout in TTP.

3.6.1 Description of the Operations

These procedures have been developed during the ground testing of the MDI experiment. They will be available during flight operations to address contingencies which may arise.

3.6.2 Operational Constraints

See 3.3.2

3.6.3 Detailed Timeline

As required.

3.6.4 Experiment Deactivation

The experiment is powered down completely using the M_OFFSCA procedure.

Table 3.6.4.1 MDI Power Down Procedure - M_OFFSCA

Configure For Deactivation and Safe mode - M_SAFE
- Close front door

Perform Controlled Experiment Power Down
- All internal mechanisms powered off
- Front door and alignment mechanism powered off
- Image Processor off
- CCD Camera off
- Power converter 1 to S/C B bus
- All heaters powered off
- Application Electronics off
- All MDI systems powered off
- Power converter 2 to S/C B bus
- Configure MDI for power on recovery

3.6.5 Emergency De-activation

MDI may be powered off in the most rapid manner by running the M_EMOFF procedure. This method of powering the instrument down is intended for emergency conditions but may be used under other conditions at the discretion of the MDI Operator.

3.6.6 Configure for Sleep Mode

Sleep mode is entered from standby mode using the M_SLEEP procedure.

3.6.7 Recover From Sleep Mode

The recovery from sleep mode to standby mode is accomplished through a wakeup procedure called M_WAKE which runs M_IPON, M_CMON, M_MCHSON and M_LTON.

3.6.8 Monitor Temperatures

A brief power up to Sleep mode, record housekeeping temperature monitors, and power down can be performed by the M_TEMPMON procedure.

3.6.9 Configure for DMC Operations

The DMC can be enabled and checked out using the MDIDMC procedure.

3.6.10 Configure for DSOS Operations

The DSOS can be enabled and checked out using the MDIDSOS procedure.

3.6.11 Configure for Cross Strap Power

MDI can be powered up and checked out for primary converters on spacecraft bus B using M_PCONSCB, for redundant converters on spacecraft bus A using M_RCONSCA and for redundant converters on spacecraft bus B using M_RCONSCB. Each of these routines, along with M_PCONSCA, allow for the configuration of MDI for redundant block commands and/or redundant high rate telemetry.

3.6.12 Power-Loss Recovery

This procedure is very similar to the initial activation associated with TTP. It differs from it by the fact that 2 Mbytes of IP tables necessary for MDI functioning should have been preserved in keep-alive memory. A subsequent table upload should not be necessary. The power up sequence will be the same as used in the initial activation, M_ON, but will be followed by memory dumps best accomplished during periods of high rate telemetry support.

4.0 GROUND SEGMENT SUPPORT

4.1 General

This section describes special support requirements from the SOHO Mission Operations and Control Center (SMOCC) for planning and performing MDI operations.

The SMOCC should monitor MDI temperatures, voltages and currents to determine out-of-limit conditions. Spacecraft pointing and gas jet firings should be monitored for unusual conditions. In the event of a problem the SOI/MDI team should be notified and MDI should be placed into a safe mode. If any contingency operations have been identified then they should be invoked.

4.2 Activation, Commissioning and Calibrations

During initial activation and calibration, many operations will be conducted in near real time. Either MDI or TSTOL procedures will be followed for these operations depending on the level of SMOCC support required, but in either case they will contain instrument team verification callouts for each significant step. This will permit review of the results of each step prior to proceeding forward. Depending on the successful completion of each step, the instrument team may give a go ahead for the next step or, alternatively, invoke contingency steps.

Part of the initial checkout for the MDI instrument will include the loading of the IP memory via the command uplink. It is estimated that MDI will use about 2 megabytes of these look-up-tables, which will be stored in error correcting memory in the MDI image processor. It is planned to uplink the entire set of look-up-tables at the start of the mission (and after any complete power failure including IP memory keep alive power). This table uplink would require approximately 10 hours of uplink time, if the 2 megabytes of mask look-up tables are uplinked at 500 bits/second. This table uplink could be performed over several weeks early in the transfer phase from the background queue. In addition to the initial uplink, the look-up-tables will occasionally be updated to provide information about other solar oscillation modes. The extent of these updates is still to be established.

4.3 Routine Operations

The SMOCC will be required to participate with the operation of the MDI high rate virtual channels, VC2 and VC3. VC2 magnetic field program operations are anticipated to occur for 5 to 10 minutes following every VC4 tape dump. VC3 high rate helioseismology program data is expected during each 8 hour pass per day during the campaign program and for 24 hours continuous during the dynamic program. SMOCC support will be required during the dynamic program during brief VC3 operation interruptions in order to meet the daily VC2 magnetic field program requirements.

4.4 Coordinated Operations with Other Experiments

No special support requirements are anticipated during coordinated operations during HOP.

Certain tests during TTP such as intra-instrument flags and jitter will require SMOCC coordination.

4.5 Special Operations

No special operations have been identified at this time.

4.6 Contingency Operations

SMOCC support will be required to provide thermal control of optics during periods of thermal maintenance mode operation. The spacecraft no-op heaters will be required to maintain temperature control for the MDI optics.

SMOCC support will be required to verify keep alive power mode successfully entered, and to provide for the reload of the IP tables if the keep alive power fails following the initial load.

SMOCC coordination will be required to allow MDI to enter Orbital Maneuver Safing mode including closing the outer door in the advent of spacecraft thruster firings.

5.0 EXPERIMENT DATA BASE

5.1 General

Rules for naming telecommands and telemetry monitors have been established following the guidelines established in SH-MAT-NT-09823. All names are less than 8 characters with the first two dictated by SH-MAT-NT-09823. Further rules adopted by SOI-MDI for naming are included in Appendix A.

5.2 Telemetry Summary

The MDI telemetry database is included in Appendix B per rev dated TBS.

5.3 Telecommand Summary

The MDI telecommand database is included in Appendix C per rev dated TBS.

Appendix A: MDI NAMING CONVENTIONS

A.1 MDI Telemetry Mnemonic Rules

First Character	
Always "M" for MDI	M
Second Character	
Current Monitor	I
Temperature Monitor	T
Variable Voltage Monitor	U
Miscellaneous Analog Monitor	X
Fixed Positive Voltage Monitor	+
Fixed Negative Voltage Monitor	-
Functional Control	F
Software Provided Information	K
Monitoring	M
Digital Relay Status	S
Zone/Digital Table	Y
Next Characters	
Mechanism/System Abbreviations	See A.3 Below

A.2 MDI Telecommand Mnemonic Rules

First Character	
Always "M" for MDI	M
Second Character	
Block Command	B
Pulse Command	C
Memory Load Command	Z
Next Characters	
Mechanism/System Abbreviations	See A.3 Below
Last Character for Pulse Commands	
Primary Command (Normal)	N
Redundant Command	R

A.3 Mechanism/System Abbreviations

Application Electronics	AE

Alignment Mechanism	AM
Alignment Mechanism Motor #1	AM1
Alignment Mechanism Motor #2	AM2
CCD Camera	CM
Calibration/Focus Wheel #1	C1
Calibration/Focus Wheel #2	C2
Degraded Motor Controller	DM
Dedicated Experiment Processor	DP
Degraded Science Operations System	DS
Electronics Package Temp. Sensor	EPTS
Front Door	FD
Front Door Motor #1	FD1
Front Door Motor #2	FD2
Front Door Both Motors Together	FDB
Heater, CCD Camera Decontamination	HCM
Heater, Operational CCD Camera	HOC
Heater, Optics Package	HOP
Heater, Prime Filter Oven	HPO
Heater, Redundant Filter Oven	HRO
Heater (generic)	HTR
Image Processor	IP
Limb Tracker	LT
Michelson Tuning Motor #1	M1
Michelson Tuning Motor #2	M2
Motor (generic)	MTR
Optics Package Temp. Sensor	OPTS
Polarization Analyzer Wheel	PA
Primary Power Converter #1	PC1
Primary Power Converter #2	PC2
Power Distribution System	PW
Redundant Power Converter #1	RC1
Redundant Power Converter #2	RC2
Sequence	SQ
Shutter	SH

Telecommand Status	TC
High Rate Telemetry	TM
High Rate Telemetry Interface #1	TM1
High Rate Telemetry Interface #2	TM2

Appendix B: TABLE OF TELEMETRY MONITORS

Include Housekeeping TLM Layout, 10 Pages

Appendix C: TABLE OF TELECOMMANDS

Include MDI Telecommand Descriptions, MDI340020, 35 pages

Appendix D: ACTIVATION &CHECKOUT PROCEDURES

D.1 TSTOL Activation/Checkout Procedure Inputs

D.1.1 M_PCONPRI

D.1.1 M_IPON

D.1.1 M_CMON

D.1.1 M_LTON

D.1.1 M_MCHSON

D.1.1 M_AMON

D.1.1 M_HTRON

D.1.1 M_OVENON

D.1.1 M_HCMON

D.1.1 M_MCHSCHK

D.1.1 M_LTCHK

D.1.1 M_AMCHK

D.1.1 M_IPCHK

D.1.1 M_DEPCHK

Appendix E: ROUTINE PROCEDURES

E.2.18 MDICAL

Appendix F: CONTINGENCY PROCEDURES

Appendix G: OBSERVATION SEQUENCES

G.2 DEP Observing Sequences

A single DEP master sequence runs at the top level and handles all repeat loops and transitions. This guarantees that cadence will be maintained through observing sequence transitions. There are seven places into which different observations (subsequences) can be entered, as well as a location for the campaign list, which is just a list of observations. An observation is a 15, 30 or 60 second list of filtergrams. This avoids the need to develop sequences that contain loops, branches, flags or tests, and instead places the emphasis on ordering the observation filtergrams. To realize some campaigns, nesting may be allowed in the campaign list, i.e. C1-R1, C2-R2, repeat that pair 10 times,then C3-R3, etc.

The top-level DEP sequence has several major components:

struct60	normal structure program operating during non-contact periods
struct60d	structure sequence during dynamics (probably identical to struct60).
struct30	30 second structure sequence that runs during the magnetogram portion of the non-contact periods.
struct30d	30 seconds structure sequence that runs during the magnetogram portion of dynamics (probably identical to struct30).
struct30c	30 second structure sequence that runs during the campaigns
mag30	magnetogram sequence that runs in conjunction with struct30.
mag30d	magnetogram sequence that runs in conjunction with struct30d mag30c magnetogram sequence that runs in conjunction with struct30c. mhead head of the magnetic program sequence
mtail	ail of the magentic program sequence

The master sequence contains 90 repeats of struct60, then the magnetic program for 6 minutes: 5 mag30, 6 struct30, and 15 seconds of head (mhead15) and tail(mtail15) for synchronization. Prior to each struct60, the sequence branches if the campaign flag is set. The campaign starts with a campaign head (chead) then a struct30. The sequence then loops through successive executions of 30 seconds of the campaign (camp30) and struct30. After each struct30 the campaign flag is tested. If it has been cleared, the campaign tail (ctail) is executed, and the 60 second structure program resumes.

Campaigns will be constructed in a way such that when the campaign is over, the next magnetogram will be on a 96 minute mark. Optionally, campaigns can be constructed in a manner that maintains the cadence thoughout the campaign, i.e., a magnetogram will be interspersed with the campaign at the proper cadence.

To setup a campaign, one would select (by telecommand) chead, ctail, camp30, and specify if the magnetic program is to occur within the campaign. The campaign starts by telecommand that sets a DEP register. The campaign continues until terminated by telecommand.

G.2 Observation Lists

G.2.1 Structure

Raw FD Images

Raw HR Images

FD Continuum Scan and Line Intensity

G.2.2 Dynamics

FD Dopplergram,

FD Intensity or HR Dopplergram

G.2.3 Campaign with Structure

Raw FD Images

Raw HR Images

FD Continuum Scan and Line Intensity

Campaign Sequence

8 Frame Magnetogram

Polarization Magnetogram

Calibration

Dark Current Test

Focus Test

CTE Test

G.2.4 Campaign Interrupting Structure

Magnetogram

Calibration

Special Calibration

G.2.5 Campaign without Structure

Raw FD Images

Raw HR Images

FD Continuum Scan and Line Intensity

Campaign Sequence

G.2.6 Magnetogram

FD Magnetogram

Structure Sequence

Calibration

FD Dynamics Sequence

FD HR Magnetogram

5 FD Dynamics

Structure Sequence

G.3 Calibration Sequences

G.3.1 ISS Offset Observation

Kuhn Type Flat Field

Disk Centering Test

G.3.2 Leg Offset Observation

Center Sun

Offset Scattered Light Test

G.3.3 Anomalous Pointing Observation - Spacecraft Roll Test

TBD

G.3.4 Standard Calibration

TBD

Dark Current Test

Focus Test

CTE Test

Appendix H: MDI OPERATIONS TIMELINE

H.1 Proposed MDI Activaton and Commissioning Timeline

10 August 1994 version - 4 pages

Appendix I: MDI SOHO COMMISIONING TEST SHEETS

H.1 MDI Commissioning Test Sheet Inputs

11/94 Submittal 7 sheets