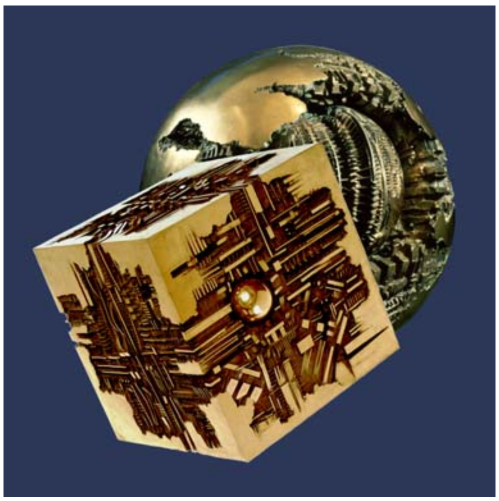
Helioseismic and Magnetic Imager
for
Solar Dynamics Observatory



Concept Study Report

Appendix L

HMI SOC Operations Plan

SU-HMI-S016
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Stanford University Hansen Experimental Physics Laboratory
and
Lockheed-Martin Solar and Astrophysics Laboratory

The cover of the NASA 1984 report "Probing the Depth of a Star: The Study of Solar Oscillations from Space" featured Hirschhorn's the Pomodoro Sphere. That report led to the helioseismic study of the global Sun. Pomodoro's Cube at Stanford symbolizes HMI data cubes for investigation of localized regions in the Sun.

HMI Mission Operations Concept

The goal of the Helioseismic and Magnetic Imager (HMI) mission operations is to produce a uniform and continuous data set of solar Dopplergrams and magnetograms. Clean multi-day time series of images are necessary for time-distance helioseismology analysis, and multi-year time series are essential for solar cycle studies. Our experience with the Michelson Doppler Imager (MDI) instrument on SOHO has demonstrated that even subtle changes in the observing program can influence the helioseismology analysis. Except for calibration and coordinated spacecraft activities, a single observing sequence is planned to operate for the life of the HMI instrument in order to achieve the cleanest possible data set with a minimum level of operator support. The HMI operations are divided into three phases: launch and checkout, nominal operations, and coordinated spacecraft activities.

The HMI Science Operations Center (SOC) will be located at Stanford University with support from scientists and engineers at the nearby Lockheed Martin Solar and Astrophysics Laboratory. The HMI SOC will be responsible for science planning and operations, instrument health and safety monitoring, and data receipt and processing. Training materials and operations scripts will be developed in coordination with the flight operations team. These activities will be similar to those performed by the Stanford and Lockheed groups for the MDI operations, data processing and science analysis.

HMI Launch and Checkout

Prior to launch, the HMI Optics Package should be kept on a continuous dry nitrogen purge in order to minimize moisture build up in the Optics Package. The timing of the purge disconnect will be detailed as part of the instrument accommodation, but should be continued as long as practical before launch. There are no special requirements during launch, and it is assumed that the instrument power will be completely off until the spacecraft solar panels are deployed.

As soon as the spacecraft is power positive, the survival heater power should be activated in order to maintain the HMI Optics and Electronics Package temperatures at acceptable levels. The CCD decontamination heater power should be activated as all survival heater power function has been verified. The CCD decontamination heater will keep the CCD detector warm during the initial instrument and spacecraft outgassing. The HMI instrument should be powered up as soon as spacecraft resources permit. Control of the HMI heaters will then be maintained by the flight instrument software. The HMI front aperture cover (front door) will remain closed until the SDO spacecraft has reached geosynchronous orbit and high rate telemetry transmission is enabled in order to minimize contamination of the front window by the Geosynchronous Transfer Orbit insertion and circularization of the orbit.

During the first month after launch, the HMI instrument will be run through a pre-planned series of commissioning and calibration activities. The goal is to verify the correct operation of all the HMI subsystems, and to tune any instrument parameters necessary to achieve optimal performance. An extensive set of calibrations will be performed to crosscheck the on-orbit HMI characteristics against the ground calibration, and to optimize the long-term on-orbit calibration sequences. A series of observing sequences will be tested to determine the most efficient observing program, both in terms of the resulting science data products and instrument resources. We expect that the coordinated spacecraft activities will be rehearsed.

During launch and checkout, HMI personnel will be located at the SDO Mission Operations Center (MOC) with support from the HMI Science Operations Center at Stanford University.

HMI Nominal Operations

Nominal operations begin at the completion of the commissioning activities, with a single observing program similar to that described in Appendix A. This sequence will only be interrupted for periodic calibration and spacecraft activities, and will continue to run through the SDO eclipses.

All observations require the spacecraft to maintain nominal Sun center pointing with the spacecraft roll adjusted to keep the projection of the solar rotation axis aligned to the HMI coordinate frame (similar to the SOHO spacecraft roll steering law).

From the HMI point of view, we plan to operate as autonomously as possible. This is primarily because we want to minimize the observing interruptions caused by changing operating modes. We will have a sequencer that will cycle mechanisms and initiate camera exposure and readout in a well defined manner, and it will be capable of switching observing lists for operational and calibration purposes. It is not clear at this time whether we will key these "framelist" changes to absolute time or as a simple framelist counter.

After commissioning is completed, HMI operations will primarily consist of instrument health monitoring and scheduling calibration and coordinated spacecraft activities. Instrument command timelines will be generated as required (a few times per week), and sent to the MOC for upload at the next scheduled command window. The HMI health monitoring will consist of automated processing of HMI housekeeping and summary science data with alerts generated when out of nominal conditions are identified. The summary health status will be reviewed daily, and long-term instrument trends will be monitored for anomalies. The MOC support described in the AO is sufficient to meet all HMI operational requirements.

The on-orbit calibration support will be similar to that implemented with the MDI instrument. A daily sequence of images will be taken in HMI “calibration mode” to monitor instrument transmission and CCD performance. This sequence will run for one to two minutes, and will be scheduled as part of the nominal observing sequence. Approximately every two weeks, a longer performance monitoring sequence will be run to measure the instrument focus, filter and polarization characteristics. This sequence will run for approximately one hour, and will likely be initiated as part of the observing sequence timeline, but may be initiated through ground command.

HMI Eclipse Operations

The primary concerns of eclipses in the SDO orbit are the loss of signal for the image stabilization system and temperature perturbations caused by the Earth’s shadow. Commands to open the image stabilization system loop and to initiate any other required activities prior to entering eclipse will be stored in either the SDO stored commands or the HMI instrument timeline. Primary thermal control will be maintained by closed loop thermal control maintained by the HMI main processor. The image stabilization system loop will be closed by stored command, with checks of the limb sensor signal to insure adequate signal and that the mirror PZT offset is within acceptable limits.

HMI Commanding Requirements

The commanding requirements for the HMI instrument will be simpler than those needed to support the Michelson Doppler Imager instrument on SOHO. The commanding for the HMI instrument is anticipated to consist of individual commands to set the instrument state (start observing sequence, set up Image Stabilization System operation, etc) and to load observing framelists. The latter will consist of blocks of commands with a maximum of a few hundred individual command blocks depending on the command string length. It is too soon to tell if we will need to reload the HMI observing framelists on a regular basis, on MDI these reloads were performed approximately every six months. Unlike MDI, the HMI instrument will not have an image processor and as such will not require very large command loads.

The HMI instrument will be configured to use the SDO spacecraft Absolute Time Commanding capability. All instrument commands that are not marked for delayed execution by the spacecraft ATC should be routed directly to the instrument. We do not anticipate any instrument commands should affect the safety of the spacecraft, but we may want to make some instrument commands as critical to insure that they are not sent accidentally (such as closing the front aperture door).

The transfer of command load files to the Mission Operations Center via a secure method should be adequate for all anticipated commanding. A mechanism for having command load files executed with minimal delay is primarily required for instrument commissioning and troubleshooting. For "immediate execution" command loads, delays of one to two minutes are acceptable. The "daily load" files can be tagged with an acceptable uplink time window.

We expect to use the immediate execution command loads for instrument commissioning and coordinated spacecraft activities such as offpoints and rolls. During normal operations, we expect a daily command load should be sufficient for operational needs.

HMI Coordinated Spacecraft Activities

The coordinated spacecraft activities envisioned are station keeping and momentum management (SK/MM) activities, and spacecraft off-point and roll maneuvers. During SK/MM activities, the HMI ISS loop will be opened to minimize the large excursions of the active mirror. The HMI ISS commands could be included in the overall SK/MM script as was done for MDI during SOHO maneuvers.

The spacecraft off-point and roll maneuvers are similar to those performed by the SOHO spacecraft. These are desired at six-month intervals, near the eclipse season in order to minimize interruptions during the non-eclipse periods.

The off-point is used to determine the instrument flat-field, and requires 5 minute dwells at 15 to 20 off-point positions on the solar disk. It is expected that other SDO instruments will also require spacecraft off-points. Appendix D details the SOHO operations timeline for an offpoint that was performed in August 2002.

The roll maneuver is essential to determining the solar shape, and a similar activity has been performed with MDI to make solar oblateness measurements. The spacecraft rolls allow the instrumental and solar components of the observed shape to be separated, and requires a 360º roll with 15 minute dwells at 12 to 16 evenly spaced roll angles. Depending on spacecraft performance, the off-point activity is likely to take 2 to 3 hours, and the roll activity 6 to 8 hours. The HMI observing sequence for both activities would be similar to the nominal observing sequence and could be initiated as part of the spacecraft script. Appendix E details the SOHO operations timeline for a 360º roll that was performed in November 2001.

Appendix A

Sample HMI Observing Sequence

The HMI observing sequence design requires careful consideration of cadence, dynamic range, noise level, required polarizations, solar feature temporal evolution, and instrumental effects. Experience with MDI observations shows that deviation from a uniform sequence, such as for synoptic magnetograms or intermittent campaign sequences, cause noise and false peaks in the velocity spectrum. The continuity requirement for helioseismology is to observe more than 95% of the time on all temporal scales with 99.99% data recovery. Therefore, it is essential to use a single continuously running sequence for all HMI observations.

Simultaneous measurements of the Doppler velocity and line-of-sight and vector magnetic field observing requirements impose significant constraints on the sequence. Scanning in wavelength is required for velocity determinations while making multiple polarization measurements quickly is a priority for the magnetic field. An optimal sequence would provide four polarization measurements at five wavelengths in less than 50 seconds. In order to provide adequate margin in the instrument performance, a two camera design has been adopted. To ensure optimal Doppler performance, one camera is used for the Doppler and line-of-sight magnetic field measurements, the other for the vector field measurements each with a specific polarization sequence. Based on the above, the baseline observing sequence is detailed in Figure A1.1. The same sequence of wavelength tunings is used for both the vector and line-of-sight measurements. This limits the wear on the tuning motors and ensures that changes in the tuning sequence do not cause artifacts in the line-of-sight measurements.

To measure the full polarization vector at a given wavelength, at least four filtergrams are required. The four polarization measurements are spread out over twice the time required for the line-of-sight measurements. The choice of polarizations and the order in which they are taken drive the observing sequence design for the vector measurements. The sequence shown in Figure A1.1 determines Q in the first half and U in the second half. A quarter waveplate followed by a half waveplate provides the required polarization states while minimizing wear in the mechanisms.

A 45 second cadence is achieved for the Doppler and longitudinal magnetic field and a 90 second cadence is achieved for the vector magnetic field. Including a continuum tuned image in the sequence results in an image cadence of 4.1 seconds for each camera. The exposures and readouts are interleaved with the estimated exposure time to be 250 msec. The images from the two cameras will not be combined during normal analysis.

Time (sec)	**0**	**8**	**16**	**24**	**32**	**40**	**45**	**53**	**61**	**69**	**77**	**85**
λ Tuning	I1	I2	I3	I4	I5	IC	I1	I2	I3	I4	I5	IC
Doppler Seq	L R	R L	L R	R L	L R	C	L R	R L	L R	R L	L R	C
Vector Seq	1 2	2 1	1 2	2 1	1 2	C	3 4	4 3	3 4	4 3	3 4	C

Polarization	L = I + V = LCP	R = I - V = RCP	1 = I + aQ + bV	2 = I – aQ + bV	3 = I + aU – bV	4 = I – aU - bV

Figure A1.1: Details of the HMI observing sequence: *Time* indicates the beginning of the exposures at a given wavelength. The *wavelength Tuning* positions I1 through I5 are spaced evenly 75 mÅ apart, with I3 centered on the line (see Figure C.8). *Doppler Seq* and *Vector Seq* indicate the order and polarizations settings for the two cameras, with the states L, R, 1, 2, 3, 4 identified by *Polarization*. For $a^2=2/3$ and $b^2=1/3$, Q, U and V have identical noise equal to 0.22% in the continuum. IC is a continuum filtergram taken in linear polarization.

Appendix B

Sample HMI Image Compression

Image data will be compressed using a look-up table followed by the lossless Rice-type compression scheme similar to that used for MDI. This algorithm can be implemented very easily in hardware to run at the required rate, and its performance is well understood. The technique has been simulated using very high-resolution images from La Palma, blurring them to make diffraction-limited HMI images, adding appropriate noise and quantization, compressing and decompressing. The compression process adds noise which is statistically well-behaved and is a small fraction of the photon shot noise in magnitude at all intensity levels. A worst case continuum image of a large sunspot required 6.2 bits/pixel, and quiet Sun areas require only 5.5 bits/pixel, Adding a 10% margin to account for potential differences between the La Palma and HMI images gives a baseline compression efficiency of 6.1 bits/pixel, and bandwidth of 55 Mbits/sec to downlink 4096^2 pixel images with a cadence of 2.05 seconds.

A few notes on expected data rates from the HMI instrument and our experience with the Michelson Doppler Imager instrument on SOHO.

1) Peak Rates:

The intent with the HMI instrument is to maintain a uniform cadence of full disk solar images taken a multiple wavelengths and polarizations (also know as filtergrams). An example of the expected HMI image data can be seen in the attached series of MDI filtergrams taken in the high resolution field of view. These images have a spatial resolution similar to that proposed for the HMI instrument (MDI - 0.62 arc-second pixels in high res mode; HMI - 0.5 arc-second pixels). In the sequence of images from left to right, the wavelength tuning is changed in 0.1 Angstrom steps (nomenclature - F1, F2, F3 & F4). The top row is taken in left circularly polarized light (LCP) and the bottom row is taken in right circularly polarized light (RCP). These 8 images have a 256x256 pixel field of view, and require a minute to downlink at SOHO telemetry rate of 160 kbits/sec.

Dopplergrams are computed from both the LCP and RCP line profiles. The mean velocity signal is the average of these two dopplergrams, and the magnetic field signal is proportional to the difference.

A simple lossless compression algorithm similar to that used in the MDI instrument gives the following compression estimates for these images - input is 16 bits; the third column gives the compression efficiency for the entire image and the fourth column gives a similar number for the bottom third of each image to remove the effect of the sunspot.

As can see from this simple estimate, active regions and plage have a secondary effect on the compression because the solar noise is roughly independent of the intensity. Similarly changing polarization has a small effect on the compression. There is, however, a 10% variation in the compression due contrast changes resulting from tuning across the observing line.

We expect that the compression efficiency will be roughly constant over any single filtergram, and that the image compression rate will highly repeatable over the full tuning cycle of the HMI instrument (45 to 90 seconds). As can be seen from this example, some variation from image to image can be expected.

Image #	Tuning	Bits/pixel whole image	Bits/pixel bottom 1/3
1	LCP F1	7.83	7.80
2	LCP F2	7.52	7.52
3	LCP F3	7.95	7.94
4	LCP F4	8.12	8.11
5	RCP F1	7.83	7.80
6	RCP F2	7.53	7.48
7	RCP F3	7.93	7.94
8	RCP F4	8.10	8.09

2) Compression Variability:

The two factors that have most influenced the variability of the MDI high rate telemetry compression have been the annual variations in the apparent solar radius due to variations in the SOHO to Sun distance and changes in focus of the MDI instrument. The ellipticity of the earth's orbit causes an annual variation in observed solar radius of about 5% resulting in an effective 10% change in observed solar area. Because the image data off the solar disk compresses more efficiently than the solar image, the overall compression efficiency decreases by several percent as the apparent size of the sun increases. The change in efficiency is less than 10% because the area off the disk still requires telemetry.

Adjustments in instrument focus change the contrast of the images resulting in changes in the compression efficiency. Focus changes have been observed in the MDI instrument primarily as a result of changing temperatures and temperature gradients. We plan to observe with HMI in "best" focus and therefore at the highest contrast, and are designing additional temperature controls to minimize focus changes. This in turn will minimize compression changes for normal operations. There are planned calibration activities, however, that will occasionally require observing in different focus settings with a corresponding change in the downlink.

We do not expect that radiation hits will have a significant effect on the compression because the entire image is relatively "bright". In addition, there are a sufficient number of pixels that the average number of bright pixels over an image would be roughly constant except in a major solar proton storm.

3) Science Data Buffering:

The high rate telemetry interface for MDI on SOHO was controlled by a readout clock provided by the spacecraft. As such the MDI data was readout at a constant rate, and it was the instrumenters responsibility for minimizing data loss at this interface. Buffering was provided by memory in the MDI image processor and the observable data was planned to slightly underfill the available downlink. If an image buffer was completely emptied before the next data was available, a "fill" data pattern was downlinked. If a new image was ready before the previous buffer was empty, the downlink was interrupted and the old image was overwritten.

Appendix C

SOHO Roll Steering Law

The SOHO Roll Steering Law (RSL) table contains 400 entries, which are uplinked and stored in the spacecraft Attitude Control Unit (ACU) memory. Each entry specifies a roll reference position used by the guide star and the ACU control law algorithms to maintain the roll attitude of the spacecraft such that the solar axis always remains constant relative to the spacecraft. As SOHO orbits the Sun over the course of a year, the RSL very gradually changes the spacecraft roll angle from approximately 7 degrees, through zero, and continuing on to approximately -7 degrees, then back through a roll angle of zero, and on up to positive 7 degrees again. The roll attitude changes in very, very small increments (on the order of approximately 0-18 arc-seconds I would estimate, although if you needed the exact minimum and maximum values, we could get them). The smallest increments would be applicable as the roll angle approaches the 7 degree extremes, and the largest increments would occur as the roll angle crosses zero degrees.

Originally, the SOHO Flight Operation Team (FOT) uplinked the RSL table daily, and the 400 entries contained enough movements to cover a 3-day period. The daily uplink assured 48-hour autonomy for the roll attitude, if the ability to command the spacecraft was lost. To cover 3 days, the 400 entries were timed to execute every 11 minutes and 24 seconds. Several years ago, among a number of initiatives to reduce the SVM activity level, a change was made to have the RSL table update the roll attitude every 22 minutes and 48 seconds. This required the magnitude of each movement to roughly double, although they are still quite small (the 18 arcsecond maximum I estimated includes the new, larger increments). The benefit was that the RSL table now covers a 6-day period, and instead of being uplinked daily, we now load a new table every Tuesday and Friday, thereby maintaining the 48-hour autonomy requirement.

One important point about the RSL table as it is stored in ACU memory is that if the last entry is reached, the RSL function does not automatically disable itself. Instead, the pointer would wrap around to the first entry in the table and the spacecraft would roll back to that attitude. This jump, reversing 6 days worth of roll movements, would almost certainly exceed the 60 arc-second roll threshold, and the Roll Anomaly flag would trigger. However, as long as the attitude jump is confined to the roll axis, no on-board corrective actions would be initiated. In order to avoid any possibility of the RSL table "rolling over" like this, the FOT uplinks a time-tagged command to disable the RSL function. This command is simply scheduled to execute after the last entry in the table.

With that basic description of the RSL function, a summary follows of the FOT management of the RSL function. Every Tuesday and Friday, a new load input from Flight Dynamics Facility (FDF) is used to generate the RSL load. The FOT disables the RSL function, deletes the existing time-tagged RSL disable command mentioned above, and uplinks the new RSL table to ACU memory. A new time-tagged RSL disable command is also uplinked to prevent the RSL rollover problem. The ACU memory is dumped so we have a ground image which can be referenced if there is ever any problem with the RSL not executing as expected. The FOT also verifies that the first movement in the new table is within 60 arc-seconds of the current roll attitude, so as to avoid triggering the Roll Anomaly flag when the RSL function is enabled and the first movement commences. The RSL function is then enabled, and a typically small roll movement is executed to set the spacecraft roll attitude to match the first entry in the RSL table.

Appendix D

SOHO Offpoint Maneuver Timeline

SOHO OFFPOINT TIMELINE- AUGUST 2002

Monday 19 August

SORR at 18 UT

NRT for UVCS safing

By 19 UT UVCS will submit a limit violation sheet for when UVCS is safed

NRT for EIT calibrations

By 19 UT LASCO will submit a limit violation sheet for the duration of the offpoint for LUBSY and LUBSX

By 19 UT LASCO will submit a limit violation sheet for when they open the C2 door

Tuesday 20 August

DSN station D66 from 10:25-18:50 UT

DSN station D16 from 18:30-02:20 UT

SSR will be dumped

NRT enabled for LASCO to close doors

Offpoint activities begin at ~11 UT (~7am local time)

Transition to VC2 for the duration of the offpoint (~11:16 UT)

If VC2 becomes unavailable, go to VC3

VC3 is required for the handover

NRT enabled for MDI for ~30 minutes

FOT will begin the Profile in NM/RMW script

Script Step 1 - Initial Verifications (~1 minute)

Script Step 2 - Instrument Status Verification (~10 minutes)

FOT will Disable the offpoint flag to MDI, LASCO, UVCS

Disable ESR flag to LASCO

Script Step 3 - Maneuver Preparation (~10 minutes)

RSL will be disabled

Enable NRT for MDI to open loop and command

Wait until MDI has completed 1 hour of observations and until

MDI and EIT have completed their Step 0 observations

Script Step 4 - Attitude Profile (~5 hours) - will begin after 8am local

Begin offpoint steps 1-13

FOT will enable NRT at each dwell point.

SOC will connect EIT for commanding.

EIT will tell SOC when they are done with the NRT and the 304 image is acceptable (~4 minutes into the dwell)

SOC will tell FOT that they can take the NRT link and prepare for the next profile.

MDI will tell SOC when they are done with their observations.

SOC will tell FOT that they can execute next profile.

NOTE: EIT will first take a 304 image (this will take about 4 minutes) and if the telemetry is good they will tell the SOC that they are done with NRT and observations. If the telemetry is bad, they will need to redo the image, which means they will need NRT for an additional 5 minutes to retake and confirm another 304 image.

The following coordinates are given with respect to spacecraft position. These numbers are deltas from the current position. To see what the sun will look like at each stop, go to: http://mdisas.nascom.nasa.gov/offpoint/plan_2002.

step#	yaw	pitch	dwell
0	0"	0"	5 min
1	0"	-100"	5 min
2	0"	-225"	5 min
3	300"	-225"	5 min
4	-225"	-225"	5 min
5	-225"	0"	5 min
6	-100"	0"	5 min
7	68"	0"	5 min
8	383"	0"	5 min
9	383"	383"	5 min
10	-300"	383"	5 min
11	0"	383"	5 min
12	0"	68"	5 min
13	0"	0"	5 min

Do not proceed unless it is after 15 UT

Begin offpoint steps 14-17

FOT will enable NRT at each dwell point

EIT and MDI will tell SOC when they are done with their observations and the NRT

SOC will tell FOT that they can take the NRT

SOC will tell FOT that they can execute next profile

Step 17 can be waived in case of serious delays threatening to overrun the total time constraints.

step#	yaw	pitch	dwell
14	-700"	0"	25 min

15	720"	0"	20 min
16	0"	0"	0 min
17	0"	-600"	25 min

Begin offpoint step 18

step#	yaw	pitch	dwell
18	0"	30"	10 min

Enable ESR flag to LASCO/EIT

Enable NRT for LASCO to open the C2 door

MDI and EIT and LASCO finish commanding and observing

Begin offpoint step 19

step#	yaw	pitch	dwell
19	0"	0"	5min

MDI, EIT and LASCO finish commanding and observing.

FOT notifies SOC that offpoint is complete.

Script Step 5 - Post-Maneuver Configuration (~30 minutes or more)

Enable the offpoint flag to MDI, LASCO and UVCS.

Enable RSL

FOT script complete

Handover at ~18:30 UT

Enable NRT with VC2

MDI will close the ISS loop

MDI needs 1 hour of NRT with VC2

LASCO needs 2 hours of NRT for EIT calibrations

NRT for UVCS recovery

Appendix E

SOHO Roll Maneuver Timeline

SOHO ROLL TIMELINE- NOVEMBER 2001

<u>TUESDAY -- 13 November 2001</u>

15:30	Test of communications between SOC, CDS, MDI, LASCO, SWAN
15:30-18:30	NRT available (estimated)
18:30-20:00	UVCS dedicated NRT for safing
18:58	CDS pre-roll observations start
20:00-22:30	NRT available (estimated)
21:00	Any limit violation sheets for the roll are due.
	Before COB, all teams confirm with SOCs that everything is set for pre-roll zero-degree observations.

*** NO NRT SCHEDULED AFTER 22:30 until after 1st roll profile has ended ***

<u>WEDNESDAY -- 14 November 2001</u>

03:25-06:45	DSN station D46
06:45-24:00	VC2 for MDI, handovers and bandwith permitting
06:35-14:10	DSN station D66
09:30-10:00	"Maneuver Prep" script
	FOT will disable offpointing flag function for everyone
	MDI loop will be kept closed, or opened (pending input)
10:00-11:00	"Profile in CRP" script *BEGINS* (note: no profile yet!)
10:00-10:30	Science teams arrive to confirm all nominal roll position observations are finished
11:00	All teams should have confirmed all nominal roll position observations are finished
	MDI confirms they are ready for the FOT to open MDI loop
11:00-22:02	Twelve 30º roll profiles, with nominal cadence about 54 minutes from one roll profile to the next.
14:00	Handover DSN station D66 to D16
13:50-22:50	DSN station D16
	SOCs will be informed immediately about the end of each roll profile, as a time reference ("END"). NRT will be enabled immediately thereafter. The time profile of each roll position will be as follows:

TIME	ACTION
END-6	Roll profile starts
END	SOCs are informed
	NRT BEGINS
	SOCs inform over loop
	CDS will move as early as possible
END+~5	MDI closes loop
END+xx	SWAN uploads commands and starts observations
END+10	LASCO uploads commands w/varying time delays
END+13	CDS uploads commands and starts observations
END+35	All teams have informed SOCs they are done with NRT
END+35	**NRT ENDS** UNLESS SOCS ASK FOR EXTENSION
END+45	All instruments have informed SOCs observations are done
	MDI has informed/will inform SOCs that loop can be opened
END+45	SOCs inform FOT they can open MDI loop and proceed
END+49	Start of (N+1)th roll profile
	*** Each team INFORMS THE SOCs when done with NRT.
	*** Each team INFORMS THE SOCs when observations are done.
	*** MDI INFORMS THE SOCs that their loop can be opened.
	*** On each stop except 180º, MDI should be last one to confirm observations are done. At 180º, LASCO will extend the dwell by about 10 minutes. MDI still needs to confirm that the loop can be opened.
	There will be a few minutes between the time the SOC says to go ahead and when the next profile starts. If we are running far behind, the 360º stop will be omitted, going directly from 330º to 270º.
22:02-22:15	After finishing observations from the 360º (or 330º) stop, MDI will confirm that loop can be opened, and we will proceed with roll profile back to 270º for overnight stay.
22:15	NRT enabled when profile has ended.
	CDS and SWAN load overnight plans.
	MDI close loop via NRT.
	If there are any limit violations that may occur, submit a limit violation sheet
22:30	AOS/Handover to DSN station D46.
22:30-06:40	DSN station D46
22:50	NRT disabled according to nominal plan - note handover.
	SVM reserved activities:
	Star map, FDF provide current roll attitude + CRS drift.
	Enable offpointing flag for MDI, SUMER, LASCO.

*** NRT can be enabled if anyone needs it when FOT is done ***

THURSDAY -- 15 November 2001

00:00-24:00	VC2 for MDI, handovers and bandwidth permitting
06:25-14:00	DSN station D66
13:45-22:50	DSN station D27
13:30	All teams will confirm that 270º observations are complete.
	MDI will confirm that ISS loop can be opened.
13:45	FOT will resume "Profile in CRP" script.
	FOT will disable offpointing flag function.
	FOT will open MDI loop.
14:30-14:43	Roll profile to nominal position.
14:43-15:18	NRT enabled to start post-roll observations.
	CDS will begin 14 hours of observations.
	MDI will close loop
15:18-17:00	SVM Reserved
	Complete "Roll Profile in CRP" script
	Begin "Maneuver End" script
	Preparations to return to Normal Mode
	If roll trim is needed, MDI's loop will be opened by FOT
	Return to Normal Mode
	Offpoint flag enabled for UVCS, MDI, LASCO and SUMER.
	(Close MDI loop if necessary)
17:40-19:00	Dedicated NRT for UVCS recovery
19:00-22:15	NRT available for everyone
22:30-06:40	DSN station D46

FRIDAY -- 16 November 2001

00:00-06:40	VC2 for MDI, handovers and bandwith permitting
13:50-21:05	DSN station D16
16:00-18:30	Intercal1, SUMER/CDS/EIT
18:30-19:00	SUMER closes door
19:10	Submode change to Submode 6
	MDI load on either DSN station D16 or D46 w/VC2 (time TBD)
20:45-05:00	DSN station D46