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Scientific Mission Planning System

User Guide

Issue 2.1

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Jon Brumfitt

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Document Change Record

Issue 1.0		Initial issue for HCSS version 0.6.0
Issue 1.1	Section 2.3 Section 4.4 Section 4.5: Section 4.6: Section 5.4	Corrected statement about SPIRE cooler recycling Schedule table added to tab bar Improved RA, DEC, NAIFID in table view (SCR-3933) Highlighting of scheduled observations (SCR-3917) Added section on schedule table (SCR-3918) Added references to schedule table view
Issue 1.2	Section 3.6 Section 9:	Updated to reflect HORIZONS ephemeris retrieval tool (get_ephem) New section explaining the new tools get_ephem & wrap_fts
Issue 1.3	Section 4.1 Section 4.5	Updated info pane interface (SCR-3907) Updated constraints symbols (SCR-3938)
Issue 1.4	Section 4.1	Sky view shows eigenaxis slew paths (SCR-3909) Updated figure 2
Issue 1.5	Section 1.2 Section 1.4 Section 3.5 Section 3.5 Section 3.7 Section 4.9.1 Section 5.4: Section 6.1 Section 8.1 Section 8.2	Updated preface Added "SSF" to list of acronyms Moved to become section 8.6 (SPR-4515) (previously section 3.5): Added "ssf" to list of directories and updated notes Reworded to clarify Updated examples to use the same OD to avoid confusion Changed "XML" to "SSF" Updated sections of saving/restoring schedules Removed note about slew lines Added "ssfdir" to list of directory properties Changed alpha range to ± 3 degrees (SPR-4580) Added property <code>hcss.mps.constraint.str_moon_min</code> Updated ground station constraints
Issue 1.6	Section 3.6 Section 4.9.2 Section 5.4 Section 8.2 Section 8.3	Removed section on "Temporary properties" (SCR-4746) Property <code>hcss.mps.groundstation</code> is now obsolete Added menu command "Show TM" (SCR-3931) Added description of "Show TM" command (SCR-3931). Added paragraph on SSF files. Deleted ground-station properties for VIL and KOU Corrected name of Maspalomas property New section describing property <code>hcss.mps.maxtm</code>
Issue 1.7	Section 9.1.1	Updated default value
Issue 1.8	Section 4.3.2 Section 4.5	Described function of new centring button (SCR-5078) Added note about proposal column (SCR-3922)

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	Section 4.9.1	Added “Batch schedules” to file menu items (SCR-4597)
	Section 4.9.2	Corrected name of “Show TM size” menu item
	Section 5.4	Added paragraph on centring button (SCR-5078) Removed obsolete note about warning of final slew Expanded discussion of SSF importing (SCR-3974)
	Section 5.8	Describes batch regeneration of schedules (SCR-4597)
	Section 6.1	Removed notes on “fixinst” tool and “proptool”
Issue 1.9	Section 4.1	Figure 2 shows 'centre' button & new table columns
	Section 4.2	Figure 3 shows AOS_CHK & R/T windows Added paragraph on special windows
	Section 4.2.4	New section on real-time observations
	Section 4.3.5	Updated section on observation pop-up menu.
	Section 4.5	Figure 10 shows concatenation and new table columns Removed note after table Added paragraphs on real-time and concatenated observations
	Section 4.10	New section on observation pop-up menu
	Section 5.4	Updated paragraph on pop-up menu
	Section 6.1	Added note on SSF files with real-time observations
	Section 8.5	Added 3 new colour properties
Issue 1.10	Section 3.5	Defined new properties for slew predictor (SCR-5507)
	Section 3.7	Clarified memory requirements
	Section 4.5	Added note on mission configuration (SCR-5543)
	Section 4.8	Added new section on the 'Info pane' (SCR-4602)
	Section 8.2	New section on ACMS properties (SCR-5507)

Note: The SMPS requires five new properties to be set, as described in section 8.2. This is important so that the slew times are calculated correctly.

Issue 1.11	Section 9.1	Added 3 new Horizon's tool properties (SPR-6401)
Issue 1.12	Section 10.1	Produce schedule summary for approval (SCR-3910)
Issue 1.13	Section 3.5, 8.1, 8.2	Updated property names

Important note: The names of some SMPS properties have changed. See section 3.5.

Issue 2.0	Section 1.2	Deleted sentence about incomplete functionality
	Section 2.2	Defined alpha and beta
	Section 2.3	Each HIFI band is now a sub-instrument (SCR-9852)
	Section 3.3	Removed reference to fixinst
	Section 3.5	Added “png” snapdir folder and property (SCR-9852) Removed mention of <code>wheels</code> property
	Section 3.7	Method of setting memory size has changed
	Section 4.1	Updated figure 3 to include new features
	Section 4.2.1	Added sentence on RA and DEC areas of sky view Added note on use of ACA coordinates
	Section 4.3	Updated figure 7 and deleted figure 8

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- Section 4.3.3 Constraints are now drawn for time of selected observation
Updated section on preferred maximum beta
- Section 4.3.5 Added paragraph
- Section 4.4 Added problems tab (SCR-8805)
- Section 4.7 Added section on problems tab
- Section 4.9 Added bullet on slew time display
- Section 4.11.1 Added “check submissions” menu option
- Section 4.11.2 Added “add slew”, “validate” and “simulate” menu options
- Section 5.4 Deleted note about memory
Added bullet on locking of observations
Added bullet on constraints depending on time
Expanded the bullet on pack left/right
Added bullet on schedule validation
Added bullet on check/fix menu option
Added bullet on adding a slew manually
Added mention of PNG files
- Section 5.5 Added paragraph on locking when optimising schedules
- Section 5.7 Added paragraph on Check Submissions (HCSS-8278)
- Section 6 New section on validation and simulation
- Section 7.1 Removed 3 known problems
- Section 7.2 Removed bullet on locking
- Section 9.1 Added property `snapdir`
- Section 9.3 Updated default values of alpha and SAA properties
Planet properties for HCSS v5
Added `hot_mga` property
- Section 9.6 Added properties `engineering` and `schedule_locked`
- Section 10 Original section 10 removed as functionality deprecated

- Issue 2.1
- Section 4.3.1 Corrected last paragraph
 - Sections 6.3, 6.4, 9.3 Changed “v5” to “v4”

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1 Introduction

1.1 Purpose

This is a user guide for the Herschel Scientific Mission Planning System (SMPS). It explains how to configure the software and use it to perform the mission planning tasks required for Herschel operations.

For further detailed information on the SMPS see the design documentation [RD10]. The format of the files read by and generated by the SMPS is described in the relevant Interface Control Documents [RD3, RD5, RD6, RD7, RD8 and RD11].

1.2 Preface

Please use the SMPS User Guide which is distributed with the HCSS. This is accessible from the main HCSS documentation index. It will ensure that you have the latest information relating to the version of the software you are using.

1.3 Reference Documents

- [RD1] "Herschel Mission Planning Concept", PT-HMOC-OPS-TN-6601-OPS-OGH.
- [RD2] "Herschel Ground Segment to Instruments Interface Control Document", FIRST-FSC-DOC-0200, issue 3.0, 15 October 2007.
- [RD3] "Planning Skeleton File ICD", PT-CMOC-FD-ICD-2104-OPS-GFT, HGS-ICD-017, issue 1.3, 24 July 2007.
- [RD4] "Scientific Mission Planning System - Pointing Modes", Herschel-HSC-DOC-624, issue 2.2, 2 October 2007.
- [RD5] "Herschel Planned Observation Sequence (POS) Interface Control Document", Herschel-HSC-ICD-0377, issue 1.6.
- [RD6] "Herschel/Planck orbital data and access software ICD", PT-CMOC-FD-ICD-2101-OPS-GFI, HGS-ICD-020/HGS-ICD-027, issue 1.1, May 2007.
- [RD7] "ICD: Herschel Spacecraft / Instrument Alignment History", PT-HMOC-FD-ICD-2111-OPS-GFT, HGS-ICD-026, issue 1.3, 7 February 2006.
- [RD8] "Solar System Object Ephemeris File ICD", HERSCHEL-HSC-ICD-0566, HGS-ICD-022, issue 1.0, 13 February 2007.
- [RD9] "Scientific Mission Planning System – Pointing Modes", Herschel-HSC-DOC-624, issue 2.2, 2 October 2007.
- [RD10] "Herschel Scientific Mission Planning System – Design Concepts and Algorithms", Herschel-HSC-DOC-741, issue 0.3, 21 May 2007.
- [RD11] "Orbit Data Messages", CCSDS Blue Book CCSDS 301.0-B-3 (see section on OEM) Consultative Committee for Space Data Systems, January 2002.

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1.4 Acronyms

ACA	Attitude Control Axes
ACMS	Attitude Control and Monitoring System
AOS	Acquisition Of Signal
APF	Attitude Parameter File
CUS	Common Uplink System
DEC	Declination
DTCP	Daily Telecommunications Period
EPOS	Enhanced Planned Observation Sequence
ESAC	European Space Astronomy Centre
ESOC	European Space Operations Centre
FD	Flight Dynamics
FDS	Flight Dynamics System
FIFO	First-In First-Out
FTS	File Transfer System
GUI	Graphical User Interface
HCSS	Herschel Common Science System
HOT	Herschel Operations Team
HSC	Herschel Science Centre
ICC	Instrument Control Centre
ICD	Interface Control Document
ICP	Instrument Command Parameter
ID	Identifier
JPL	Jet Propulsion Laboratory
L2	Second Lagrangian point
LEV	Long-term orbit Event file
LOF	Long-term Orbit File
LOS	Loss Of Signal
MGA	Medium Gain Antenna
MIB	Mission Information Base
MOC	Mission Operations Centre
MPS	Mission Planning System
NAIF	Navigation and Ancillary Information Facility
NNO	New Norcia

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OBSID	Observation Identifier
OD	Operational Day
PHS	Proposal handling System
POS	Planned Observation Sequence
PSF	Planning Skeleton File
PST	Project Scientist Team
RA	Right Ascension
RMS	Reference Mission Scenario
SAA	Solar Aspect Angle
SCR	Software Change Request
SEV	Short-term orbit Event file
SIAM	Spacecraft Instrument Alignment Matrix
SMPS	Scientific Mission Planning System
SOF	Short-term Orbit File
SOPS	Spacecraft Operations (PSF window)
SPR	Software Problem Report
SSF	Schedule Summary File
SSO	Solar System Object
STR	Star Tracker
TBC	To Be Confirmed
TBD	To Be Defined
TOO	Target of Opportunity

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2 The Mission Planning Process

2.1 Overview of Planning Process

The Herschel Scientific Mission Planning System (SMPS) forms one part of an overall mission planning process that involves both the Herschel Science Centre (HSC) and Mission Operations Centre (MOC). This section outlines this complete process and the role played by the SMPS. Additional information can be found in the Herschel Mission Planning Concept document [RD1] and other documents referenced below.

The Herschel spacecraft operates autonomously for 21 hours each day, by executing a daily *schedule* of telecommands that is uploaded once per day. This includes commands to the Attitude Control and Monitoring System (ACMS) to manoeuvre the spacecraft, commands to the scientific instruments to perform measurements and commands to perform various engineering operations such as recycling the cryogenic cooler. The purpose of the Scientific Mission Planning System (SMPS) is to generate these daily schedules.

Communication with the ground station takes place in a 3-hour Daily Telecommunications Period (DTCP), during which the spacecraft is manoeuvred to point its Medium Gain Antenna (MGA) at the Earth. This period is used to uplink telecommands and downlink the resulting telemetry from the previous day. In principle, scientific observations can be performed during DTCP, but only a very limited part of the sky is visible during this time because the antenna must be pointed within a few degrees of the Earth. Consequently, DTCP is used to perform other activities, such as cooler recycling and biasing of the reaction wheels; any remaining time can be used for scientific observations, if there are suitable targets that do not violate the antenna constraint.

The spacecraft is in Lissajous orbit around the second Lagrangian point (L2) of the Sun-Earth-Moon system, at about 1.5 million kilometres from the Earth. This provides a stable thermal environment, with a large part of the sky visible at any time. The Earth and Moon constraints normally fall within the Sun constraint, such that the overall visibility remains at around 50%. Another advantage of the L2 orbit is that the Sun constraint moves at only about 1 degree per day. Hence the visibility constraints are almost constant throughout the day.

As a result of the orbit around L2, the spacecraft is overhead the ground station when it is approximately local midnight¹. The 35m dish at the New Norcia ground station is used for both Herschel and Planck, the order of the two DTCPs depending on their relative positions in their orbits. Consequently, the Herschel DTCP may be earlier or later than the overhead time.

For scheduling purposes, the mission is divided into *operational days* (OD) that cover the period from the start of one DTCP to the start of the next. The duration of an operational day is nominally 24 hours, but may vary depending on the ground station scheduling for the two missions.

The spacecraft executes a continuous *timeline*, held in a First-In First-Out (FIFO) on-board buffer. This buffer has sufficient memory to hold the commands for two days and is

¹ In the case of the nominal New Norcia ground station, this is approximately 16:15 UTC.

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topped-up with an uplinked schedule each day, so that it has enough commands for at least 24 hours. This ensures that the timeline will not run out even if a DTCP is missed due a problem at the groundstation. In fact, the commands are uplinked in blocks of 24 hours, running from the *end* of one DTCP to the end of the next, this being out of phase with the Operational Days that run from the *start* of an OD. Consequently, if a DTCP is missed, the on-board timeline extends long enough to cover the DTCP period during which the commands are uplinked and there is never a break in the timeline.

The overall mission planning process starts with the generation of an orbit file by Flight Dynamics (FD). A Long-term Orbit File (LOF) is delivered to the HSC once a month, after trajectory optimisations, covering the remaining period to the end of the mission. A more accurate Short-term Orbit File (SOF) is delivered once a week, after orbit determinations, covering the following two months.

Based on the orbit information for both Herschel and Planck, FD generate a Short-term Orbit Event File (SEV) and a Long-term Orbit Event File (LEV) [RD6]. These contain key events such as the Acquisition Of Signal (AOS) and Loss Of Signal (LOS) for each of the ground stations. This information allows FD to schedule the ground station allocation for the two missions, which in turn determines the DTCP times and hence the time interval covered by each OD.

The process continues with the generation of Planning Skeleton Files (PSF) [RD3], each covering a single OD. The PSF is effectively an empty schedule that defines time constraints on various operations, such as commanding the instruments and manoeuvring the spacecraft. It also includes certain key event, such as AOS/LOS and the start/end of DTCP. Spacecraft Operations (SOPS) windows are included to reserve time for MOC to insert commands for orbit corrections, reaction wheel biasing, etc, when they receive the completed schedule from the HSC.

The SMPS is used to add scientific observations and other activities to the schedule. When the Mission Planner is satisfied with the schedule, he generates a Planned Observation Sequence (POS) file [RD5] that expand the observations down to the level of individual telecommands. The parameters of the telecommands are placed in a separate Instrument Command Parameter (ICP) file, so that the POS file is shorter and easier to understand.

The POS contains pointing commands that invoke basic ACMS pointing patterns, such as fine pointing, raster and line scan. More complex pointing modes are constructed using these basic modes as building blocks. The complete set of pointing modes are described in [RD9]. While the spacecraft is executing a pointing pattern, such as a raster, the instrument is sent a sequence of telecommands, which must be carefully synchronised with the sequence of spacecraft manoeuvres. This synchronisation is achieved by defining the spacecraft and instrument commands for each observing mode in a single script which is executed by the Common Uplink System (CUS).

Scheduling observation of moving Solar System Objects (SSO), such as planets, comets and asteroids, makes use of ephemeris files that are obtained from the JPL Horizons system. In addition, the SMPS uses a Spacecraft Instrument Alignment Matrix (SIAM) [RD7] file that describes the alignment of the instrument boresights with respect to the spacecraft X-axis. The SSO ephemeris files [RD8] and the SIAM files [RD7] are delivered to MOC for information, although MOC do not currently use them.

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The Mission Planner prints a summary of the schedule and gives it to the Project Scientist for approval. When it has been approved, the mission planner exports the schedule to MOC for further processing and uplink. The POS and ICP files are combined in a wrapper file and delivered to MOC using the Herschel File Transfer System (FTS). The FTS is also used for transferring the orbit file, ephemeris files, SIAM files and PSF files.

When MOC receives the schedule, they insert various commands such as orbit correction manoeuvres, into the SOPS windows reserved for them, and perform checks on spacecraft constraints and slew times. As a result of this expansion and checking, the POS becomes an Enhanced Planned Observation Sequence (EPOS) file and the ICP becomes an Attitude Parameter File (APF). These form the the basis for uplink. If MOC encounter a problem, they may notify the HSC and request that the affected days are replanned.

Each time the SMPS generates a POS/ICP, it commits the changes in the database and marks the observations as 'scheduled' so that they are no longer available for scheduling in subsequent ODs. The SMPS does not allow further changes to the schedule unless it is first *decommitted*. This allows the OD to be replanned and releases the observations so that they can be rescheduled. Decommitting a schedule requires a procedural interaction with MOC to ensure that schedules are not changed once they have been uplinked to the spacecraft or executed. It also requires authorisation from the Project Scientist. When a schedule is replanned, it may affect the subsequent schedules. Consequently, a schedule may only be decommitted if all the subsequent schedules are also decommitted.

The mission planning process is usually carried out on a weekly basis. MOC deliver a set of seven PSFs at least 15 working days prior to uplink. The HSC delivers the corresponding POS/ICP files back to MOC at least 10 days before uplink. This allows time for up to two iterations if problems are encountered. A shorter turn-around is possible in special cases, such as dealing with a Target Of Opportunity (TOO). A TOO may require decommitting the affected schedule(s) and replanning.

2.2 Constraints

The Herschel spacecraft axes are shown in figure 1. Rotations about the X, Y and Z axes are called “roll”, “pitch” and “yaw” respectively. The spacecraft orientation with respect to the Sun is specified by a pair of angles “alpha” and “beta”:

- Alpha is the angle between the Sun vector projected onto the spacecraft YZ plane and the Z axis. It increases as the spacecraft rotates clockwise about its X axis.
- Beta is the angle between the Sun vector projected onto the spacecraft XZ plane and the Z axis. It increases as the spacecraft rotates clockwise about its Y axis (i.e. As the telescope points further away from the Sun.

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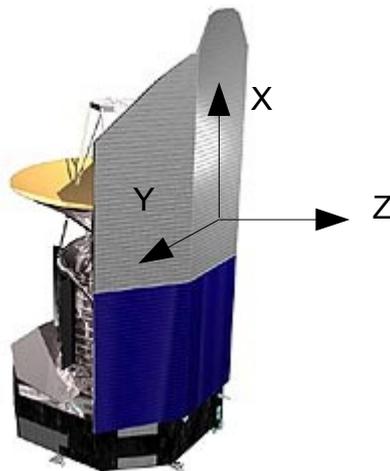


Figure 1: Spacecraft axes

The scheduling of observations is subject to many temporal and spatial constraints. For example:

- Thermal and power considerations constrain the spacecraft XY plane (solar panel and Sun shade) with respect to the Sun. The beta angle is constrained to $\pm 30^\circ$, while the alpha angle is tightly constrained to $\pm 3^\circ$.
- In order to reduce heating of the star-tracker, with consequent loss of pointing accuracy, the beta angle should preferably not exceed $+20^\circ$.
- During DTCP, communications considerations constrain the Medium Gain Antenna (MGA) (i.e. spacecraft +Z axis) to point within 15° of the Earth (depending on the ground-station in use). Combined with the alpha (roll) angle constraint, this translates into two roughly elliptical-shape constraints on the pointing direction (+X axis).
- In the PSF, MOC may reserve periods of time for spacecraft operations, such as reaction wheel biasing and orbit correction manoeuvres.
- Instrument considerations constrain the telescope (+X axis) direction with respect to bright objects, including the Earth, Moon, Jupiter, Saturn and Mars. Normally, the Earth and Moon constraints lie within the SUN constraint.
- The Star Tracker (STR) points in the -X direction (i.e. in the direction opposite to the telescope). The STR has a 20° constraint angle around the Moon, which sometimes extends beyond the Sun constraint.
- Observers may specify constraints on the time of scheduling, chopper avoidance angle, map orientation, etc.

Some of these constraints are specified in the PSF file, whilst others are derived from orbit and ephemeris calculations and some are given in individual observation requests.

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2.3 Instrument Scheduling

The Herschel spacecraft has three instruments, HIFI, PACS and SPIRE. However, for mission planning purposes, each instrument is treated as a number of *sub-instruments*, as follows:

HIFI	HIFI bands 1A,1B,2A,2B,3A,3B,4A,4B,5A,5B,6A,6B,7A,7B
P_PHOT	PACS photometry
P_SPEC	PACS spectrometry
S_PHOT	SPIRE photometry
S_SPEC	SPIRE spectrometry
PARALLEL	SPIRE/PACS parallel mode

Each Operational Day is typically assigned to a single sub-instrument in order to improve efficiency. This reduces the overheads in switching between sub-instruments. In the case of HIFI, several bands are often scheduled in an OD.

The largest overhead is recycling the liquid Helium cooler. The PACS and SPIRE instruments each have their own cooler system, which requires recycling separately, each taking about 3 hours. Once, recycled, the instrument can be used for two days. For PACS, recycling is only needed for photometry and not for spectrometry.

For example, having spent three hours recycling the PACS cooler, it is most efficient to perform only PACS photometry observations for the following two days. Similarly, after recycling the SPIRE cooler, the following two days should be devoted to SPIRE. In parallel mode, the PACS and SPIRE coolers can be recycled in parallel, taking about three hours, after which parallel mode observations should be performed for two days.

Since the spacecraft attitude is severely constrained during the three-hour DTCP, this time is less valuable for scientific observations. Consequently, it is a good time to recycle the cooler and perform any other instrument preparation.

The other instrument preparation times are less significant than cooler recycling, but nevertheless make it desirable to keep to one sub-instrument per day. For example, preparing PACS for either photometry or spectrometry takes about 2000 seconds (each), in addition to the cooler recycling time needed for photometry.

Instrument preparation operations, such as cooler recycling and detector curing, are known as *engineering observations*, as they do not perform a scientific measurement. They are scheduled like scientific observations but do not require any particular spacecraft attitude.

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3 Installation and Configuration

3.1 Hardware Requirements

It is recommended to run the SMPS on a Linux platform with 4 GB of memory (see section 3.7). It should also be possible to run it on Solaris or Windows XP platforms, but this has not been tested.

A three-button mouse is required. The screen size should be at least 20 inches with a resolution of at least 1600x1200 pixels.

3.2 Installation

The SMPS is distributed as part of the Herschel Common Science System (HCSS). Please see the HCSS installation instructions for general information. In addition, the SMPS requires certain Java properties to be defined and certain data files to be present, as explained below.

The following property should specify the HCSS installation directory:

```
var.hcss.dir = /local/software/hcss
```

3.3 Database

The following generic HCSS database property is required:

```
var.database.devel = database@hostname
```

The following property is set by default and should not normally be overridden:

```
hcss.mps.database = ${var.database.devel}
```

3.4 Site ID

For normal in-flight operations, using the system at the HSC, the following property should be set:

```
hcss.ccm.siteid = 5
```

For multi-instrument IST tests, such as the Reference Mission Scenario (RMS), the value should be 12. For SMPS installations at the ICC sites, the relevant site-specific value should be used [RD2].

The purpose of this property is to initialize the observation counter to a site-specific value (see section 3.8). This allows different sites to allocate unique numbers independently.

3.5 Data Directories

The SMPS requires a set of data directories to be defined. These contain the various files used by and generated by the SMPS. Some of these files are also used by the Proposal Handling System (PHS).

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A top-level data directory should be created that is pointed to by the Java property:

```
var.mps.datadir = /home/hsc/data
```

Within this directory, the following sub-directories should be created:

Directory	Example of Contents
orbit	H20070328_0001.SOE, H20070328_0001.LOE
psf	0080_0001.PSF
posicp	0080_0001.POS, 0080_0001.ICP
ssf	0080_0001.SSF
png	0080_0001.PNG
horizons	501
de405	ascp2007-2020.405
siam	0001_0001.SIAM
transfer/files	POS__HSCSDA_D_0080_0001_____00000.HERS
transfer/msg	pushPOS__HSCSDA_D_0080_0001_____00000.HERS
stpf	STPF_00000_2008109.csv
obdb	OBDB_4_0_B000_20080924.csv

Notes:

- The PSF, POS, ICP, SSF, PNG and SIAM files have file names of the form DDDD_VVVV.TTT, where DDDD is the OD number, VVVV is the version number and TTT is a suffix denoting the file type. In the case of the SIAM file, the OD number is simply the day on which the file was generated rather than the OD to which it applies.
- MOC deliver both a short-term (SOE) and long-term (LOE) orbit file. The SMPS should use the SOE file. The orbit file must cover at least the time period needed for the set of ODs to be planned.
- The PSF files are imported by the FTS and placed in the 'psf' directory. The SMPS automatically chooses the file with the highest version number for a given OD. If it is required to revert to an earlier version, MOC should be asked to redeliver the required file with a new version number.
- The POS, ICP, PNG and SSF files always have matching same version numbers. The version number is not necessarily the same as that of the PSF file. Do not delete these files as the SMPS uses them to keep track of version numbers.
- The ephemeris files for SSO targets are obtained from the JPL Horizons system, See section 10.1 for a description on how to run the tool to retrieve those files. Under the horizons directory a new directory /yymmdd_hhmmss is created for each tool execution. The file names under that directory are simply the NAIFIDs

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of the targets (e.g. 501 for Jupiter's moon “Io”). Note that the SSO files sent to MOC are reformatted and have different file names, according [RD8].

- The DE405 file is a set of ephemerides for the major planets and the Moon, obtained from JPL². This file should be valid for the entire duration of the mission.
- When the SMPS exports files to MOC, they are wrapped in an FTS wrapper file and placed in the transfer/files directory. A message file is placed in the transfer/msg directory to initiate the transfer. When the transfer is complete, the FTS deletes the message file.
- The STPF is the Slew Time Predictor File and the OBDB file is the On-Board Database file, containing various parameters used by the ACMS. These files are delivered by MOC via FTS.
- The PNG files contain snapshots of the SMPS screen when the POS/ICP files are generated.

The directories where the files are located are specified by the following properties, with default values as shown:

```

hcss.pointing.orbitdir      = ${var.mps.datadir}/orbit
hcss.pointing.ephemdir     = ${var.mps.datadir}/de405
hcss.pointing.siamdir      = ${var.mps.datadir}/siam
hcss.pointing.ssodir       = ${var.mps.datadir}/horizons
hcss.mps.posdir            = ${var.mps.datadir}/posicp
hcss.mps.psfdir            = ${var.mps.datadir}/psf
hcss.mps.ssfdir            = ${var.mps.datadir}/ssf
hcss.mps.snapdir           = ${var.mps.datadir}/png
hcss.mps.fts.files         = ${var.mps.datadir}/transfer/files
hcss.mps.fts.message       = ${var.mps.datadir}/transfer/msg
hcss.pointing.stpf_dir     = ${var.mps.datadir}/stpf
hcss.pointing.obdb_dir     = ${var.mps.datadir}/obdb

```

The default value of `${var.mps.datadir}` for the top-level directory allows many of these properties to be omitted if the data directories are placed within this top-level directory.

The following Java properties specify the files currently in use within these directories. They should be updated when a new files are received.

```

hcss.pointing.orbitfile    = H20070328_0001.SOE
hcss.pointing.ephemfile    = ascp2007-2020.405

```

² The original ASCII file, covering the 20 years from 2000-2020, was obtained from <ftp://ssd.jpl.nasa.gov/pub/eph/planets/ascii/de405/ascp2000.405>. This file has been shortened to cover only the period 2007-2020 and renamed `ascp2007-2020.405`.

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```

hcss.pointing.siamfile = 0001_0001.SIAM
hcss.pointing.obdb_file = OBDB_4_0_B000_20080924.csv
hcss.pointing.stpf_file = STPF_00000_2008109.csv

```

3.6 Initial Conditions

Normally, the SMPS remembers the attitude of the spacecraft at the end of one OD and uses it as the starting attitude at the beginning of the next OD. When the SMPS is used for the first time after launch (say at OD 30), MOC will notify the HSC of the initial attitude of the spacecraft, expressed as a quaternion. This attitude and the first OD number are entered using a set of properties, as in the following example:

```

hcss.mps.initial.od = 30

hcss.mps.initial.attitude.x = -0.06840235461084
hcss.mps.initial.attitude.y = -0.73299585583512
hcss.mps.initial.attitude.z = -0.39824039007191
hcss.mps.initial.attitude.w = +0.54721365564797

```

In the event that a serious problem occurs during operations, such that HSC has to stop generating schedules for one or more days, these properties can be used to set the OD number and attitude at which planning is to resume.

Note: In operations, MOC provide the initial attitude. For maintenance purposes on a test system, it may sometimes be useful to generate a suitable initial attitude. This may be done using the following command on the command line, with the OD number as the argument:

```
initatt 30
```

This command prints properties that may be copied into the property file.

3.7 Memory

The SMPS requires sufficient Java heap space to load the observation requests and other data into memory. Since only one sub-instrument is used per day, the number of requests loaded is less than the total number of unscheduled requests in the database.

The heap size is set by the “java.vm.memorymax” property in the user .props file:

```

java.vm.memory.min=512m
java.vm.memory.max=3G

```

In principle, the Java VM allows up to 4GB on a 32-bit machine and essentially unlimited memory on a 64-bit machine, subject to there being sufficient memory available on the computer (physical + virtual). However, UNIX/LINUX (32-bit) may further limit this to around 2-3 GB depending on the kernel settings. SUSE-10.3 32-bit appears to allow settings of up to 2642m.

If the heap space setting is too large, the following error message may occur:

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Error occurred during initialization of VM
 Could not reserve enough space for object heap
 Could not create the Java virtual machine.

If the physical memory is too small for the requested heap size, the program may start to use virtual memory and become extremely slow.

For a 32-bit machine, it is recommended that there should be 4GB of physical memory and the heap size should be as large as possible (at least 2GB).

3.8 Database Administration

This note is only relevant for database administrators.

The object database maintains counters to allocate unique numbers to every observation and every telecommand generated throughout the mission. When a new database is created, the telecommand ID is initialized to 0 and the observation ID is initialized to a value depending on the 'siteid' property (see above).

If, for any reason, it is necessary to create a new database after the start of the mission, it is important to set these counters to their previous values, otherwise they will be reset to zero and the numbers will no longer be unique.

This is not an issue for draft schedules generated by the ICCs, since the IDs are allocated during POS generation, which always takes place on the operational system at the HSC.

4 User Interface

4.1 Main Window

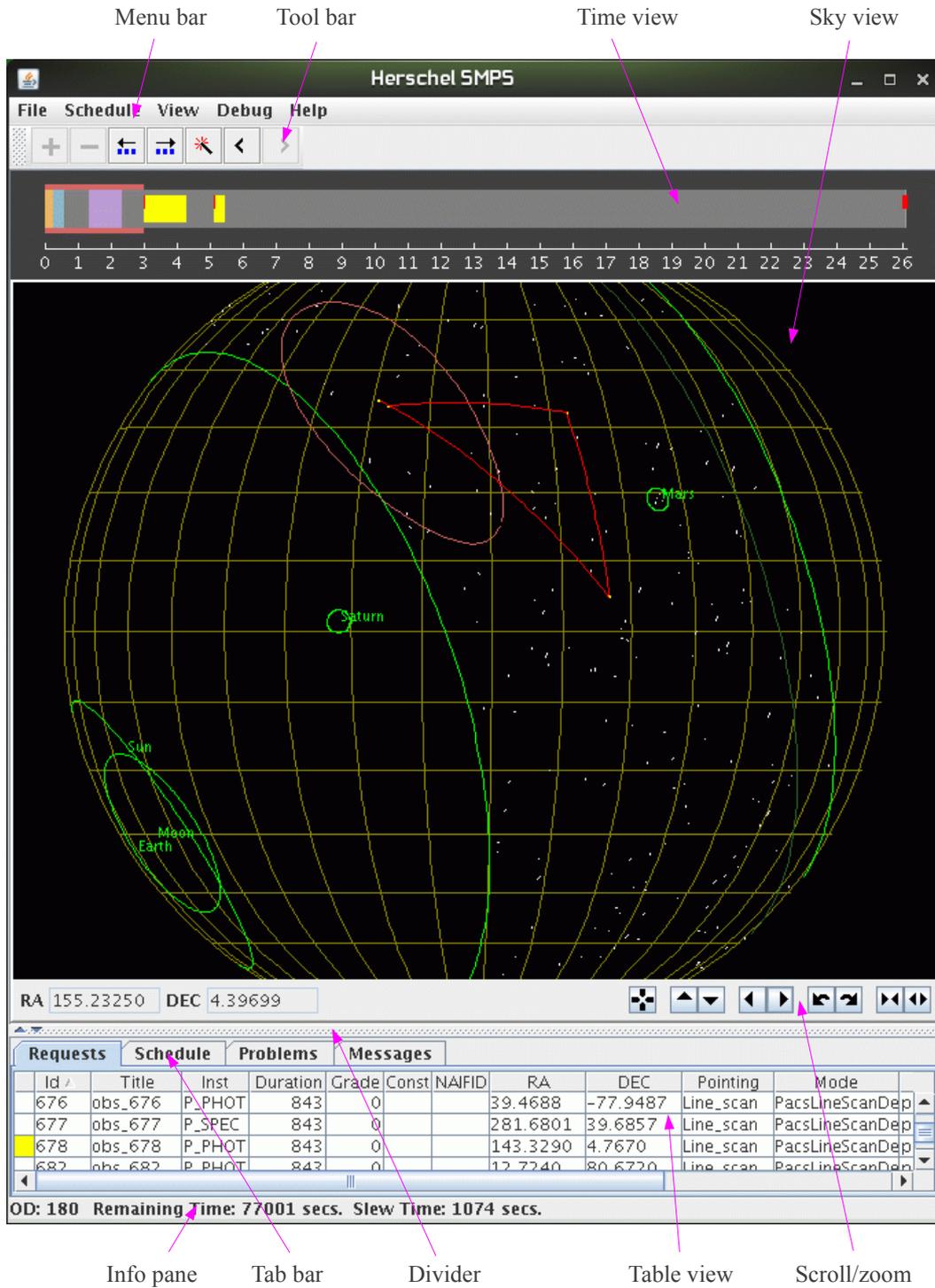


Figure 2: The SMPS main window

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The SMPS User Interface has four main views of the data, as shown in figure 2.

- The *time view* displays the scheduled observations on a time-line, in addition to any temporal constraints on their placement.
- The *sky view* displays the candidate observations that could be scheduled on that OD, plus any spatial constraints on their placement. In addition, it highlights the scheduled observations and draws the slew path that links them.
- The *requests table view* displays the candidate observations as a multi-column table, giving details about each observation.
- The *schedule table view* displays the scheduled observations as a time-ordered sequence.

The table views are displayed by selecting the appropriate tab in the *tab bar*. There are also tabs displaying problems and messages.

The four views are linked together, so that selecting an observation in one will cause it to be selected in the others. An observation only appears in the time view or schedule table view if it is already scheduled.

Where appropriate, matching colours are used when an item is displayed in both the time view and sky view. For example, observations are shown in yellow and slews in red. Similarly, the DTCP/MGA constraint is shown in pink in both views and the selected observation is highlighted in cyan.

4.2 Time View

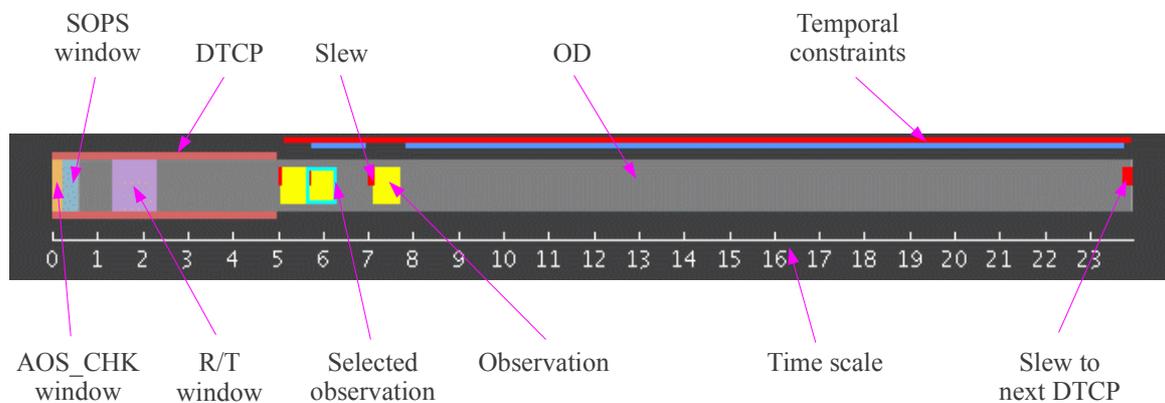


Figure 3: The time view

The time view displays the time-line for a single OD and the relevant temporal constraints.

The time view shows only the scheduled observations, whereas the sky view shows all the observations that are available for scheduling. The time scale is in hours starting from the beginning of the OD.

Special windows are displayed in different colours. The AOS_CHK and SOPS windows are reserved for use by MOC. The R/T (Real-Time science) window allows observations to send real-time telemetry (see section 4.2.4).

4.2.1 Observations and Slews

The observations in the time view are shown as yellow rectangles, the length of which indicates the duration of the observation (see figure 4). The slew from the previous observation is shown in red and belongs to the observation so that this time is available for instrument set-up prior to arriving at the target. The set-up period is shown by an extension of the lower half of the yellow rectangle to the left.

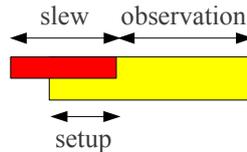


Figure 4: Slew longer than set-up

If the slew takes less time than the instrument set-up, the spacecraft will slew to the target, complete the set-up and then begin the observation, as shown in figure 5:

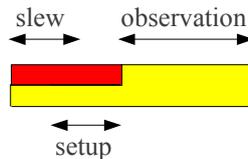


Figure 5: Slew shorter than set-up

Figure 6 shows various situations that arise in a schedule:

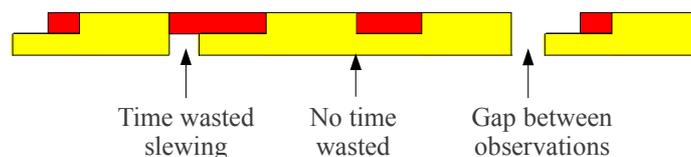


Figure 6: Observations and slews

If the yellow lower parts of the observations join up without a break, it indicates that no unnecessary time is wasted slewing. In practice, the set-up times of typical observations are around 1 to 2 minutes, allowing slews of a degree or so without wasting time.

In general, once an observation is scheduled, the start time of the measurement (after the slew) remains fixed, but the slew start time may change as other observations are added to or deleted from the schedule.

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4.2.2 Moving Observations

Observation can be dragged around in the time view using the middle mouse button. If an observation is dragged to an invalid time (e.g. overlapping another observation), it will snap to the closest allowed time to that point.

Tip: If you deliberately try to overlap observations slightly, they will be packed as tightly as possible.

When the order of the observations in the schedule is changed, by dragging one past another, the red slew bars change length to reflect the new slew times.

The Pack Left and Pack Right buttons on the tool bar provide an easier way to pack all observations to the left or right.

The selected observation is outlined in cyan blue in the time view and sky view. All observations can be deselected by clicking a blank area of sky in the sky view.

4.2.3 Time Constraints

The pink region in the time view (see figure 3) is the DTCP and has a corresponding attitude constraint shown in pink in the sky view. Only observations within this constraint region can be scheduled during DTCP.

When an observation is selected, red and blue lines will appear in the time view showing the placement constraints. Red indicates where the observation may be placed if no other observations are scheduled. Blue indicates where it may be placed taking into account the other observations.

The red constraint is often simply the periods corresponding to instruments windows (less slew times). However, this may be further restricted by fixed-time constraints etc.

4.2.4 Real-Time Science Window

Observations may be flagged as Real-Time, meaning that they will send real-time telemetry. This is indicated by a tick mark in the 'RT' column of the requests table. This flag may be set or cleared using the "Toggle real-time" command on the observation pop-up menu. This menu may be invoked from the sky view, time view, requests table or schedule table, using the right mouse button.

Observations which are flagged in this way may only be scheduled in the Real-Time science window, which is shown in purple in the time view. The real-time status cannot be set for an observation that is currently in the schedule; in this case, first delete the observation from the schedule, set its real-time flag, then reschedule it.

When the POS file is generated, any observations with the real-time flag set are marked with the POS keywords RT_SCIENCE_START and RT_SCIENCE_STOP.

Note: The current implementation does not save the real-time status in the SSF file. Hence if a schedule is reloaded from an SSF file, the real-time observations will still be placed in the real-time window but will not be marked in the POS file. Hence, no real-time

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telemetry will be sent. Until this is fixed, it is important to manually set the real-time on any real-time observations loaded from an SSF file.

4.3 Sky View

The sky view displays the observations and spatial constraints on the sky as shown in figure 7.

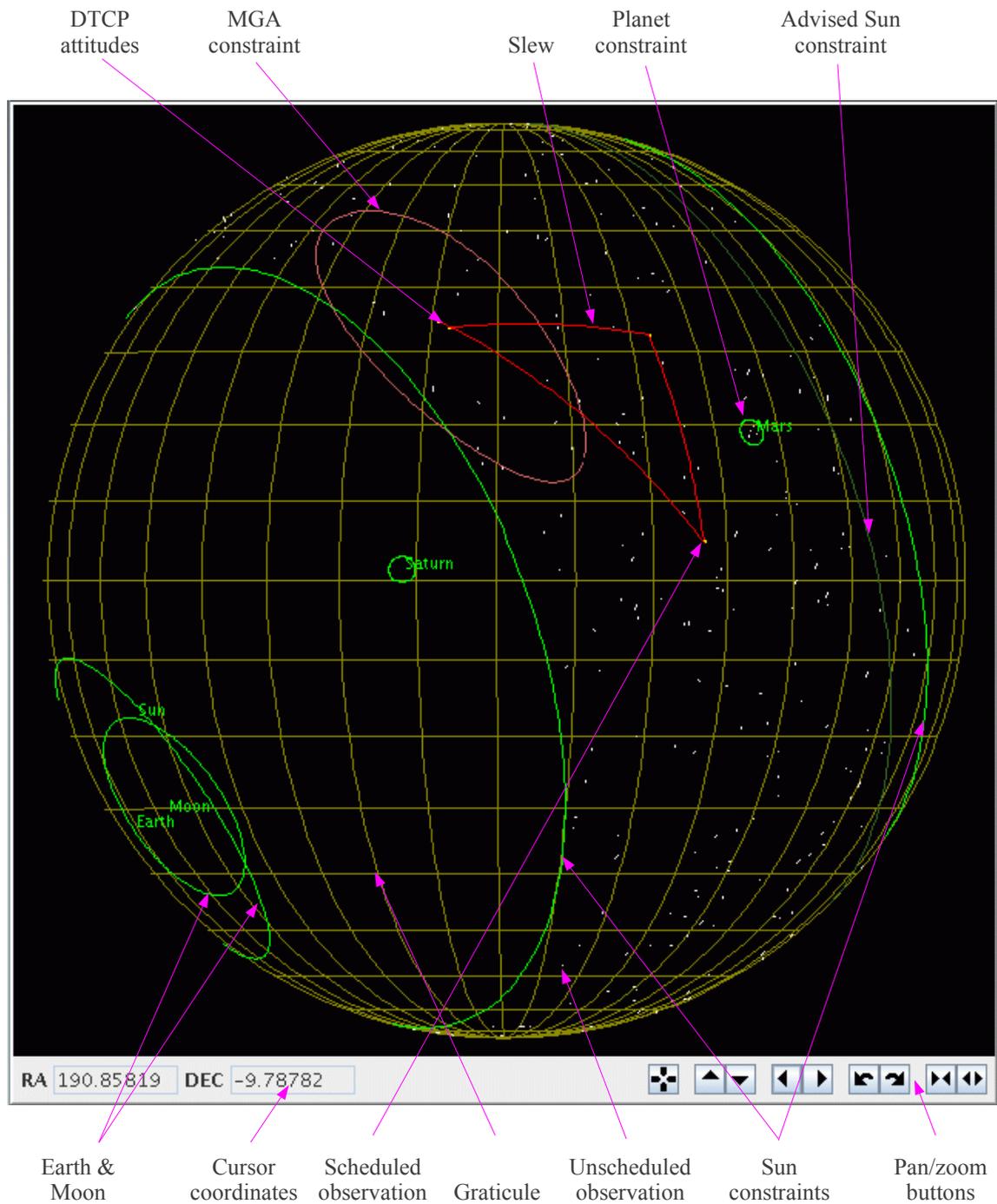


Figure 7: The sky view

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4.3.1 Coordinates and Projections

The graticule shows meridians and parallels in equatorial coordinates, with lines of right ascension (RA) and declination (DEC) every 10 degrees. The “RA” and “DEC” areas below the sky view show the cursor coordinates.

The projection can be changed using the Projection command on the View menu. The Orthographic projection is a good general purpose one for normal use. The Gnomonic projection has the property the great circles passing through the centre are shown as straight lines. The Mollweide projection is an equal-area projection which displays the whole sky at once.

The Mission Planner will normally choose a small area of sky for a particular OD to avoid excessively long slews that waste time. In this case, the sky view is zoomed in to the area of interest and it does not make too much difference which projection is used. When the zoom factor is high, the different projections are essentially the same for the small area of sky displayed.

The sky view shows the sky as seen by an observer at the spacecraft looking at the sky. When equatorial North is at the top, the right ascension increases to the left and the declination increases upwards.

Note: When the orthographic view is zoomed out, so that the entire celestial sphere is visible, the view is effectively that of the rear hemisphere, with the front hemisphere removed. If the view were of the *outside* of the celestial sphere, it would be reversed compared with that seen by an observer at the spacecraft.

Note: The sky view displays pointings and slews as the path of the spacecraft X-axis (ACA coordinates) rather than instrument boresight coordinates. These may differ slightly as a result of the SIAM offset.

4.3.2 Scrolling and Zooming

The sky view can be zoomed, rotated and scrolled using the nine buttons along its bottom edge. If the cursor is held over one of the buttons, a tool-tip message appears after a few seconds to explain the purpose of the button.

To zoom in to a particular area more easily, select a rectangular region by dragging the mouse in the sky view with the middle button depressed. (The resulting view may differ slightly from the selected area because the selected rectangle may not be a rectangle after zooming, given the projection in use.)

The “centre” button scrolls the sky view so that currently selected observation is at the centre of the view. If no observation is selected, the button returns the view to its default centred on a right ascension and declination of zero, with equatorial North at the top.

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4.3.3 Spatial Constraints

The sky view shows a number of constraints:

- Bright green - Sun, Earth, Moon, Mars, Jupiter and Saturn constraints
- Dark green - Advised Sun constraint
- Pale blue - Star tracker Moon constraint
- Pink - MGA (antenna) constraint on pointing during DTCP

The Sun constraints are currently at beta angles of approximately $\pm 30^\circ$. However, if possible it is recommended to keep the beta angle in the range -30° to $+20^\circ$ to avoid heating of the service module by the Sun. The dark green advised Sun constraint shows the $+20^\circ$ limit.

There are two MGA antenna constraints, which appear as approximately elliptical regions, diametrically opposite one another. These are the two regions that simultaneously satisfy the MGA-earth constraint on the Z-axis and the Sun constraint on the X-axis, whilst keeping the alpha (roll) angle at zero. Normally the DTCP region nearest the Sun is used to minimize heating of the service module.

When the Sun-Earth angle subtended at the spacecraft is less than the maximum antenna angle the two MGA regions merge into one. This happens for short periods twice a year for the New Norcia ground-station. During these times, a larger area of sky is usable for scientific observations during DTCP.

The constraints are drawn for the time of the currently selected observation. If no observation is selected, the constraints are shown for the middle of the OD. Hence, clicking on an observation will display the constraints for that observation. Similarly, dragging the observation in the time view will cause the constraint to be redrawn.

4.3.4 Selecting Observations

Selecting an observation in any of the views will cause it to be selected in the other views.

Tip: If two observations are very close together in the sky view, it may help to zoom in so that you can select the one you want. If the observations are in *exactly* the same location, it may be difficult to select the correct one in the sky view, in which case it may be easier in one of the table views.

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4.3.5 Viewing Pointings

Right-clicking on an observation in one of the views brings up a pop-up menu which shows operations that may be performed on the observation. The 'Display pointing' command on this menu displays the pointing pattern in detail.

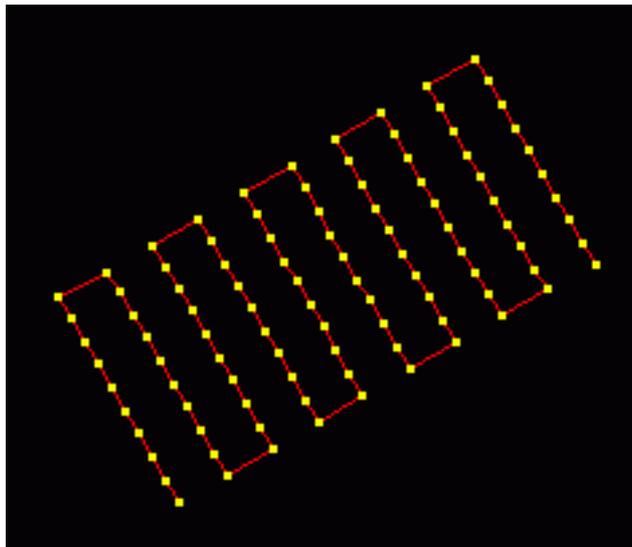


Figure 8: Display of raster pointing

Fine pointings and scan lines are shown in yellow and slews in red. The window has the same zoom and scroll controls as the sky view and a File menu with the option to print the view.

The “display pointing” command provides a schematic view of the pointing, which does not necessarily include all the complexities of the real observation, such as interrupted slews in line scans. The observation does not need to be scheduled, so the orientation is an approximate one for the OD. Once an observation is scheduled at a particular time, it is possible to generate a more accurate view using the ACMS simulator (see section 6).

For further details of the pointing patterns see [RD9].

4.3.6 Observations and Slews

Unscheduled observations are shown as small white dots. If the pointing pattern (e.g. raster) covers a larger area of sky, the observation may start and end at different attitudes. In this case, the observation is drawn as a white line connecting the two points (This will be replaced by a rectangle showing the raster, in a later release).

Scheduled observations are shown as yellow dots, connected by red slew lines. The initial and final attitudes for the OD are shown as yellow dots within the pink DTCP/MGA constraint in the sky view. These are normally about a degree apart as the Sun constraint moves at about 1 degree per day. When a new OD is opened for planning, no observations

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are yet scheduled and the sky view shows a red slew path connecting the initial and final DTCP attitudes.

As observations are added to the schedule, the slew path is drawn connecting these together in the sky view.

4.4 Tab Bar

The lower part of the window has a *tab bar* that allows the following to be selected:

- Requests table view (see section 4.5)
- Schedule table view (see section 4.6)
- Problems pane (see section 4.7)
- Message pane (see section 4.8)

The divider bar under the sky view allows the sky view and tab area to be resized relative to one another. The small arrows on the left-hand end of this bar allows either view to be expanded to its maximum size and then returned to the original setting.

4.5 Requests Table View

The requests table view shows a list of the candidate observations that are available for scheduling. This view is selected by clicking on the “Requests” tab in the tab bar.

	Id	Title	Inst	Duration	Grade	Const	NAIFID	RA /	DEC	Pointing	Mode	Proposal	Target	RT
	74	obs_74	H_3b	1840	0			161.1645	-32.0510	Basic-fine	HifiBasicFinePointing	proposal_1		
	4	obs_4	H_3a	1840	0			161.2638	-46.8117	Basic-fine	HifiBasicFinePointing	proposal_1		
	162	obs_162	H_7a	1840	0			161.7533	-20.2048	Basic-fine	HifiBasicFinePointing	proposal_1		
	216	obs_216						162.3351	13.2417	Basic-raster	HifiBasicRasterDemc			
	217	obs_217	H_4b	3634	0	G		161.0464	70.5613	Basic-raster	HifiBasicRasterDemc	proposal_1		
	218	obs_218						339.0851	-13.3052	Basic-raster	HifiBasicRasterDemc			
	115	obs_115	H_3b	1840	0			163.7539	3.9269	Basic-fine	HifiBasicFinePointing	proposal_1		
	107	obs_107	H_1a	1840	0			164.2424	-23.9936	Basic-fine	HifiBasicFinePointing	proposal_1		

Figure 9: The requests table view

Clicking on a column header causes the table to be sorted in ascending order on that key. Clicking a second time sorts the table in descending order and clicking a third time cancels the sorting. A triangular arrow head in the header indicates the sort key and sorting direction. The table can be sub-sorted on further fields by control-clicking on additional column headings. Sub-sorting preserves the previous sort order when the items have equal values. A smaller arrow head appears in the header of these columns. Sorting the table is useful to find a particular observation by ID or to look at all observations of a particular type.

A small yellow marker at the left-hand side of an entry indicates that the observation is currently in the schedule. Clicking on the header of this column will group together all the scheduled observations, although not necessarily in the order they appear in the schedule. A time-ordered view of the schedule is given by the schedule table view which can be displayed by pressing the Schedule tab on the tab bar.

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The column headers can be dragged left and right to rearrange the order. It is also possible to resize the column widths by dragging the edges of the column headers.

Most of the column titles are self explanatory. The 'inst' column shows the sub-instrument, with the band as a suffix in the case of HIFI. The 'const' column may contain the letters T, G and F to indicate that various types of constraint are present, as follows:

- T Fixed-time constraint (including chopper avoidance and map orientation)
- G Group, sequence or concatenation constraint
- F Follow-on constraint

T constraints are applied automatically. The G and F constraints are not yet implemented and it is necessary to check for concatenations manually.

The 'MC' column shows the Mission Configuration of the observation. Note the the SMPS is able to schedule observations from more than one mission configuration in a single OD.

The 'RT' column displays a tick mark if the observation is flagged to send real-time telemetry. This flag may be toggled by right-clicking the observation and selecting the "Toggle real-time" command.

Concatenated observations are shown as multi-line entries in the table. Such observations are treated as a single entity for scheduling purposes. The duration column in the table shows the total duration of the sequence of observations.

4.6 Schedule Table View

The schedule table view shows the sequence of observations included in the schedule and any additional slews such as the one to the final DTCP attitude.

The entry for each observation shows the slew duration preceding the start of the observation, the start time, the duration (excluding the slew) and the end time. The start and stop times change when an observation is moved in the time view.

The table cannot be sorted as the order of the schedule is fixed.

Id	Title	Inst	Slew	Start	Duration	Stop	NAIFID	RA	DEC
66	obs_66	H_7a	261	2008-12-19T16:01:46Z	5083	2008-12-19T17:26:29Z		353.5...	-23.0...
17	obs_17	H_1b	503	2008-12-19T17:34:52Z	5083	2008-12-19T18:59:35Z		5.4543	19.6...
76	obs_76	H_4a	279	2008-12-19T20:34:41Z	5083	2008-12-19T21:59:24Z		351.2...	31.1...
60	obs_60	H_3b	243	2008-12-19T23:05:20Z	5083	2008-12-20T00:30:03Z		337.9...	25.2...
89	obs_89	H_1b	273	2008-12-20T01:37:45Z	5083	2008-12-20T03:02:28Z		330.4...	10.3...
	Slew		506	2008-12-20T12:54:56Z	0	2008-12-20T12:54:56Z		339.6...	-29.7...

Figure 10: The schedule table view

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4.7 Problems Pane

The problems pane displays any validation problem detected in the schedule when the POS is generated or when the user performs a validation or a simulation of the schedule, as shown in figure 11.

Type	Id	Start	Stop	
ERROR	299	2009-11-09T23:29:54.75Z	2009-11-09T23:31:49.25Z	Mars
ERROR	830	2009-11-09T23:31:49.25Z	2009-11-09T23:32:46.25Z	Mars
WARNING	830	2009-11-09T23:34:36.50Z	2009-11-10T01:04:12.25Z	Sun_preferred
WARNING	741	2009-11-10T01:04:12.25Z	2009-11-10T01:06:01.25Z	Sun_preferred
INFO	741	2009-11-10T01:31:34.00Z	2009-11-10T01:31:34.25Z	LREQ deceleration interrupted at cycle 232
INFO	741	2009-11-10T01:32:23.00Z	2009-11-10T01:32:23.25Z	LREQ deceleration interrupted at cycle 196
INFO	741	2009-11-10T01:34:36.00Z	2009-11-10T01:34:36.25Z	LREQ deceleration interrupted at cycle 232

Figure 11: The problems table view

Two types of problems are shown: ERROR and WARNING. The pane also displays INFO messages; these are for information purposes only and may be safely ignored. The tab is highlighted in red when problems are found and it is brought to the foreground. The user is able to generate a POS file if there are warnings but not when there are errors.

The problem table can be sorted in a similar way to the requests table by clicking on a column heading. Clicking on a problem entry will select the affected observation so it can be located in the other views.

Schedule validation and errors are described in section 6.

4.8 Message Pane

- The bottom pane has a tab "Messages" to display any log messages.

4.9 Info Pane

At the very bottom of the SMPS main window is a bar that shows information about the schedule:

- The OD number being planned
- The unused time remaining, excluding any in DTCP
- The total slew time

4.10 Undoing Changes

The Undo button on the tool bar allows changes to the schedule to be undone. The Redo button allows undone changes to be reapplied.

This undo/redo mechanism applies to changes to the schedule but not to the view (e.g. zooming or projection). Once the POS/ICP files have been generated, changes cannot be undone.

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Another way to undo changes is to save a snapshot of a schedule as an XML file and subsequently reload it.

4.11 Menu Bar

The Menu bar at the top of the main window contains the following menus.

4.11.1 File Menu

The File menu contains the following commands:

New Schedule...	Starts planning of the next OD in sequence
Close	Close the schedule being edited
Open schedule...	Load a schedule saved as an SSF (XML) file
Save schedule...	Save a schedule as an SSF (XML) file
Batch schedules...	Regenerate sequence of schedules from SSF files
Generate POS	Generate the POS/ICP files and commit to database
Submit to MOC...	Send all completed POS/ICP files to MOC
Check submissions...	Check whether schedules have been transferred to MOC
Decommit...	Decommit schedules for one or more ODS
Print...	Print the SkyPane to a printer or file
Quit	Quit the SMPS program

4.11.2 Schedule Menu

The Schedule menu contains the following commands:

Undo	Undo changes to the schedule
Redo	Redo changes that have been undone
Add	Add the selected observation to the schedule
Delete	Delete the selected observation from the schedule
Add slew...	Add an extra slew
Pack left	Pack all observations in schedule to the earliest time
Pack right	Pack all observations in schedule to the latest time
Exclude DTCP	Don't allow scheduling in the DTCP window
Optimize	Optimize the order of observations in the schedule
Check/Fix	Check for some subtle timing issues (temporary command)
Validate	Validate the schedule
Simulate	Validate the schedule and display a simulation
Print schedule	Print a summary of the schedule to the messages pane

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Show TM size... Display the total size of TM data that will be generated

4.11.3 View Menu

The View menu contains the following commands:

Refresh Redraw the graphics (not normally needed)

Projection Select the projection used in the Sky View:

- Orthographic
- Gnomonic
- Mollweide

4.11.4 Help Menu

The Help menu contains the following commands:

About... Display information about SMPS including the build number

4.12 Observation Menu

Right-clicking on an observation in one of the views brings up a pop-up menu with special operations that may be performed on the observation. This menu contains the following commands:

Display pointing Displays the pointing pattern in a new window

Toggle real-time Sets/clears to real-time flag (shown in requests table 'RT' column)

4.13 Tool Bar

The Tool Bar appears under the Menu Bar when a schedule is open. It duplicates a number of commonly used menu functions as buttons for quick access. The button icons are displayed beside the menu items so that this correspondence is clear.

If the cursor is held over a Tool Bar button, a tool-tip message will appear after a few seconds to explain the purpose of the button.

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5 SMPS Tutorial

5.1 Introduction

This section describes the tasks performed by the Mission Planner in tutorial form. The relevant features of the SMPS user interface are introduced as they are needed. It is suggested that new users should work through this tutorial introduction using the SMPS to gain familiarity with the planning process and the software.

Note: Training should not be carried out on the operational system as it will generate data in the database.

5.2 Seven-Day Plan

When a new set of PSFs are received (normally seven at a time), the sub-instrument to be used on each of the days should first be decided (see section 2.3). Then, planning of the individual days can proceed as described below.

5.3 Starting the SMPS

- Ensure that the necessary PSF files and orbit file have been imported using the FTS.
- Ensure that the following property references the orbit file:

```
hcss.mps.orbitfile = H20070328_0001.SOE
```

- Type "smps" to start the SMPS Software.

5.4 Creating Schedules

- Select "File/NewSchedule..."

A dialog displays the number of the next Operational Day (OD) to be planned.

Select the sub-instrument(s) for that day and press "OK". The SMPS will read the observations from the database and display any that could be scheduled on this OD. This may take a few minutes if there are a large number of observations in the database.

Normally, an OD is dedicated to a single sub-instrument (see section 2.3). However, in special circumstances it is possible to select more than one sub-instrument.

- The SMPS main window is displayed (see section 4.1). There are four main views of the data:
 - the *time view* (see section 4.2)
 - the *sky view* (see section 4.3)
 - the *requests table view* (see section 4.5)

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- the *schedule table view* (see section 4.6)

You can select an observation in any of the views and it will be selected in the other views where applicable.

- The time view shows the time-line of scheduled observations and the relevant temporal constraints. The time scale is in hours starting from the beginning of the OD. The pink region is the DTCP and has a corresponding attitude constraint shown in pink in the sky view. Only observations within this constraint region can be scheduled during DTCP.

- The sky view shows the observations that are available for scheduling.

Tip: If two observations are very close together in the sky view, it may help to zoom in so that you can select the one you want. If the observations are in *exactly* the same location, it may be difficult to select the correct one in the sky view, in which case it may be easier in one of the table views.

- You can right-click on an observation in one of the views to get a pop-up menu. This has three options:
 - Display the pointing pattern in detail (see section 4.3.5). In this view, fine pointings and scan lines are shown in yellow and slews in red. The window has a File menu with the option to print the view.
 - Set the real-time flag. This force the observation to be scheduled in the real-time window and enables real-time down-linking of telemetry.
 - Toggle locking of an observation. A locked observation cannot be moved or deleted. Consequently, it is not affected by the pack-left, pack-right or optimise commands.
- The requests table view shows details of the observation requests. You can click the column headers of this view to sort in ascending or descending order. This is useful to find a particular observation by ID or to look at all observations of a particular type. You can control-click on further column headings to sub-sort. You can drag the column headers left and right to rearrange the order if you want.
- The divider bar under the sky view allows the sky view and table views to be resized relative to one another. The small arrows on the left-hand end of this bar allow you to expand either view to its maximum size and then return to the original setting.
- The bottom pane has a tab "Messages" where you can see any log messages.
- The sky view shows a number of constraints:
 - Bright green - Sun, Earth, Moon, Mars, Jupiter and Saturn constraints
 - Dark green - Recommended Sun constraint
 - Pale blue - Star tracker Moon constraint

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Pink - MGA (antenna) constraint on pointing during DTCP

- The sky view can be zoomed, rotated and scrolled using the eight buttons along its bottom edge. You can change the projection using the Projection command on the View menu. To zoom in to a particular area more easily, just drag with middle mouse button in the sky view.
- The “centre” button allows an observation to be located quickly. Pressing the button centres the sky view on the currently selected observation. If no observation is selected, the view is returned to the equatorial origin (right ascension and declination of zero) with North at the top.
- The schedule table view shows the scheduled observations in the form of a table with their start and end times.
- To schedule an observation, select it in the sky view or requests table view and then press the "+" button on the tool-bar. The observation will then appear in the time view, initially positioned at the earliest time at which it can be scheduled. To remove an observation, press the "-" button.
- You can drag the observation around in the time view using the middle mouse button. If you try to place the observation at an invalid time (e.g. overlapping another observation), it will snap to the closest allowed time to that point.

Tip: If you deliberately try to overlap observations slightly, they will be packed as tightly as possible.

- The constraints in the sky view are drawn for the time of the currently selected observation. Hence they will change if an observation is dragged to a different time. If no observation is selected, the constraints are drawn for the middle of the OD.
- The Pack Left and Pack Right buttons (with blue dots) pack all the observations in the schedule as far left or right as possible, whilst preserving the order. This is much easier than trying to pack them manually. Locked observations are not moved.
- If you want to prevent scheduling during DTCP, select "exclude DTCP" from the Schedule menu. Then when you Pack Left, the first observation will start immediately after DTCP.
- The initial and final attitudes for the OD are shown as yellow dots within the pink DTCP/MGA constraint in the sky view. These are joined by a red slew line. As observations are added to the schedule, the slew path is drawn connecting these together in the sky view.

Some observations such as rasters may start and end at different attitudes. In this case, the observation is drawn as a white line connecting the two points (This will be replaced by a rectangle showing the raster area, in a later release).

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- The selected observation is outlined in cyan blue in the time view and sky view. You can deselect all observations by clicking a blank area of sky in the sky view.
- The observations in the time view are shown as yellow rectangles the length of which indicates the duration of the observation (see section 4.2.1). The slew from the previous observation is shown in red and forms part of the observation.
- Observations may specify a minimum slew time so that the instrument can be prepared during the slew. This is shown by an extension of the lower half of the yellow rectangle to the left. The actual slew, which is shown in red may start before this if the actual slew time is greater than the minimum slew time. If all the slews are smaller than the minimum, the yellow lower parts of the observations will join up without a break (after packing), indicating that no unnecessary time is wasted slewing.
- When an observation is selected, red and blue lines will appear in the time view showing the placement constraints (see section 4.2.3). Red indicates where the observation may be placed if no other observations are scheduled. Blue indicates where it may be placed taking into account the other observations.
- The red constraint is often simply the periods corresponding to instruments windows (less slew times). However, this may be further restricted by fixed-time constraints etc.
- If you make a change to a schedule and don't like the result, it is easy to undo it. The Undo/Redo buttons allow changes to the schedule to be undone right back to the start of the session.
- If you want to save a snapshot of a schedule, select "Save schedule" from the File menu. This will create an XML file in Scheduling Summary File (SSF) file format. To reload it, use "New schedule" to create an empty schedule for the correct OD, then use "Open Schedule" to load the SSF file.

Tip: This is useful if you want to close down SMPS, while you are in the middle of creating a schedule, and then carry on the next day. It is also useful to create a snapshot so that you can easily return to a given point.

By default, these files are saved in your home directory, whereas the SSF created during POS/ICP generation is placed in the "ssf" directory (see below).

- The Open Schedule command loads an SSF file, adding the observations to any that are already in the schedule. If there are clashes it may adjust the scheduled times and give a warning.
- The Print command on the File menu allows the sky view to be printed to a printer or file.
- When a suitable schedule has been created, perform a quick visual check that the time-line in the time view and slew-path in the sky view look sensible.

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- The command “Show TM” on the Schedule menu displays the total amount of telemetry data that will be generated in MB. It is also shown as a percentage of a limit set by the property `hcss.mps.maxtm` (see section 9). If this exceeds 100%, you will be asked for confirmation to proceed when generating the POS file.
- The schedule can be validated by selecting “Validate” from the schedule menu. Any problems are shown in the problem pane; Note that this pane is not updated automatically. The “Simulate” option performs the validation and then displays the detailed pointing (see section 6 for details).
- Occasionally, a warning dialog may report that an observation cannot be scheduled at a certain time. This is due to subtle cases where there are interactions between consecutive observations. In this case, use the “Check/Fix” command on the “Schedule” menu. This will make small adjustments to the start times of observations as necessary to fix the problem. Then, try validating the schedule again.
- If a constraint is violated by a slew, it may be possible to avoid it by changing the order of the observations. Alternatively, it is possible to insert an extra slew manually, to create a “dog-leg” around the constraint. Decide where to place a “way-point” and read the coordinates from the RA and DEC fields. Then select “Add slew...” from the Schedule menu and enter the coordinates. The resulting slew is shown in red in the Time View. It may be dragged like an observation.
- The POS, ICP, PNG and SSF files are generated using "Generate POS" on the file menu. After performing a validation, this creates a pair of files in the "posicp" directory, such as 0084_0003.POS and 0084_0003.ICP, a Scheduling Summary File (SSF) in the “ssf” directory and a snapshot file (PNG) in the “png” directory. In this example, 84 is the OD number and 3 is the version number. Do not delete these files.
- The Scheduling Summary File (SSF) is an XML file that contains a summary of all the observations in the schedule. This can be read back in using the “Open schedule” command on the File menu. If you want to edit these files, do not modify the original files in the “ssf” directory, but first copy them to your home directory with a different name.

Tip: If you delete the time fields from this file and then reload it, the observations will be scheduled at the earliest possible time, whilst retaining the specified order. The simplest possible file need only list the IDs of the observations to be scheduled, as in the following example:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE schedule SYSTEM "schedule.dtd">
<schedule od="50">
  <observation id="123"/>
  <observation id="456"/>
</schedule>
```

If the `<proposal>` and `<title>` fields are present, these will be used to identify the observation, otherwise the observation “id” attribute will be used. This allows

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SSF files to be imported from another system where the observations have different “id” numbers. However, for local use, the “id” numbers are sufficient as shown by the example above.

- Generate a schedule summary for approval by the Project Scientist.
- Normally schedules are generated in batches of seven to cover a week. The above steps should be repeated for each of the schedules.

5.5 Schedule Optimisation

Optimisation of schedules is partially implemented, to the extent that it is useful, although it cannot yet handle all situations.

To try it, create a schedule by hand. Then press the "magic wand" button on the tool-bar. This will reorder the observations in the schedule to minimize the slew time. This will often recover enough time that it is possible to schedule an extra observation. It may then be useful to optimize the schedule again.

The “Toggle locking” command can be used to prevent engineering observations such as cooler recycling and instrument set-up and set-down at the start and end of the schedule from being moved.

5.6 Saving and Restoring Schedules

The Save/Open mechanism is also used by ICCs when they want to perform a trial scheduling run themselves and then deliver their schedule to the HSC. It is possible for the HSC to load multiple contributions into a single schedule (allowing for any clashes).

5.7 Submitting Schedules to MOC

When the schedules have been approved by the Project Scientist, the next step is to deliver them to MOC.

Select “Submit to MOC”.

This will display a list of the schedules ready for export. Pressing the “OK” button causes the POS and ICP files to be wrapped into an FTS wrapper file and placed in the transfer/files directory. A message is placed in the transfer/msg directory to inform the FTS server that a file is waiting for transfer. The message file is automatically deleted when the transfer has taken place.

The command “Check submissions...” on the File menu can be used to verify that the POS and ICP files up to a specified OD have been sent to MOC. This works by checking whether the files exist in the folder specified by the property 'hcss.mps.fts.sentdir'. This confirms that the MPS → PushPullDaemon → SendDaemon chain is working properly.

5.8 Replanning

Sometimes it is necessary to modify a schedule after the POS file has been generated or after it has been delivered to MOC. For example, this may happen if:

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- the schedule is rejected by MOC
- a problem is detected by the HOT that requires replanning
- a Target of Opportunity (TOO) has to be scheduled

In such cases, approval is required from the PST. It is also necessary to inform MOC who should confirm that the schedule has not already been uplinked.

Once approval is obtained, the schedule should be decommitted and then replanned. When a schedule is is replanned, it may affect the subsequent schedules. For example:

- The prime instrument may change, invalidating the cooler state for the next day.
- The final attitude may change leading to increased slew time at the start of the next schedule.
- Deleting an observation may invalidate observations in subsequent schedules that form part of a sequence of observations. Similarly, deleting a calibration observation may affect subsequent schedules.

Consequently, a schedule may only be decommitted if all the subsequent schedules are also decommitted.

The procedure is as follows:

- Select Decommit from the File menu. This displays a list of the schedules that have been committed.
- Select the *first* schedule to be decommitted and press OK. The SMPS will decommit this schedule and all subsequent ones. The observations from these schedules are reset to an unscheduled state, so that they are available for scheduling again.
- Repeat the planning process. The SMPS will allow the schedules to be replanned starting with the first one that was decommitted.
- Subsequent schedules can be regenerated automatically from the SSF files using the “Batch schedules...” option on the File menu.

If one of the schedules cannot be recreated, the regeneration will stop with a warning. You may then open the failing schedule, edit or accept the changes and commit it. The batch regeneration can then be run again to regenerate the remaining schedules.

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6 Validation and Simulation

6.1 Validation

The SMPS contains a detailed simulator for the Herschel Attitude Control and Monitoring System (ACMS). This simulates of the execution of the ACMS commands, calculating the spacecraft attitude each 0.25 seconds (the ACMS cycle time). The simulation accurately models details such as the accelerations and decelerations within a line scan, tracking and different types of slew (eigenaxis and sun-safe).

Each calculated attitude is checked against the Sun (alpha and beta), Earth, Moon, Mars, Jupiter, Saturn, star tracker and antenna (MGA) constraints. The timing of the commands is also modelled to detect, for example, when an ACMS command is prematurely interrupted by another command.

If a constraint violation is detected, it is displayed in the “Problems” table. Each entry has an associated severity which may be one of the following:

ERROR	Serious problem such as violation of beta constraint (+30°). POS generation cannot proceed.
WARNING	Minor problem such as exceeding the preferred beta angle (+20°). The mission planner must confirm acceptance before a POS can be generated.
INFO	Information message on a minor anomaly that requires no action. For example, line-scan return slews are deliberately interrupted to save time.

A validation may be performed using the “Validate” or “Simulate” commands on the “Schedule” menu:

- “Validate” runs the simulation and validates the schedule.
- “Simulate” runs the simulation, validates the schedule and displays the resulting attitudes in a new window. This is useful for examining any errors in more detail.

Validation is also run automatically as part of the POS generation process to ensure that POS files cannot be generated when there are errors.

Note that the problems table is not updated automatically when the schedule is changed, because the simulation is quite time consuming.

Occasionally, a warning dialog may report that an observation cannot be scheduled at a certain time. This is due to subtle cases where there are interactions between consecutive observations. In this case, use the “Check/Fix” command on the “Schedule” menu. This will make small adjustments to the start times of observations as necessary to fix the problem. Then, try validating the schedule again.

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6.2 Simulation

When the “Simulate” command is used, a new window appears that displays the attitude evolution for the OD in a sky view. It is possible to zoom in to inspect the details of an individual observation. This is more accurate than the view produced by the “Display pointing” command as it models subtle details of the ACMS behaviour.

Figure 12 shows the simulation window zoomed-in to display the details of a line-scan observation. It can be seen that the scan slews back to the end of the scan line after deceleration because holds are inserted between the scan lines. This is a level of detail that is not shown by “Display pointing”.

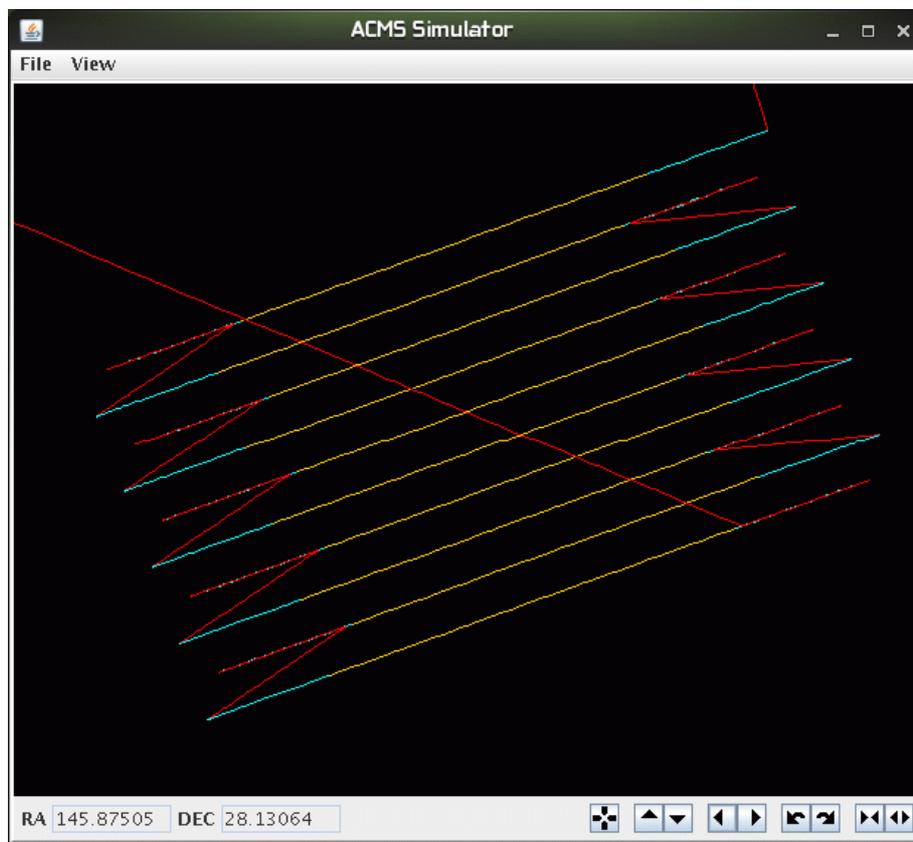


Figure 12: Detailed simulation of a line-scan

The simulation view is not linked to the other views. For example, selecting an observation in the requests table will not highlight it in the simulation view. This is because the simulation is performed at the level of individual ACMS commands, rather than observations.

Like the main sky view, the simulation view also uses spacecraft (ACA) coordinates rather than instrument aperture (boresight) coordinates. This is because it is simulating the spacecraft attitude. This also avoids discontinuities when the boresight changes.

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The simulation view uses the following colours:

Colour	Function
red	slew
yellow	point or scan
cyan	scan acceleration or deceleration
green	tracking of pointing

6.3 Planetary Constraints (SMPS v4 and later)

There are special constraints associated with the planets Mars, Jupiter and Saturn to avoid unwanted stray light. These constraints are displayed as green circles in the sky view, as shown in figure 7. The radius of the constraint depends on which instruments are selected when starting to plan the OD. The value used is the worst case for the selected instruments.

Technical note: Strictly, the planetary constraints apply to the instrument aperture (boresight) in use, whereas the Sun, Earth and Moon constraints apply to the spacecraft (ACA) X axis. This is handled by using ACA coordinates for the planetary constraints, but increasing the radius of the constraint circle by the worst-case SIAM offset for the selected instruments. This allows a single constraint circle to be displayed for all observations, even if they use different apertures. It also avoids complications with slews and pointings that do not have an associated instrument aperture. The increase in constraint radius might occasionally prevent an observation close to a planet, but this is not a major problem because the constraint can be disabled in such cases.

The following rules are applied:

- It is permitted to point within the constraint circle, provided that the target of the observation is the planet itself or one of its moons.
- If the target is not the planet or one of its moons, an observation may not be performed within the constraint circle and it is not allowed to slew through the constraint circle.

Strict application of these rules would make it impossible to perform an observation of another target following observation of a planet, because the slew to the second observation would start inside the constraint circle! This is avoided by giving a warning for such slews, rather than an error. The mission planner then needs to confirm that the second observation will not be affected by following immediately after observation of the bright target.

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These rules is summarised in the following table. In this context, “planet” means the planet itself or one of its moons.

Condition	Severity
Target is the planet	OK
Target is not the planet	ERROR
Slew through circle when start and end are not the planet	ERROR
Slew from planet to target that is not the planet	WARNING

If it is required to perform an observation of another target (other than one of the moons) close to a planet or one of its moons, the following properties can be used:

```
hcss.mps.constraint.mars_enable = false
hcss.mps.constraint.jupiter_enable = false
hcss.mps.constraint.saturn_enable = false
```

The default values for these properties are 'true'. Setting them to 'false' simply downgrades the ERROR cases in the above table to WARNINGS. The constraint checks are still performed.

There are also properties defining the planetary constraint radius for each of the instruments. These should not be modified.

6.4 Planetary Constraints (SMPS v3)

In SMPS version 3, the planetary constraint checking was less exact. There were three properties specify the constraint radius (in degrees) for the three planets:

```
hcss.mps.constraint.mars_min = 1.5
hcss.mps.constraint.jupiter_min = 1.5
hcss.mps.constraint.saturn_min = 1.5
```

All observations within this radius, including the planet and its moons, were disallowed. The only way to observe a planet was to set the relevant property to '0' to disable the constraint check. There were then no constraint checks for this planet for the whole OD. This could result in unintentional scheduling of another target close to a planet.

These properties are no longer used in SMPS v4. Observation of planets or their moons no longer requires disabling the constraints.

6.5 Hot MGA Region

There are two MGA constraint regions, corresponding to the hot and cold service module cases. By default, the SMPS always uses the cold region, as this leads to better pointing accuracy.

In special cases, this behaviour can be overridden by setting the following property:

```
hcss.mps.hot_mga = true
```

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When this option is used, a warning will appear in the problems pane if the DTCP attitude is in the part of MGA region beyond the preferred maximum beta angle (+20°).

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7 Known Problems and Limitations

7.1 Known Problems and Solutions

A number of features are not yet complete and work-around solutions are necessary in order to use the software.

- The scheduling preferences dialog is not yet implemented. However, some help is given by selecting a single sub-instrument for an OD and using the requests table view to find/group relevant observations.
- The real-time status of an observation is not saved in the SSF file. This must be reset manually after reloading the file.

7.2 Limitations

Not applicable.

7.3 Miscellaneous

To be written:

- Exporting SIAM and SSO files to MOC

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8 Problem Reporting

If problems are encountered, please submit a Software Problem Report (SPR). This should specify the HCSS build number (which can be found by selecting “About...” from the Help menu).

If relevant, please attach (or send separately):

- any stack-trace from the terminal window in which the SMPS was started
- the log which can be cut-and-pasted from the “Messages” pane.

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9 Special Properties

In addition to the standard properties described in section 3, the SMPS uses a number of additional properties. These should not normally be changed by users. They are documented here for completeness.

9.1 Directory Properties

By default, the SMPS assumes the directory structure given in section 3.5. This is achieved using the following properties that are set by default:

```

hcss.pointing.orbitdir    = ${var.mps.datadir}/orbit
hcss.pointing.ephemdir   = ${var.mps.datadir}/de405
hcss.pointing.siamdir    = ${var.mps.datadir}/siam
hcss.pointing.ssodir     = ${var.mps.datadir}/horizons
hcss.mps.posdir          = ${var.mps.datadir}/posicp
hcss.mps.psfdir          = ${var.mps.datadir}/psf
hcss.mps.ssfdir          = ${var.mps.datadir}/ssf
hcss.mps.snapdir         = ${var.mps.datadir}/png
hcss.mps.fts.files       = ${var.mps.datadir}/transfer/files
hcss.mps.fts.message     = ${var.mps.datadir}/transfer/msg

```

9.2 ACMS Properties

The following properties specify the location of the Slew-Time Predictor File (STPF) and On-Board Database file (OBDB):

```

hcss.pointing.stpf_dir   = ${var.mps.datadir}/stpf
hcss.pointing.obdb_dir   = ${var.mps.datadir}/obdb
hcss.pointing.obdb_file  = OBDB_4_0_B000_20080924.csv
hcss.pointing.stpf_file  = STPF_00000_2008109.csv

```

In addition, the following property specifies the number of reaction wheels in use:

```

hcss.pointing.acms.wheels = 4

```

9.3 Constraint Properties

The Sun alpha (roll) angle and Solar Aspect Angle (SAA) constraints are specified by the following properties (in degrees):

```

hcss.mps.constraint.alpha_min    = -2.9
hcss.mps.constraint.alpha_max    = 2.9
hcss.mps.constraint.saa_min      = 60.6
hcss.mps.constraint.saa_max_rec  = 110
hcss.mps.constraint.saa_max      = 119.4

```

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The constraint angles (in degrees) on other bright bodies are given by:

```
hcss.mps.constraint.earth_min    = 23
hcss.mps.constraint.moon_min     = 13
hcss.mps.constraint.str_moon_min = 20
```

Planet constraint properties (SMPS v3 only):

```
hcss.mps.constraint.jupiter_min = 1.5
hcss.mps.constraint.saturn_min  = 1.5
hcss.mps.constraint.mars_min    = 1.5
```

Planet constraint properties (SMPS v4 and later):

```
hcss.mps.constraint.hifi_planet_min = 0.6
hcss.mps.constraint.pacs_planet_min = 1.5
hcss.mps.constraint.spire_planet_min = 1.5
hcss.mps.constraint.mars_enable     = true
hcss.mps.constraint.jupiter_enable  = true
hcss.mps.constraint.saturn_enable   = true
```

The MGA constraint angles (in degrees) for the ground-stations are given by:

```
hcss.mps.constraint.mga_kru_max = 10
hcss.mps.constraint.mga_nno_max = 15
hcss.mps.constraint.mga_ceb_max = 10
hcss.mps.constraint.mga_per_max = 10
hcss.mps.constraint.mga_mas_max = 10
```

The following property allow HOT MGA region to be used:

```
hcss.mps.hot_mga = false
```

9.4 Miscellaneous Properties

The following property specifies the maximum amount of telemetry per OD in kilobytes:

```
hcss.mps.maxtm = 1404000
```

The default value corresponds to 130 kb/s for a 24 hour OD.

9.5 GUI Layout Properties

The following properties specify the initial size of the SMPS main window in pixels, and the position of the divider (in the range 0 to 1):

```
hcss.mps.gui.width    = 900
hcss.mps.gui.height   = 950
```

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```
hcss.mps.gui.divider = 0.8
```

9.6 Colour Properties

The following properties specify the colour of various Graphical User Interface (GUI) components:

```
hcss.mps.gui.color.observation      = 0xFFFFFFFF
hcss.mps.gui.color.scheduled        = 0xFFFFF00
hcss.mps.gui.color.slew              = 0xFF0000
hcss.mps.gui.color.selected         = 0x00FFFF
hcss.mps.gui.color.constraint        = 0x00FF00
hcss.mps.gui.color.constraint2      = 0x326420
hcss.mps.gui.color.star_tracker     = 0x89C0C0
hcss.mps.gui.color.graticule        = 0x8A8A00
hcss.mps.gui.color.sky              = 0x000000
hcss.mps.gui.color.timebackground   = 0x404040
hcss.mps.gui.color.log              = 0xE6E6C8
hcss.mps.gui.color.dtcp             = 0xD76666
hcss.mps.gui.color.aos_chk          = 0xEAB560
hcss.mps.gui.color.psf              = 0xA0A0A0
hcss.mps.gui.color.rt_science       = 0xBE9BD0
hcss.mps.gui.color.engineering      = 0x40A0A0
hcss.mps.gui.color.sops             = 0xC88B8C9
hcss.mps.gui.color.instrument       = 0x808080
hcss.mps.gui.color.scale            = 0xFFFFFFFF
hcss.mps.gui.color.placement1       = 0xFF0000
hcss.mps.gui.color.placement2       = 0x5096FF
hcss.mps.gui.color.scheduled_locked = 0xFF9900
```

Each value is in hexadecimal number of the form 0xRRGGBB, specifying Red, Green and Blue components in the range 00 to FF.

9.7 FTS Properties

The source and destination for FTS transfers are set by the following properties:

```
hcss.mps.fts.source = HSC
hcss.mps.fts.dest   = SDA
```

9.8 Mission Configuration

The mission configuration is set by the following property:

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`hcsm.mission.config = name`

The name is a label that refers to a set of command definitions (CUS definition, calibration tables and MIB) in the database. A new mission configuration is created each time these definitions are updated.

This property is not used by the SMPS but is needed by the 'proptool' program used for creating dummy observations for test purposes.

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10 Tools

10.1 Horizons ephemeris retrieval and FTS conversion

As stated in 3.5 the MPS needs a set of ephemeris files to be installed in the MPS data directories. At the time of writing, 421 SSOs need to be considered. Those ephemeris are retrieved from Horizons system³ Mail interface. For the automation of this process a tool have been written to automatize this task:

10.1.1 Properties needed

The following properties have to be defined:

Property name	Default value	Description
hcss.mps.ssodir	<code>\${var.mps.datadir}/horizons</code>	Horizons file directory
.horizons.imap.host ⁴	scimail.esac.esa.int	IMAP host used for receive Horizons mail
.horizons.start_time	2008-07-31T00:00:00	Start time for Horizons ephemerids generation
.horizons.end_time	2013-04-21T00:00:00	End time for Horizons ephemerids generation
.horizons.step_size	12 hour	Step size
.imap.username	hers_ephem	IMAP user name
.imap.password		IMAP user password
.mail.sender	hers_ephem@sciops.esa.int	Horizons sender's e-mail
.imap.folder	inbox	Horizons incoming folder
.mail.horizons	horizons@ssd.jpl.nasa.gov	Horizons service e-mail

The first property identifies where the incoming data (one file for each SPKId⁵), the rest of them determines the configuration parameters of the email account created for sending and receiving Horizons' mails.

10.1.2 Running the `getephem` tool

This tool simply sends one mail for each object requested to the HORIZONS system, it waits till the incoming mails are received and store its content in the corresponding directory. There are the ways of run the tool:

³<http://ssd.jpl.nasa.gov/?horizons>

⁴Add `herschel.mps.tools.horizons` prefix

⁵SPKId stands for Spacecraft and Planet Kernel id, and is strictly speaking the unique designation for a SSO.

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For one object

In this example we are interested in retrieve ephemeris for SPK-ID 1000032 (21P/Giacobini-Zinner)

```
> getephem -o 1000032
```

```
Jun 16, 2008 11:12:30 AM herschel.mps.tools.horizons.HorizonsManager
INFO: A unique SPK-ID was requestedJun 16, 2008 11:12:30 AM
```

```
Jun 16, 2008 11:12:30 AM herschel.share.util.Configuration <init>
```

```
INFO: Build number is 1627
```

```
INFO: Sending email to horizons@ssd.jpl.nasa.gov for spkId= 1000032
```

```
INFO: Starting ....
```

```
INFO: Connected to scimail.esac.esa.int as hers_ephem
```

```
INFO: Default folder:
```

```
INFO: Going into folder: INBOX
```

```
INFO: Waiting for incoming mails from horizons ...
```

```
INFO: Received multiple comet apparitions for a requested SPK-ID...  
resubmitting
```

```
INFO: possibleSpkId=900245
```

```
INFO: Resending an email for: 900245
```

```
INFO: Sending email to horizons@ssd.jpl.nasa.gov for spkId= 900245
```

```
INFO: Saving output file:  
/home/pgomez/opt/mps_files/mpsdata/horizons/20080516_111232/1000032
```

```
INFO: Email reception completed for this run.
```

A number of remarks about this example (marked in the above log in bold):

- Although SPK-ID is supposed to be the unique reference for SSOs, there are several objects (prominent periodic comets as the one in the example) whose ephemeris are considered different for each apparition. This is recognized by the tool and the email is resent with the last apparition ID (9xxxxx). The returning ephemeris is stored with the original SPK-ID though.
- Note that the ephemeris is stored in `hcss.mps.ssodir` in a directory named with the `yyyymmdd_hhmmss` format. This will create a different directory for each tool run.

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For a range of objects

The system sends the mails for those objects defined in the system⁶ in a range:

```
> getephem -r 1000017 1000094
```

For all defined objects

The system sends the mails for all the objects configured in the system

```
> getephem -a
```

10.1.3 FTS conversion

This tool wraps the ephemeris files in the latest directory created by the previous tool and converts it to the FTS format, see [RD8]. The format of the resulting file is that described in [RD8]. Several executions of the tool generate files with incremented version.

Tool execution

```
> wrap_fts EPHEM
```

```
INFO: Inspecting directory: /home/pgomez/opt/mps_files/mpsdata/horizons
```

```
/home/pgomez/opt/mps_files/mpsdata/horizons/20080516_111232
```

```
INFO: Final File: 01000032_0001_20080031120000_20130021120000.SSOL
```

```
INFO: Creating tar file:
```

```
/home/pgomez/opt/mps_files/mpsdata/transfer/files/SSOL_HSCSDA_D20080616_001_0000.HERS
```

⁶Note that there are sent only those objects configured in the system (in the file mps/tools/horizons/resources/Ephemeris_SPKIDs.properties)