Astro-2
Mission Planning Handbook and Interface Requirements Document (MPHIRD)

Final

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This document is an agreement made by the Astro-2 Mission Planning Team. This team is composed of representatives of the three instrument teams: HUT, UIT, and WUPPE; the File Manager (FLM), the Lead Orbit Analysis Engineer (OAE, or ORBIT), and the Payload Activity Planner (PAP). It is maintained by the Astro-2 Lead File Manager. If you have questions about its contents, please contact the FLM using the information below.

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1. Introduction and Overview

This document, the Astro-2 Mission Planning Handbook and Interface Requirements Document (MPHIRD), provides an overview of the mission planning process and describes a variety of protocols between the Astro-2 Investigators Working Group (IWG) and the Marshall Space Flight Center (MSFC) Spacelab mission operations personnel. A person called the File Manager (FLM) plays a key role as an interface in this process, and hence, this document describes many of the duties of the person in this position. This document also defines the location, content, format, access and protection of the data files which are needed to define the scientific program of the Astro observatory and from which various products are generated for the use of the crew, the instrument science teams and the Payload Operations Control Center (POCC) cadre. It assigns responsibility for the generation and maintenance of the files and for the creation of the products. It describes recommended procedures and guidelines for the creation of the detailed scientific program for the Astro-2 mission. The primary goal of this process is to maximize the scientific return of the effort.

The process of planning a science mission on the space shuttle is a complicated one, especially if "astronomy" is the science being pursued. The nominal Astro payload includes three ultraviolet telescopes (the Hopkins Ultraviolet Telescope [HUT], the Ultraviolet Imaging Telescope [UIT], and the Wisconsin Ultraviolet Photo-Polarimeter Experiment [WUPPE]) coaligned on the Spacelab Instrument Pointing System (IPS) and mounted on pallets in the shuttle's cargo bay. Hence, the planning process has to include all of the constraints intrinsic to the actual observations (e.g. visibilities of the objects from low-earth orbit, brightness of the objects, position relative to the day/night terminator of the orbit [or the sun or the moon], etc.), as well as all of the constraints that arise due to the shuttle itself (e.g. propellant available for maneuvers, maneuver rates, thermal constraints, crew cycles, availability of TDRS coverage for communications, etc.). Even though the three UV telescopes are co-aligned, the science goals of each team are sufficiently different from one another that mechanisms are needed to assure that the resources are shared equitably between the teams. In addition, the actual science programs defined by the instrument teams can cause additional constraints (e.g. ephemeris targets, moving targets, or objects that should only be observed in conjunction with another object, etc.). The following section describes the overall process of planning an Astro mission, based on experience from Astro-1 and changes instituted in response to discussions held by the Astro-2 Continuous Improvement/Mission Planning Team (CI/MPT) during 1992/1993. A more detailed discussion of the interfaces involved in this process is given in section 2 (and section 2.3 in particular), while the specifics of the interface file formats and protocols are given in section 3. Section 4 discusses the real-time replanning capabilities that are used during the mission to adjust the schedule in response to a variety of possible conditions.

1.1 Overview of Pre-mission Planning

Pre-mission planning for Astro Spacelab missions is a complex process which involves planners from the science instrument teams, the Marshall Space Flight Center Mission Operations Laboratory and the Johnson Space Center Mission Operations Directorate and their contractors. The common goal of these teams is to produce those products necessary to fly a successful Space Shuttle mission and ensure the greatest scientific return to the Astro investigators. On the largest scale, the nominal pre-mission flow involves the generation of two mission plans, one which we refer to as the "Basic Timeline" and one which we call the "Final Timeline." The basic timeline is a full-up planning effort but is not expected to be the flight document. It therefore allows leeway for timeline analysis and adjustment, unlike the final timeline, which is expected to have all potential problems and/or conflicts in resources, etc., eliminated. The basic timeline is useful for a number of reasons; a) it provides an excellent training opportunity for any new planning personnel involved in the mission, b) it is used for various engineering analyses (such as thermal, etc.), and c) the output products are used in the mission simulations (up to the Joint Integrated Sims (JISs)). However, the basic timeline planning begins near L - 18 months, and it may be little more than a representative or example timeline. (For Astro-2, for instance, the Guest Investigator inputs will not even be available at the time of planning the basic timeline. This is not always the case; other missions may have a basic timeline that is "flight-ready.") The final timeline is the one that is expected to be executed on-orbit, and most of this document deals implicitly (if not explicitly) with the generation of the final timeline.

The science instrument teams (HUT, UIT, and WUPPE) are responsible for developing a proposed sequence of observations (science plan) that best accomplishes the goals of the science teams and their Guest Investigators. The final product, an ASCII file, must be approved by the Investigators Working Group (IWG). The teams are also responsible for selecting any particular roll values of the IPS that are needed for observations as well as building the observing sequence files and target procedure information. The MSFC planners take the science plan as an input to create the payload timeline. Orbiter attitudes are designed to accomplish science pointing as well as satisfy various Orbiter and Spacelab needs. IPS checkout and "housekeeping", crew availability and Orbiter maintenance activities are married to this schedule. The final paper products are the Payload Timeline Summary (PTS), the Payload Crew Activity Plan (PCAP), the Joint Operations Target Procedure Book (JOTP) and the Target Book. JSC planners then use the PCAP as the core of the Flight Plan to which they add secondary payload activities and detailed work plans for the Orbiter crew members. These paper products are loaded on board for the use of the crew in carrying out the minute by minute operations of the mission. In addition, several products are created for loading on the Mass Memory Unit (MMU) of the Spacelab Computer. These are the Joint Operations Target File (JOTF), the Instrument Pointing System (IPS) objective loads for each planned science observation, the actual science instrument operational sequences, and the MMU orbital environment data sets.

1.2 Pre-mission Launch Slips

The detailed observability of each astronomical source from low-earth orbit (represented by what we call Acq/Losses) is driven not only by the time of year (i.e. sun position), but by the specific assumed launch time and orbit. Therefore, any change to the launch day or time of day will affect the accuracy of the pre-mission plan. Also, because the planning process takes a considerable amount of time (approximately 9 months in the nominal mode, including generation of the documentation), slips or changes in the launch parameters within a month or two of launch can cause considerable headaches. (The Astro-1 mission provided experience in many different launch slip scenarios.) Of course, the larger the slip the greater the impact. For a slip of a few days to a couple of weeks the plan can be "biased" and individual target opportunities checked to make the plan workable again. Also, if the launch time of day is appropriately shifted for each day of launch slip the orbit plane can be positioned as originally planned. Then only sun position and orbital day/night problems remain. In any case, as slips become longer, repair techniques become less effective. When the Shuttle is on orbit, however, many targets can be replaced or swapped in time to make the timeline more efficient. This is done in twelve hours blocks in a real-time replanning process (See section 1.3). Finally, if the slip is larger than about six weeks, a compressed design cycle may be begun and a new timeline created from scratch.

1.3 Real-time Replanning Capabilities

Astro-1 also provided a wealth of experience in real-time replanning activities. The extent of this capability is being enhanced with better software to allow replanning activities to be streamlined as compared with Astro-1. These capabilities are extremely important to the scientific return of the mission since they permit adjustments to the timeline based on a wide range of real-time situations that may occur, including launch slips "on the pad" (due to weather or other causes), hardware problems, or non-optimal orbit conditions.

Every twelve hours during the mission a cycle is begun that is similar to a "mini" timeline design. It begins with science teams submitting Replanning Requests (RRs) which are evaluated and approved or disapproved at the Science Operations Planning Group (SOPG) meeting. At this point the MSFC Payload Operations Control Center (POCC) cadre begin the process of updating the timeline and recreating all the products (12 hours worth) mentioned in section 1.1 above. At the end of each 12-hour process paper products are sent to JSC for uplink to the crew and updated MMU files are uplinked to the Spacelab computer. Besides this 12-hour process there is also a more immediate change route. Changes to the timeline may be requested through an Operations Change Request (OCR) and can generally be implemented if worked at least 2 hours before the event being changed.

The presence of an effective real-time replanning capability is also crucial for dealing with the effects of possible launch slips during the month or so before the mission. Launch slips in this time period can be particularly detrimental because the documentation products and instrument sequences are at an advanced state of development, and very little time is available to fix the products before the flight. Demonstrated real-time replanning capability allows us to confidently plan to make updates during the mission instead of "chasing" launch dates and wasting effort on pre-mission updates that may themselves become outdated before launch. One does not have to be as concerned about launching with products that are non-optimal because they can be fixed in "real-time" replanning. No matter how smooth the pre-mission planning flow is, or whether the launch occurs exactly on time, the need for an effective real-time replanning capability cannot be over-emphasized.

2. Mission Planning Guidelines and Constraints

This section contains a general discussion of the guidelines, procedures, and constraints affecting the planning of a science timeline for Astro-2. The planning process has been adjusted from that used during Astro-1, based on the experience gained and the subsequent discussions of the CI/MPT. The intention of these changes has been to simplify and streamline the planning process while still meeting all of the requirements of the science teams and NASA.

2.1 General Rules and Planning Philosophy

The following rules have been formulated to allow mission planning to proceed as efficiently as possible, and to create a system that allows each instrument to accomplish its primary science goals. The rules have been formulated to maintain as much flexibility in the mission planning process as possible while remaining as equitable as possible to all involved.

Astro-2 will involve observations to support Guest Investigators (GIs) as well as the PI Teams, as described in the NASA Research Announcement NRA 93-OSSA-14, Astro-2 Mission Guest Investigator Program. Ten GIs have been selected for Astro-2, working among the three PI Instrument teams. To ensure the needs of the GIs can be accommodated, the fraction of time allotted to each instrument team is negotiated with input from the GIs, the Mission Scientist (MSCI), and the CI/MPT, with approval by the IWG.

For most situations, the critical resource is observing time, and in particular, night observing time because of the difficulties with residual UV airglow emissions and scattered light on the daylit side of the orbit. There exist some scenarios where the number of shuttle maneuvers available becomes a critical resource, depending on such intangibles as overall length of mission and co-manifested payloads (if any). If Astro-2 is forced into such a situation, a combination of observing time and number of maneuvers will need to be used in accounting equitability between the teams, and between PI and GI fractions. The goal for this process is to arrive at the TOTAL observing time allotted to each of the three instrument teams (i.e. PI + GI) so that detailed planning can ensue.

In the past, the equitability between the instrument teams was driven at each step of the process, including especially the building of the MTL file and the generation of the SCIPLAN. This was a cumbersome and laborious process during Astro-1, and an accurate accounting was intrinsically difficult to construct. For Astro-2, the IWG has adopted a different strategy called block scheduling, which is intended to ensure equitability of resources, simplify the pre-mission activities, and provide added flexibility for real-time replanning.

In outline form, block scheduling involves the following: for a given launch assumption (including specific orbit and length of mission), a blank timeline is divided into blocks of integral numbers of orbits (typically 2-4). The lengths of the blocks, placement relative to SAA-affected orbits, and total orbits assigned to each team are negotiated by representatives of the science teams for the entire (assumed) mission. Hence, "equity" amongst the science teams is built into the timeline up front. This process negates the need to negotiate every last kilosecond and priority that goes into the MTL, greatly simplifying the process of building the MTL file. Science planning proceeds with the science teams selecting targets to efficiently fill each of their pre-planned blocks of time, although some inter-team negotiation may be necessary at the boundaries of the blocks. During the mission, the process of replanning is greatly simplified because each of the teams "controls" their own blocks of observations, and can replan observations "downstream" with only minimal negotiation with the other teams.

While these advantages are overriding, there are some subtleties to this process of block scheduling that need to be recognized. The IWG has always professed a planning guideline that encourages collaborative science, which basically amounts to selecting targets whenever possible that are of interest to two or more science teams. This guideline has the potential to substantially increase the scientific return of the mission for each of the instruments, but has always been difficult to implement. In the past, targets that were "co-science" observations were basically hand-accounted separately as part of assuring equity in the final timeline. The concept of block scheduling, where the pointings during a certain time period "belong" to an instrument team, potentially complicates the picture for collaborative science. Mechanisms need to be put in place to ensure that such targets are handled fairly in any real-time replanning that occurs.

Another potential difficulty involves targets that have certain timing constraints (ephemeris targets). If dictated by real-time events, these observations will need to be replanned, but the proper "ephemeris" time may not be available within a given team's blocks. Hence, the IWG will need to provide a mechanism to allow real-time "horse trading" in order to preserve the needed flexibility to handle such situations.

2.2 Constraints Affecting Mission Planning

The following are the guidelines to be used in the development of the final mission timeline. They reflect constraints placed on the mission activities by science requirements, Space Transportation System (STS), Orbiter, Spacelab Pallet requirements and capabilities, payload configuration, instrument pointing constraints, and TDRS characteristics.

2.2.1 General Scheduling Constraints

- Two TDRS's are assumed to be operational, therefore minimum attitude timeline optimization for TDRS coverage will be performed.
- The experiments will be scheduled as desired by the PI's, as defined by the Experiment Functional Objectives Requirements Document (EFORD) and as defined in the Astro-2 Mission Planning Handbook and Interface Requirements Document (MPHIRD).
- All HUT, UIT, and WUPPE target opportunities (acq/loss) will be calculated using the following Earth-limb constraints: Day: 10 degrees; Night: 5 degrees
- Orbiter maneuvers are performed at an inertial rate of 0.2 degrees per second.
- Whenever possible, an IPS slew will be performed rather than an orbiter maneuver.
- The science plan (SCIPLAN) will be planned to avoid sun transits within 45 degrees both day and night. In some cases this will entail the use of non-optimal slews (i.e. slews that are not along great circles on the celestial sphere).
- The moon avoidance angle for science targets will be 25 degrees, but may be relaxed on individual targets as directed by the IWG.
- There is no moon avoidance requirement during slews.
- In general, WUPPE plans to observe during SAA passages while HUT and UIT do not.

(Note: HUT may relax this constraint after on-orbit testing of their sensitivity to SAAs.) Targets that can be planned during SAA are flagged with a 3 in the Constraints column of the MTL file. However, SAA times are still less desirable than non-SAA times and should be used to bury slews, target acquisitions, STS tests, crew handovers, etc., whenever possible.

- Joint Focus and Alignment will occur as soon as possible after the IPS OSP calibration and IDOP tests, and IMC gyro calibration.
- Experiment operations are considered to begin with the Joint Focus and Alignment and will continue until the final IPS stow.
- The UIT early quit time at shadow exit will not be shown in the timeline summary data.
- During the first 48 hours MET, the IPS target observations should be limited to 2 per orbit (this is due to crew adaptation to the space environment).
- Due to sensitivity of the HUT primary mirror coating to oxidation, the IPS pointing direction must be maintained more than 20 degrees away from the instantaneous Ram vector at all times (i.e. including during both observations and slews).

2.2.2 Orbital Parameters and Definitions

- The altitude of the circular orbit will be approximately 190 nautical miles.
- The inclination of the orbit will be 28.4 degrees.
- It is desired that the beta angle (orbit-plane-to-sun angle) be contained within the bounds: -40 degrees <= Beta <= +40 degrees.

2.2.3 Space Shuttle Program (SSP) Constraints

- To satisfy the payload mandatory constraint of keeping as much of the orbital shadow out of SAA as possible, the requirement for a daylight launch will have to be waived. However, as many SSP constraints as can be satisfied within the SAA out of shadow window will be. The SSP Launch Window constraints are detailed in the JSC document SPACE SHUTTLE OPERATIONAL FLIGHT DESIGN STANDARD GROUNDRULES AND CONSTRAINTS.
- The Launch Window opens at sunrise minus 15 minutes at the Trans-Atlantic Landing site.
- The Launch Window closes at the point where the orbiter would land at sunset plus ten minutes at the end of mission landing site.
- K-band antenna deployment begins at 2:10 minutes MET.
- K-band antenna stow begins at deorbit TIG minus 3:05 and continues for a duration of 15 minutes.
- Payload bay doors close at deorbit TIG minus 2:40 with a duration of 15 minutes.
- IMU alignments can be made every 12-14 hours or as required without maneuvers, using

the attitudes required for science target viewing. The only exceptions are for the first and last IMU alignments, and a co-az alignment at the end of the first day, which will be specified by JSC.

- All potable water management will be done with the Flash Evaporator System (FES). Waste water dumps will last approximately 50 minutes and will occur approximately every 68 hours. Following the completion of each waste water dump, 20 minutes must be allowed for water dissipation before experiment operation can begin. These dumps will be scheduled during real-time operations.

- Waste water dumps will be performed in a +Y/VV attitude.

- TDRS handovers will be scheduled outside of science observations wherever possible.

- The FCS and Hot Fire Test will be of approximately 1.5 hours duration and occur at approximately TIG minus 48 hours. The FCS Checkout and Hot Fire Test will initially be scheduled by JSC relative to a 14 day mission; however, science planning can consider this activity to be rescheduled during real-time operations assuming a 16 flight day mission is possible.

- The IPS must be stowed no later than deorbit TIG minus 12 hours.

- The attitude timeline will be developed to maximize science requirements while remaining within thermal and RAM limits for the orbiter.

- The attitude deadband is 2 degrees in pitch, yaw, and roll.

2.2.4 Mission Profile

- The nominal mission duration will be 14 + 2 (+ 2 for landing contingency) days.

- The payload timeline will be built for 16 days, with the realization that the last two days are contingent on prevailing conditions. This corresponds to 14.5 days of "science" activities, assuming a 24 hour activation period and a 12 hour period for shutdown activities.

- The nominal EOM will occur at Edwards Air Force Base on rev 214, MET 13/14:15.

- EOM + 1 occurs on rev nnn (XX/XX:XX MET), and EOM + 2 occurs on rev nnn (XX/XX:XX MET). (This information is still pending JSC approval and has not yet been made available to MSFC representatives.)

- It is assumed that the cargo bay doors open by 0/01:50 MET. Spacelab activation will begin at 0/02:10 MET followed by experiment and IPS activation.

2.2.5 Instrument Pointing System (IPS) Constraints

- IDIN is the procedure by which the IPS determines absolute pointing, using one of a set of 74 bright, isolated stars spaced relatively uniformly over the sky. NOTE: Because all these stars violate UIT's bright object limits, UIT's DOOR MUST BE CLOSED DURING

SLEWS TO AND FROM IDIN STARS, AND DURING IDIN OPERATIONS.

- There are two modes of nominal acquisition/tracking operation for the IPS for Astro-2, named 'IDOP' and 'Manual' (called MTA/LOT, for Manual Target Acquisition/Lock On Target) respectively: IDOP is the procedure in which the IPS star trackers acquire AND identify sets of guide stars from stored data. The stored data are predicted star tracker field positions and predicted brightnesses, which are generated assuming the target positions and rolls, as part of the objective loads.

  Manual operations consist of two steps: Manual Target Acquisition, (MTA) followed by Lock On Target (LOT) tracking. In MTA the Payload Specialist identifies the target and places the instrument line of sight on the target using the HUT or WUPPE TV camera view. This procedure may be performed even when the target itself is invisible by aligning guide stars with their predicted fiducials in the HUT TV camera view, for example. LOT tracking is an IPS mode, new for Astro-2, in which IPS star trackers acquire and lock onto, but do not identify, stars in their field of view.

- MTA/LOT will probably work at smaller limb angles than IDOP will. Also, Astro-1 data show that MTA works more quickly than IDOP. Note that for some targets, this difference is critical, because they do not ever rise far above the limb. (Targets in general do NOT rise perpendicular to the horizon.) For example, in the Astro-2 Basic science plan, the quasar 1700+64 never rises above a limb angle of about 37 degrees. The normal IDOP limb angle restriction would cut the available observing time per pass by almost a factor of two compared with a >0 degree restriction. Most targets are less extreme. However, some, such as the SMC, are more extreme, and the difference in limb angle constraint may be critical.

- We expect that, if the IPS is operating normally, any target that can be acquired by IDOP can also be acquired by MTA. We emphasize that targets do not have to be seen by the PS (on the HUT TV screen) to be acquired by MTA.

- We expect that, if the IPS is operating normally, IPS pointing characteristics, including both long-term absolute accuracy and jitter, will be the same for IDOP and MTA/LOT operations. In particular, the function of IDOP in updating absolute pointer accuracy will be duplicated by MTA/LOT.

- The preferred IPS operational mode will not be determined until after on-orbit testing, and may depend on the target. Therefore objective loads and guide star sets, required for IDOPs, will be generated for all targets.

- IPS off-axis guidestars are assumed to be available when the IPS target meets its limb constraint.

- The IPS sun avoidance angle is 45 degrees.

- The IPS boresight acquisition and loss constraints are as follows:

Earth Limb Constraint (degrees)

	Acquisition	Loss
Bright	30	30
Dark	10	10

- The IPS slew rate is 0.5 degrees per second. The IPS gimbal capability of 26 degrees (half cone angle) is reduced to 22 degrees to meet IPS software stop and orbiter deadband limits.

- There are no IPS operational constraints due to radiation. When Idle Time exists in the SAA, the IPS will remain on the target (using up the Idle Time) until the target sets.

- An IDOP or MTA/LOT must be performed for every target acquisition. Seven minutes after the start of IDOP or ten minutes after the start of MTA/LOT, the experiment "All Begin" command may be issued.

- 4 minutes is allowed (or the length of the orbiter maneuver if the maneuver is greater than 4 minutes) between the Quit command and the start of the next IDOP or MTA/LOT.

2.2.6 Crew Cycle Scheduling Constraints

- The crew scheduling constraints listed below were taken from Appendix K of the Space Shuttle Crew Procedures Management Plan "Crew Scheduling Constraints" (JSC-22354) and are to be used in developing the Astro-2 crew cycles.

- A 15 minute handover between shifts must be scheduled.

- Handovers may be scheduled during long science observations.

- If experiment operations demand it, an occasional variation (up to 15 min.) in the placement of handover may be acceptable. This movement of handover is only available if the total 3 3/4 hour PSA (nominally 2 1/4 hours for Pre-sleep and 1 1/2 hour for Post-sleep) time is maintained. Such changes should be justifiable and infrequent.

- JSC suggested (ideal) handover times are listed in Appendix D.

2.2.7 Real-Time Operations Guidelines

- The preceding sections are also applicable for this section unless superseded below.

- Water dumps will not be crew-scheduled in the Final timeline. Instead, they will be inserted into the timeline during real-time replanning with the aid of unattended placeholder models scheduled pre-mission.

- Water dumps will be nominally expected every 72 hours.

- Hot fire tests ascertain the nominal operations of the reaction control system used during landings. They are performed enough in advance of reentry that repair can be performed if necessary, but not so early that a late-occurring malfunction will be overlooked.

- Hot fire tests are performed approximately 48 hours prior to reentry TIG.
- FCS checkout tests the flight control systems used during landings. It is performed enough in advance of reentry that repair can be performed if necessary, but not so early that a late-occurring malfunction will be overlooked.
- FCS checkouts are performed approximately 24 hours prior to reentry TIG.

2.3 Detailed Flow of Planning Activities

This section discusses the details of the process that results in the generation of a SCIPLAN and the subsequent products to support the mission. In outline form, the process looks like this:

1. Launch date, time & mission duration are fixed.
2. MSFC computes orbital parameters.
3. Individual teams choose their desired target times, constraints, & priorities.
4. IWG assigns joint priorities, times, constraints (Final MTL).
5. "Planning committee" negotiates scheduling blocks.
6. "Planning committee" plans targets into nominal SCIPLAN.
7. IWG approves SCIPLAN.
8. MSFC constructs observation schedule and attitude timeline; also generates IPS-related information.
9. PIs construct instrument sequences and ALTs.
10. Various documents produced to support the mission (e.g. PCAP, JOTP, etc.).
11. MMU is loaded with mission-specific information.
12. Launch and realtime replanning ensues.

Below this general outline is discussed in detail.

2.3.1 Nominal Planning Flow

Science planning starts long before an object is ever placed into a timeline. Each instrument team is made up of scientists, and it is a combination of the scientific interests of each team member and the unique capabilities of each instrument that need to be combined to formulate each team's scientific priorities. Also, Astro-2 will include a number of Guest Investigators (GIs), each of whom will bring a certain set of targets and scientific interests to the program. The first step in the planning process is to assemble a file containing basic information on all potential objects that are under consideration for observation on Astro-2. This list, called the Program Target List (PTL), contains targets available at all times of year.

When an official launch date is announced, visibility information on the PTL targets in conjunction with science team prioritization can be used to cull this list down to a set of targets to be considered for scheduling for that assumed launch date. The end product of this step is called the Mission Target List, or MTL, and this file contains specific priorities and requested exposure times for each selected target (as well as other information). The MTL is built by an iterative process between the science teams, with input and coordination from the File Manager (FLM).

Visibility information is computed relative to the assumed orbit and earth-limb viewing angles for the entire PTL. This permits the scientists to judge which targets for each science program are best placed for observation in the night part of each orbit, which bright objects are available for planning the daylit portion of each orbit, and which targets were unavailable because of proximity to the sun. For most objects, visibilities do not change significantly over an assumed 16 day mission, but objects near the orbit poles can change visibility dramatically. These effects can be checked by running visibilities for times near the beginning, middle, and end of the assumed mission. (The HUT team has software well suited to this task.)

The File Manager (FLM) constructs a Pre-MTL file containing these visibilities and blank columns for each of the instrument teams to fill in with appropriate information (e.g. priorities, requested observing times, and other constraints). With this information in hand, the teams cull their lists and assign priorities to the objects; each team should assign enough objects (PI and GI time) to priorities 1 and 2 to fill their allotted portion of the mission, and assign a number of targets as priority 3, to permit a degree of oversubscription and scheduling flexibility. (The amount of priority 3 time chosen is up to the teams to decide.) (Because of the Astro-1 experience with launch slips, we may also place objects into the list as priority 4 that will be added in the event of a significant launch slip.) This information is returned to the FLM, who collates the separate team lists and recirculates the combined lists so that overlaps can be negotiated. After a final iteration involving the negotiation of overlap targets, the final MTL is produced and baselined. The official list of overlap targets and accounting is archived by the FLM for future reference. The final MTL becomes the main input file to planning the science timeline.

During Astro-1, this was a time-consuming and rather difficult step because each team was expected to put in exactly the agreed-upon amount of time of each priority (especially priority 1 and 2), and thus there had to be a lot of detailed checking. Also, the science overlaps had to be negotiated explicitly and "charged" to one team for accounting purposes. With the block scheduling scheme, the block negotiations do away with the need to expend this level of effort on the details in the MTL file. However, it is to everyone's advantage to basically follow this same rough breakdown of priorities vs. expected observing time. It is assumed that each team's GIs will be involved in building the MTL file and that the PI/GI time breakdown for each team will be in accord with the selection rules.

With the availability of a finalized MTL, the planning of a science timeline can begin in earnest. Figure 2.3.1-1 displays a flowchart of planning activities, highlighting the major flows and interactions in the mission planning process. Time basically flows from left to right in this diagram, and three general areas of activity are charted. The top line follows the IPS-related activities, the middle line shows the PI team planning activities, and the bottom line shows the activities of the MSFC Payload Activities Planner (PAP) team. The flow of activities has been revised based on Astro-1 experience, with an improved flow and compressed timescale for many of the steps of the process. Even so, the chart provides an indication of the complexity of the mission planning process and the extent to which various steps of the process are inter-related.

With the exception of some necessary but very general work related to IPS guide stars and the activation portion of the timeline, detailed timeline work awaits the generation of a "Science Plan", or timeline of science observations desired by the IWG. The SCIPLAN file is generated by representatives of the science teams using the MTL file and software that allows the various constraints to be analyzed for each proposed observation.

As indicated above, the activation portion of the timeline is generated separately from, and at this point, in parallel with, the science plan. The PAP team at MSFC integrates the Functional Objectives (FOs) from each science instrument and the IPS with the Space Shuttle Program (SSP) constraints. An attitude timeline is then produced which satisfies all of the activation requirements. Not until all of the activation objectives have been completed and the SCIPLAN finished can the

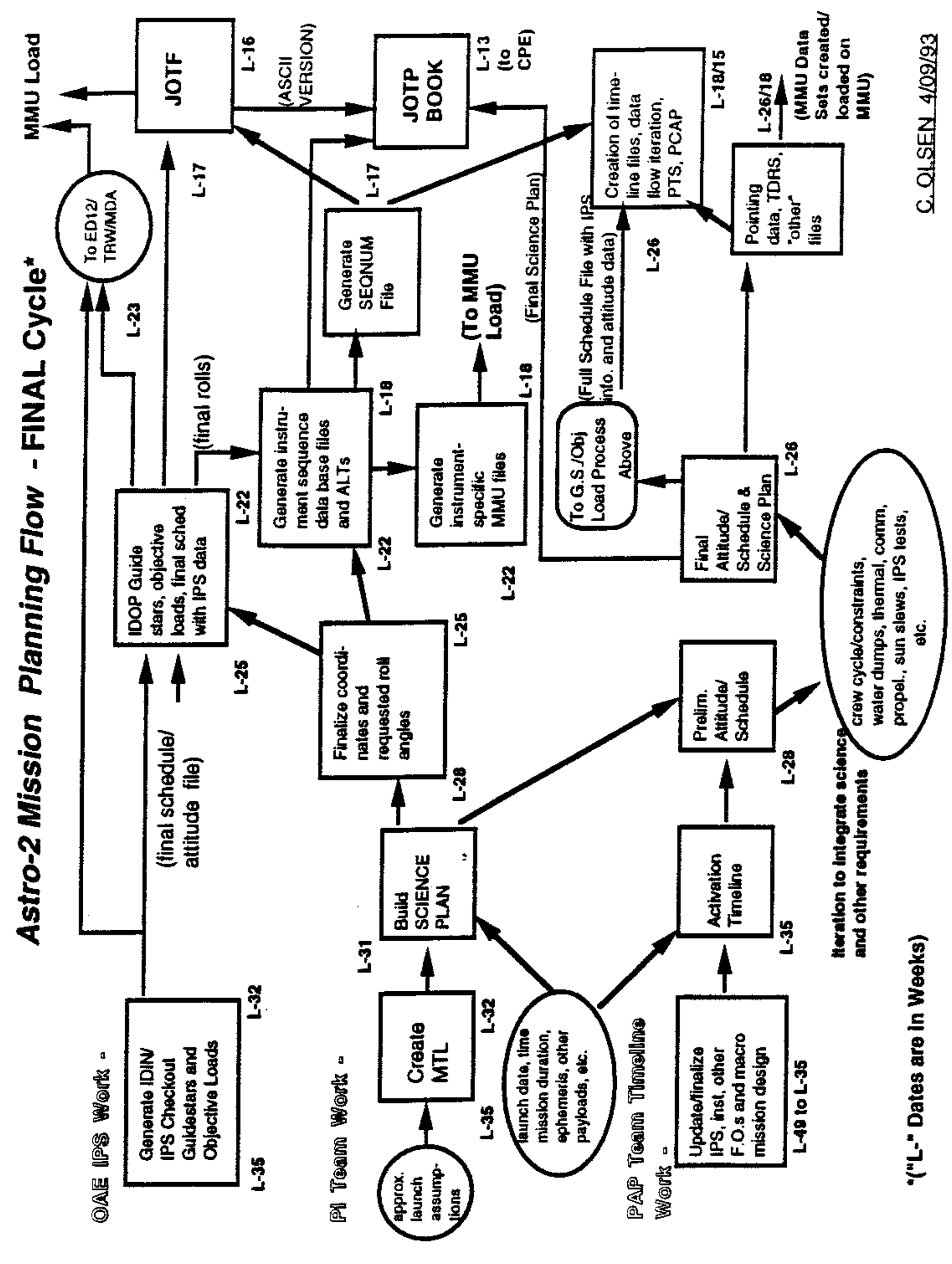


Figure 2.3.1-1 - Planning Activity Flowchart

science portion of the timeline begin.

For reasons described elsewhere in this document, we have adopted the concept of block scheduling for Astro-2. Ground rules for block scheduling are still in development, but include the following:

a) Integral-orbit blocks are assumed, rotating amongst the teams. The block boundaries are nominally placed in mid-day, but may be negotiated as needed. In some cases, tying the block boundaries to the movement of the SAAs may be advantageous. For Basic T/L development, 2-orbit blocks and strict rotation (H,U,W) were assumed, but both of these assumptions may need to be relaxed for the Final T/L.

b) As blocks are being scheduled, each team should plan for a slew to start the block, and may plan right to the end of their block. (Any deviations from this pattern can be negotiated after the blocks are put together.)

c) GI targets are planned in these blocks right along with the PI team targets, based on the priorities and times assigned in the MTL.

In principle the block planning can be accomplished using whatever software each team chooses; for example, the program 'jsciedit', developed at JHU during Astro-1 and modified for use on Astro-2, provides a reasonably straightforward way to insert targets, check constraints, and adjust start and stop times of observations. This program calculates the visibility of chosen targets at specified times, and will insert the target if desired. If constrained by other nearby targets, the program calculates and inserts "great circle" slew times and provides good estimates of the observing time available. This software is made available to planners on all of the teams.

One ramification of block scheduling is that SCIPLAN development can be accelerated since the three teams can work on planning their targets autonomously, coming together at the end to negotiate the block boundaries. If the ground rule about planning for a slew at the beginning of each block is followed, there is minimal negotiation in putting the blocks together. Any "holes" at the block boundaries can be readily filled by team planners after the blocks are assembled into a single file. As a final step, the JHU program 'extend' is run on the draft SCIPLAN to incorporate any usable idle time into planned observations. After checking, this file is delivered to the FLM for general distribution to all interested parties.

After a complete SCIPLAN is available, the science teams work to finalize any coordinate updates or requested roll angles for scheduled targets while the PAP team builds a shuttle attitude timeline and schedule file to support the science timeline, which will be spliced onto the activation timeline. The PAP team's work may affect some observations, including the effects of non-optimal slews, and changes due to thermal or TDRS coverage constraints or known STS tests. Final coordinates and roll angle requests for all targets are fed into the IPS planning at this point and IPS objective loads (IPS roll angles and OSP guide stars) are built for each planned observation. IPS roll angles are fed back to the science teams via the IPOL file; the science teams use this information to finalize their instrument sequence files (which drive the instrument set-ups for each observation). Information is provided by the science teams and the PAP team to FLM and the Crew Procedures Engineer (CPE) in support of the production of the Target Book and the Joint Operations Target Procedures Book (JOTP). Also, the PAP team produces various products such as the Payload Crew Activities Plan (PCAP), Payload Timeline Summary (PTS), and TDRS coverage files in this time period. IPS Objective Loads, the Joint Observation Target File, and individual team sequence files, etc., are finally loaded onto the shuttle's Mass Memory Unit (MMU). Astro is now ready for flight.

2.3.2 The Role of the FLM

The File Manager (FLM) will serve as the main interface between MSFC and Principal Investigator (PI) Team mission planners. The FLM will help develop and document interface requirements, and develop and/or modify software to perform file management functions. The FLM must be knowledgeable of the MSFC MIPS VAX software as well as the scientific aspects of the mission.

The FLM wears many team hats. The FLM is a member of the Payload Activity Planner's (PAP's) team for pre-mission science planning. In general, the FLM will receive direction from the PAP but it is understood that all FLM work will be done with the knowledge and agreement of the Investigators' Working Group (IWG). During simulations and mission operations the FLM is a member of the Mission Manager's Cadre team in the Payload Operations Control Center (POCC). The FLM will reside in the Science Operations Area (SOA) in close proximity to the science teams, and overall direction for FLM work will be dictated by the decisions of the IWG's operational arm, the Science Operations Planning Group (SOPG); because of this, the FLM is also responsible to the MSCI's team. This also makes the FLM a member of the CI/MPT. The FLM is also a member of the Operations Controller's (OC's) team for JOTP Book production pre-mission. During missions the FLM will continue to report to the OC for JOTP production.

Pre-mission, the FLM will be involved in a number of activities pertaining to timeline development. The FLM will: review documentation, including the Payload Operations Handbook (POH), Payload Operations Guidelines (POG), Joint Operations Interface Procedures (JOIP), and Integrated Payload Requirements Document (IPRD); develop and/or modify and check out software necessary to file management activities; develop and maintain this document, the Mission Planning Handbook & Interface Requirements Document (MPHIRD), with PI & Cadre coordination; receive, concatenate, validate, format, and maintain PI science files; distribute PI science files to Cadre as needed; generate Joint Operations Target Procedures (JOTP) Book pages; receive on/off data files and tabular output files from Cadre and distribute to PIs; develop and maintain the FLM Console Handbook; attend all Cadre, PI, and PRT pre-mission briefings and meetings; and participate in POCC training activities, simulations, JISs, and premission tests.

During the mission, the FLM will support the replanning and realtime scheduling efforts in the POCC, including file updating, formatting & distribution; provide the realtime interface with the Crew Procedures Engineer (CPE) for JOTP Book production & procedures; maintain the console log; and attend Science Operations Planning Group (SOPG) meetings as required.

Post-mission, the FLM will attend all post-mission Cadre, PI, and PRT debriefs; generate a post-mission console report and lessons learned; finalize the console log and turn it in; and develop the As-Flown Science Plan.

For specific information on certain tasks, see the appropriate section in this document or the FLM Console Handbook.

2.4 Dealing with Pre-mission Launch Slips

The circumstances which lead to the need to replan can be roughly divided into two categories depending on the time of their occurrence. The two categories are pre-mission and real-time. First, by "pre-mission replanning" we mean "fixing up" an existing plan as opposed to starting over from scratch. This would be the result of a change in the launch date, time, orbital parameters or other aspects (e.g. co-manifested payload) of the mission which occurs so late in the process that complete ab initio planning is impractical, but which can benefit from pre-launch analysis and planning of corrective measures for use in real-time replanning. This will be covered in this section. Real-time replanning is necessitated by events which occur from shortly before launch to the very end of the mission and may be of either technical or scientific origin. Examples of the former include launch slips due to weather or malfunctions of equipment on orbit while examples of the latter include targets of opportunity and important observations suggested by results during the mission. Section 4.1 covers real-time replanning.

The complete definition of the limits of and exact activities involved in pre-mission replanning is virtually impossible for it is a complex, non-linear combination of time, magnitude, cause and nature of the "deviation" as well as unquantifiables such as the evolving expectations of experimenters. Nonetheless we can identify several scenarios with substantial probabilities of occurrence. With each of these we can associate approximate limits on when in the flow the "hit" can occur and and how large it can be yet still be accommodated in a "replanning" mode. We can then also identify those replanning responses which are appropriate to each scenario. These scenarios are addressed in the following subsections.

Changes in the expected date of launch of days or weeks that become known less than about [3] months prior to the new date and are less than about [6] weeks in magnitude need to be accommodated with pre-mission replanning. Such launch slips affect the planned timeline very significantly and yet insufficient time is available before launch for a new round of the nominal pre-mission planning cycle. The need to alter the scientific mission plan is a direct result of the inexorable apparent motion of the Sun across the sky coupled with 1) the Sun avoidance angles of the Astro telescopes and 2) the requirement that some observations MUST be performed ONLY during orbital night. In the former case even relatively small slips can render many previously scheduled targets unobservable as well as bring back into view objects of very high priority which were behind the sun avoidance zone. In the latter case, although the majority of prescheduled targets remain formally "visible", the mission elapsed times (MET) of acquisition and loss of a target can change and the day/night boundaries can change substantially. This requires, at the very least, rework of instrument sequences (start-stop times, filters, apertures, etc.). There are a variety of strategies and activities associated with response to launch slips which are outlined in the following subsections.

2.4.1 The Constant RAAN2 Constraint

For a given orbital altitude, inclination and eccentricity, the single parameter which uniquely determines the METs of target acquisition and loss times (acq/loss) is the right ascension of the ascending node of the orbit at some particular epoch. This is in turn determined by the date and time of launch and the details of the orbital insertion procedure. Since in general an orbit insertion burn occurs at or near the first ascending node, it is common practice to choose the second node passage as the defining epoch. Hereinafter we denote the right ascension of the second ascending node as RAAN2. Thereafter the node precesses at a rate of approximately 7 degrees per day under the influence of torques established at creation by God Him/Herself. Thus, if the date of launch changes by an integer number of days, the RAAN2 (and thus METs of acq/loss of each scheduled observation) can be held constant by altering the time of launch by 3 minutes and 56 seconds for each day of the slip. If the launch date is delayed, the launch time time must be earlier for the new launch date while if the launch schedule is moved earlier the launch time must slide later. If this procedure can be accommodated within other Shuttle constraints, launch slips of up to [6] weeks can not only be tolerated but accommodated with minimum replanning effort. The only problems not fixed by way of applying this constraint are a) the changing day/night fractions of each observation, and b) any targets which slide into (or come out of) the solar avoidance zone.

The Astro-2 IWG and Mission Manager have requested that the Constant RAAN2 constraint be made a "Highly Desirable" constraint in the mission Payload Integration Plan (PIP).

2.4.2 Application of a Bias

Once a new launch date and time have been adopted, it is possible to compute new acq/loss times for each target. The differences between these values and those in the original plan can be minimized by applying an optimum average delta time, or "bias", to the timeline. This bias, rounded to the nearest integral minute, is subtracted (or added, depending on the slip involved) to the METs in the original plan. Although day/night fractions may change somewhat, and targets next to SAAs (for HUT and UIT) may be affected adversely by launch slips, the application of a bias is a simple technique that can save hours of observing time (cumulative over the mission) that would otherwise be lost from a launch slip.

The bias as a function of launch slip (either days/weeks or hours on the pad) is determined experimentally by repeatedly running the JHU program 'slip analysis' on a given SCIPLAN and determining what amount of bias minimizes the amount of total integration time lost. From Astro-1 experience, the bias ranges from 0 to -7 minutes for slips of 1 - 30 days, and 0 to -10 minutes for slips up to three hours on the pad. Timelines slipped earlier in time have positive biases.

2.4.3 Pre-mission RRs

With or without a constant RAAN2 and after application of a bias, there will remain some problems which must be fixed. This is particularly true for targets which have gone into the Sun or Moon avoidance zones. In this case the instrument responsible for the target(s) in question will prepare a standard format Replanning Request (RR). The totality of pre-mission RRs (PMRRs) will, after IWG approval, be forwarded to the Cadre and insofar as possible these will then be "worked" in advance and then during the course of the mission treated in the flow just as would regular RRs (see below).

2.4.4 The Astro-2 Philosophy

While a number of situations requiring pre-mission replanning can readily be conceived, the demonstrated ability to replan the mission in near real-time (see section 4) should make it possible to reduce (and in some cases eliminate) the amount of premission replanning required. In discussions since Astro-1, the CI/MPT has professed a philosophy whereby we try not to "chase" launch slips. A tremendous amount of effort on Astro-1 went into trying to fix problems in the premission timeline caused by changes in the official launch date or time. Much of this work went into trying to update various hardcopy deliverables, such as the PCAP or target book (NB: in the case of Astro-2, the JOTP book). Much of this work, especially for observations after the first 24 hour period, was completely wasted effort as circumstances caused the need to replan much of the timeline in real-time anyway. The goal now is to reduce the amount of effort expended premission fixing problems that may ultimately go away anyway (or at least become different problems). At some level, this amounts to being prepared for changes that might be needed to the premission timeline, but not implementing the changes into official files and deliverables until real-time replanning during the mission. The ability to adopt this philosophy is partly in response to actual Astro-1 experience, partly due to the adoption of the "block scheduling" idea (whereby each team has more flexibility to replan with impunity), and partly because we expect better real-time planning tools (e.g. software) to be available to incorporate the necessary changes.

3. Interface File Descriptions and Formats

3.1 Baseline File Directory Structure

3.1.1 Directories and Contents

The following directories and files are to be found in the FLM account.

Name	Originator	Contents
• **PROGRAM(dir)**		Current versions
PTLCHANGE.DOC	FLM	Changes from the last version
MTLCHANGE.DOC	FLM	Changes from the last version
PTLHISTORY.DOC	FLM	All previous changes
MTLHISTORY.DOC	FLM	All previous changes
ASTRO2PTL.DAT	PI's	Program Target List (ID number order)
ASTRO2PTLCOORD.DAT	PI's	Program Target List Coordinate Reference List
• **OLD(dir)**		Previous versions of files
• **BASIC or .FINAL(dirs)**		
PTLCHANGE.DOC	FLM	Changes from the last version
MTLCHANGE.DOC	FLM	Changes from the last version
ddmonhhORB.DAT	MSFC	Orbit data for mission
ddmonhhSAA.DAT	MSFC	SAA data for mission
ddmonhhCREW.DAT	MSFC	Crew data for mission (on request)
ddmonhhSHAD.DAT	MSFC	Earth Shadow Entry/Exit (on request)
ddmonhhPMTL.DAT	PI's	Pre-Mission Target List
MTL.DAT	IWG	Mission Target List-seasonal PTL
SCIPLAN.DAT	IWG	Science Observation Plan
SEQNUM.DAT	IWG	Instrument Sequence Numbers
OBJSUM.DAT	MSFC	IPS Objective Data (on request)
JOTF.LIS	MSFC	Joint Ops Target File
• **OLD(dir)**		Previous versions of files
• **SW(dir)**		Contains source, object, command and test files for MOVE, VIS and assorted miscellaneous programs.
MOVE.EXE	PI's	Executable defining moving targets
SOLAR.DAT	PI's	Contains orbital parameters for Solar System objects (used by MOVE)
PM.DAT	PI's	Contains proper motion data (used by MOVE)
TIME.EXE	PI's	Executable defining ephemeris phasing
VIS.EXE	PI's	Executable calculating day and night visibilities
REF.EXE	FLM	Executable reformatting pre-MTL into MTL format

TEMPLATE.EXE	FLM	Executable creating SEQNUM.DAT template
MSTRSEQNUM.EXE	FLM	Executable merging science team data for SEQNUM.DAT
IPOLCONV.EXE	FLM	Executable extracting roll data from IPOL & placing it in SCIPLAN
• JOTP(dir)		
HSF.mmddyy	HUT	HUT Sequence Database
WSF.mmddyy	WUPPE	WUPPE Sequence Database
USF.mmddyy	UIT	UIT Sequence Database
SCIPLAN.DAT	IWG	Science Observation Plan
SEQNUM.DAT	IWG	Instrument Sequence Numbers
• HUT(dir)	PI's,JPL	Alternate procedure text files
• WUP(dir)	PI's,JPL	Alternate procedure text files
• UIT(dir)	PI's,JPL	Alternate procedure text files
• MPIRD(dir)		
MPHIRD.TXT	MPT	Mission Planning Guidelines

3.1.2 File Protection

"World" (anyone with network permission into node):
"R" (Read Only)

"Group" (logged on as WUPPE, HOPKINS, UIT, ASTROS, MSFC, ASTRO2FLM):
"RE" (Read and execute)

"Owner" (FLM only: S.A. Gannaway-Osborn)
"RWED" (Read, Write, Execute, Delete)

"System" (Node system manager)
"RE" (Read and execute)

3.2 Target ID Numbering

3.2.1 Astro-2 Science Classes

0 Calibration
0.0 HUT Camera Sensitivity Targets
0.1 HUT Spectrometer Focus Targets
0.2 HUT
0.3 UIT Flat Field Sources
0.4 UIT
0.5 WUPPE Aperture Position Calibrators

0.6 WUPPE Unpolarized & Polarized Standards
0.7 Not Assigned
0.8 Not Assigned
0.9 Joint Focus and Alignment Targets

1 Solar System Objects
1.1 Comets
1.2 Planets
1.3 Asteroids, etc.

2 Individual Stars
2.1 Supergiants
2.2 O/B and Oe/Be Stars
2.3 Wolf-Rayet Stars
2.4 Rapid Rotators
2.5 Normal White Dwarfs
2.6 Magnetic/Pulsating White Dwarfs
2.7 Planetary Nebula Nuclei
2.8 Normal Stars A0 & Later
2.9 O/B Subdwarfs

3 Variable and Binary Stars
3.1 Pre-Main Sequence Stars
3.2 Cataclysmic Variables
3.3 Interacting Binaries
3.4 Symbiotic Stars
3.5 Active Chromospheres
3.6 Pulsating Variables
3.7 Low Mass X-Ray Binaries
3.8 High Mass X-Ray Binaries
3.9 X-Ray Transients

4 Interstellar Medium & Nebulae
4.1 Planetary Nebulae
4.2 Reflection Nebulae
4.3 H II Regions
4.4 Supernova Remnants
4.5 Interstellar Polarization Probes
4.6 Interstellar Absorption Probes (Nearby & Hot)
4.7 Herbig-Haro Objects
4.8 Dark Clouds
4.9 Diffuse Galactic X-Ray Emission Regions

5 Star Clusters
5.1 Metal Poor Globulars
5.2 Metal Rich Globulars
5.3 Open (Galactic) Clusters
5.4 O/B Associations

6 Normal Galaxies
6.1 Nearby Galaxies
6.2 Spirals

6.3 Ellipticals
6.4 Irregulars
6.5 Dwarfs
6.6 Edge On Systems

7 Abnormal Galaxies
7.1 Interacting Galaxies
7.2 Amorphous Galaxies
7.3 Rapid Star Formation
7.4 W/Circumgalactic Matter
7.5 E/S0 with Interstellar Matter

8 Active Extragalactic
8.1 Seyfert I Galaxies
8.2 Seyfert II Galaxies
8.3 Radio Galaxies
8.4 Radio Loud Quasistellar Objects
8.5 Radio Quiet Quasistellar Objects
8.6 BL Lacertae Objects
8.7 LINERs
8.8 Optically Violent Variable (OVV) Quasars

9 Clusters of Galaxies
9.1 Spiral Poor Clusters
9.2 Spiral Rich Clusters
9.3 X-Ray Selected Clusters
9.4 Deep Survey Fields
9.5 Cooling Flow Clusters

9.6 Spacecraft Specific
9.7 Gyros/IMC
9.8 IPS Tests
9.9 Waterdumps/Handovers

3.2.2 Target Numbering Scheme

A single 4-digit ID is assigned to each astronomical target name. This 4-digit ID should be mission-independent and is the target ID given in the Program Target List (PTL). This ID may correspond to RA's and Declinations over a roughly 5 arcmin range. The size of this range is chosen under the assumption that this precision is good enough to compute acquisition/loss times and orbiter maneuvers, and that 5 arcmin is large enough for flexibility in, for example, choosing specific HUT or WUPPE targets within UIT galaxies. If the ID has a solar system ('S') flag set to 1, it may have any RA or Dec. If a target is used both as a calibration target and a science target it may be given two ID numbers, depending on the purpose of the particular acquisition. This permits more accurate accounting of time usage.

IPS and IMC tests, waterdumps, handovers and similar occurrences are included in SCIPLAN with numbers starting at 9800 as follows:

9800-00 IDIN's (Gyro Updates)

9801-00	OSPCAL
9802-00	IDOPTEST
9803-00	IMC-GYRO
9804-00	IMC-CAL
9808-00	OPT-HOLD
9809-00	IPS-PINT (IPS Pointing & Stabilization)
9810-00	IPS-IPT (IPS Initial Pointing Test)
9811-00	IPS-LOTS (IPS Lock-On-Target Search)
9812-00	IPS-LOT (IPS Lock-On-Target Test)
9813-00	IPS-MTA (IPS Manual Target Acquisition Test)
9814-00	IPS-SSUB (IPS Sensor Substitution Test)

NOTE: For the above activities only, the SRC (Source) column of the SCIPLAN will contain the corresponding IPS Objective Load number, supplied by the Orbit.

At the MTL stage, a fifth digit gets added to the ID number. This digit identifies a particular set of parameters that have been assigned to a target. For instance, if multiple pointings at a target were required, but different roll angles were needed on each pointing, a different fifth digit would be assigned to each pointing. Likewise, slightly different positions (within the 5 arc min constraint) for revisits within the same extended target could be handled this way. Finally, for targets needing longer integration times, it is common for some time to be ascribed to different priorities; the total P1 time requested would be given one fifth digit, and the P2 time a separate fifth digit within the MTL.

Finally, at (and subsequent to) the point of SCIPLAN planning, a sixth digit is added to the ID numbers. This sixth digit (in conjunction with the first five) makes the ID number unique to a particular planned shuttle pointing, and ties that particular pointing to the other planning files. For MTL entries with only one pointing, the sixth digit remains as zero, but for MTL entries requiring two or more pointings, the SCIPLAN entries contain sixth digits starting with 1, 2, etc. The following table summarizes this convention.

Digit	Meaning
1	Science Class
2	Science Subclass
34	Target Numbers within Subclass
5	For primary pointings: N => Nth pointing at target with different roll, offset (RA & Dec), or priority.
6	0 => Only one pointing on this target; N => Nth pointing, for targets with >1 pointing.

3.3 Interface File Definitions

3.3.1 Orbit and Related Data Files

Here we will discuss individual files containing useful data which are often, but not always, passed from the PRT to the science teams. These files are available upon request. The proper file flow is: OAE/TLE --> FLM --> PI Team Representative. Also included here is the block description file which passes from the PIs to the PRT and is useful with respect to the other files listed in this subsection.

3.3.1.1 File names

File names should be ddmmmhhORB.DAT and ddmmmhhSAA.DAT for the orbit and SAA information, respectively, where dd = day, mmm = month and hh = hours UT. Thus a January 19, 1989 launch at 12 hours UT would produce the files 19JAN12ORB.DAT and 19JAN12SAA.DAT.

3.3.1.2 Orbital data

Orbital Data File Format:

ASCII file with blanks as field separators

Contents	Format	Bytes
Parameter	A8,1X	01-09
Value of Parameter	F15.10,1X	10-24
Units	A10	25-34

Example:

19JAN16ORB.DAT (supplied by MSFC)

period	1.5243647	hrs	ave node period
an2	1.2124010	hrs	MET of second node passage
raan2	188.20407	deg	RA of node at 2nd passage
dran	-0.3013825	deg/day	deg/day change in RA of ascending node
inc	28.483	deg	orbit inclination
pday	1.526896	hrs	average time between shadow exits
d2	1.23199	hrs MET	shadow exit on orbit 2
pnight	1.526377	hrs	average time between shadow entries
n2	2.23185	hrs MET	shadow entry on orbit 2

3.3.1.3 SAA Data

Each line of the file should contain the entry and exit times of a given SAA passage in decimal hours MET, separated by spaces.

File Format:

ASCII file with blanks as field separators

Contents	Format	Bytes	Comments
SAA Entry Time	F8.4,8X	01-16	decimal hrs MET
SAA Exit Time	F8.4,11X	17-35	decimal hrs MET
Time in SAA	F8.4	36-43	minutes

Example: Part of File 19JAN16SAA.DAT (supplied by MSFC)

JANUARY 19 1989 RADIATION FILE

ON TIME(HR)	OFF TIME(HR)	DELTA TIME(MIN)
2.1635	2.2760	6.7529
3.5566	3.9021	20.7317
5.0803	5.5063	25.5646
6.6609	7.0952	26.0583
8.2600	8.6491	23.3495
.	.	.
.	.	.
198.9801	199.2739	17.6312
200.5963	200.8451	14.9304
202.2271	202.3722	8.7085
213.9710	214.2189	14.8764
215.4469	215.8341	23.2306

3.3.1.4 ASTRO Crew Cycle

File format:

Contents	Format	Bytes	Comments
On time	F12.3,5X	01-17	Decimal hours
Off time	F12.3	18-30	Decimal hours

Example of Crew Cycle File (19JAN16CREW.DAT):

JSC ASTRO CREW CYCLE - 4/17/87 (DECIMAL HOURS)

ON TIME(HR)	OFF TIME(HR)	11.000	11.250
22.000	22.250		
34.500	34.750		
46.500	46.750		
58.500	58.750		
70.500	70.750		
82.500	82.750		
94.250	94.500		
105.500	105.750		
118.000	118.250		
129.500	129.750		
143.000	143.250		
154.500	154.750		

3.3.1.5 Earth Shadow Entry/Exit

File Format:

ASCII file with blanks as field separators

Contents	Format	Bytes	Comments
Umbra Entry Time	F8.4,8X	01-16	decimal hrs MET
Umbra Exit Time	F8.4,11X	17-35	decimal hrs MET
Time in Shadow	F8.4	36-43	minutes

Example of Shadow File (29JUN13SHAD.DAT):

JUNE 29 1989 SHADOW FILE

ON TIME(HR)	OFF TIME(HR)	DELTA TIME(MIN)
0.7662	1.3669	36.0425
2.2925	2.8931	36.0382
3.8187	4.4192	36.0336
5.3449	5.9453	36.0289
6.8711	7.4715	36.0240
8.3973	8.9976	36.0190
.	.	.
.	.	.
209.8874	210.4412	33.2291
211.4144	211.9675	33.1879
212.9414	213.4938	33.1476
214.4684	215.0202	33.1064
215.9954	216.0000	0.2765

3.3.1.6 IPOL File

The IPOL list file is an ASCII listing of the Silvabase IPOL file. It contains chronological science target information including IPS gimbal angles and PI Roll, which is used by the instrument teams to generate their sequences. It is created by the Orbit and is delivered to the FLM for the science teams to access. The IPOL list file is not placed in the Interface Directory and is not updated each 12 hour replan shift.

IPOL List File format:

ASCII data, field delimiter = space

Contents	Format	Bytes	Comments
MET	3x,4(I2,1x)	01-15	DD/HH:MM:SS
OBJ	I3	16-18	Objective Load Number
Target ID	1x,A7,2x	19-28	xxxx-yz
RA	F6.2,1x	29-35	RA Decimal Degrees
DEC	F6.2,2x	36-43	DEC Decimal Degrees
EL	F6.2,2x	44-51	IPS Elevation Gimbal Angle
XL	F6.2,1x	52-58	IPS Cross El. Gimbal Angle

RL	F7.2,2x	59-67	IPS Roll Gimbal Angle
C_ROLL	F6.2,1x	68-74	Celestial Roll (0-360)
O_ROLL	F7.2,2x	75-83	Objective Roll (+/- 180)
PI_ROLL	F6.2	84-89	PI Roll (0-360)

An example of the IPOL List File is found in Appendix A.

3.3.1.7 Block Description File

In the "Block Scheduling" scenario, the team representatives come together early in the planning process for a given timeline and lay out a pattern of 2-orbit blocks that are assigned to each team. These blocks are then used as a guideline for planning, as described in Section 2.1. For use in generating timeline plots and tracking the nominal block boundaries, an ASCII file called "blocks.dat" is generated that gives the start/stop times and "ownership" of each block. The format of the file is given below.

It should be noted that these block boundaries are present in the timeline plots for INFORMATIONAL PURPOSES ONLY: they are not a "constraint" that is applied to terminate observations.

When this file is finalized, it will be provided to the FLM by the HUT team for possible use in the MSFC graphical user interface program.

The format of this file will be as follows:

The columns are EVENT, METstart, METstop, and Duration. (For historical reasons, the format is similar to the ASCII "schedule" file.) The Duration column is always 0.0 in "blocks.dat". There are no header lines in the file.

```
HUT       23.65     26.70 0.00
UIT       26.70     29.75 0.00
WUPPE     29.75     32.80 0.00
HUT       32.80     35.86 0.00
WUPPE     38.91     41.96 0.00
HUT       41.96     45.01 0.00
UIT       45.01     48.07 0.00
WUPPE     48.07     51.12 0.00
HUT       51.12     54.17 0.00
UIT       54.17     57.23 0.00
WUPPE     57.23     60.28 0.00
.
.
.
etc.
```

3.3.2 Program Target List (PTL)

The Program Target List (PTL) is the receptacle for basic planning information on all potential Astro targets, independent of launch assumptions or time of year. Although planning information for mission-specific applications may sometimes be updated from that shown in the PTL, in general it is important to have the highest fidelity information possible in the PTL. Hence, it is important to have accurate and verifiable coordinates for targets in the PTL (and its ancillary files). The PTL forms the starting point for all mission planning efforts, and provides the main cross reference between individual targets and science program numbers.

PTL file format:

ASCII data - field delimiter = space

Contents	Format	Bytes	Comments	Unspecified Value
Resp Instrument	A1,1X	01-02	H,U,W,J	_ (underscore)
Target ID	I4,1X	03-07	xxxx	9999
Name_1	A8,1X	08-16	8 chars	_
Name_2	A8,1X	17-25	8 chars	_
RA (1950)	I2,1X,I2,1X, F6.3,1X	26-38	hh mm ss.sss	99 99 99.999
Dec (1950)	A1,I2,1XI2, 1XF5.2,1X	39-51	sdd mm ss.ss	+99 99 99.99
Coord Source	I3,1X	52-55	numerical ref (see PTLCOORD.DAT)	999
Coord Acc	F5.2,1X	56-61	ss.ss	99.99
Offset Flag	I1,1X	62-63	=1 if offs req	9 [Note 1]
Roll Flag	I1,1X	64-65	=1 if roll req	9 [Note 1]
Time Flag	I1,1X	66-67	=1 if GMT req	9 [Note 1]
Solar System Flag	I1,1X	68-69	=1 if sol sys tgt	9 [Note 1&2]
Proper Motion Flag	I1,1X	70-71	=1 if prp mot tgt	9 [Note 1&3]
WUP Science Pgm	A8 ,1X	72-80	8 chars	_
HUT Science Pgm	A8 ,1X	81-89	8 chars	_
UIT Science Pgm	A11,1X	90-101	11 chars	_
GI Science Pgm	A8 ,1X	102-110	8 chars	_
Comments	A22	111-132	22 chars	_

Note 1: Flags are set to "1" to make them active and "0" to make them inactive.

Note 2: Setting the solar system flag really indicates that the moving target software is to be used. For Astro-2, coordinates will be updated in real-time replanning as needed, and so this flag should always be "0".

Note 3: For Astro-2, proper motion corrections are to be made manually and the coordinates should already be corrected for proper motion. Hence, proper motion flags should all be set to "0".

An example of the PTL file format is to be found in Appendix A.

Ancillary files:

PTLCOORD.DAT (contains references for coordinates)
ASCII text file:
Reference
I3,1X,A128

An Example of PTLCOORD.DAT is to be found in Appendix A.

PTLCOM.DAT (contains additional comments)
ASCII text file:
Comment
I3,1X,A128

PTLSCIPROG.DAT (contains relationship between science program numbers in PTL and actual program names)
ASCII text file:
Comment
A3,5X,A70

3.3.3 Pre-Mission Target List (PMTL)

The PMTL file is a tool used to get from a PTL to a Mission Target List, or MTL (which is a mission-specific [or launch-specific] target listing-- see next section). The following is the procedure for the construction of the Mission Target List (MTL) from the Program Target List (PTL).

1. ASTRO FILE MANAGER
   Run MOVE on Solar System and Proper Motion Objects
   (if any are designated for this action)
   Run VIS on PTL
   (which creates a Pre-MTL file from the PTL blank columns for flags for each instrument and can automatically delete Zero Visibility Objects)
   Circulate file to PI team Planning Representatives

PMTL File Format:

ASCII data, field delimiter=space

Contents	Format	Bytes	Comments	Unspecified Value
Resp Instrument	A1,1X	01-02	H,U,W,J	-
Type (PI,GI,Cal)	A1,1X	03-04	P,G,C	-
Observation ID	I4,A1,I1,1X	05-11	xxxx-y	9999-9
Name1	A8,1X	12-20	8 chars	-
Name2	A8,1X	21-29	8 chars	-
RA (1950)	I2,1X,I2,1X, F6.3,1X	30-42	hh mm ss.sss	99 99 99.999
Dec (1950)	A1,I2,1XI2, 1XF5.2,1X	43-55	sdd mm ss.ss	+99 99 99.99
Solar sys flag	1,1X	56-57	1 if moving tgt	9
Day visibility	I5,1X	58-63	seconds	-999
Night visibility	I5,1X	64-69	seconds	-999
WUPPE Sci Plan	A3,1X	70-73	W00 is not reserved	
HUT Sci Plan	A3,1X	74-77	H00 is not reserved	
UIT Sci Plan	A3,1X	78-81	U00 is not reserved	

GI Sci Plan	A3,1X	82-85	Open to W00,H00,U00
WUP roll flag	I1,1X	86-87	0=none,1=abs, 2=+/-180,3=modulo 90
WUP Offset flag	I1,1X	88-89	1 if coords yet to be finalized
WUP Time flag	I1,1X	90-91	1 if GMT requirement
WUP Constraint	I1,1X	92-93	0=no constraint 1=night,2=day,3=SAA OK, 4=day->night,5=night->day 6-9=TBD
WUP Priority	I1,1X	94-95	1=highest,3=lowest
WUP Req. Time	I5,1X	96-101	seconds
HUT roll flag	I1,1X	102-103	as above
HUT Offset flag	I1,1X	104-105	as above
HUT Time flag	I1,1X	106-107	1 if GMT requirement
HUT Constraint	I1,1X	108-109	as above
HUT Priority	I1,1X	110-111	1=highest,3=lowest
HUT Req. Time	I5,1X	112-117	seconds
UIT roll flag	I1,1X	118-119	as above
UIT Offset flag	I1,1X	119-120	as above
UIT Time flag	I1,1X	121-122	1 if GMT requirement
UIT Constraint	I1,1X	123-124	as above
UIT Priority	I1,1X	125-126	1=highest,3=lowest
UIT Req. Time	I5,1X	127-132	seconds

An example of the PMTL file format is to be found in Appendix A.

2. INDIVIDUAL INSTRUMENT TEAMS
   Combine Pre-MTL with Instrument specific PTL info.
   Make initial selection of Constraint, Priority & Requested Time.
   Fill in new values of R, O, and T flags as needed.
   Return to FLM by designated time.

3. FILE MANAGER
   Concatenate team PMTLs into single PMTL file ordered by object ID.
   Make initial listing of potential overlap targets.
   Circulate overlap list to teams.

4. INSTRUMENT TEAMS
   Review overlaps and arrange collaborations, negotiating changed priorities and allocating the amount of exposure to be "charged" to each instrument.
   Fill in instrument specific data (flags) for objects chosen by other teams (e.g. HUT roll on a UIT galaxy).
   Return information to FLM by designated time.

5. FILE MANAGER
   Incorporate overlap information into PMTL.
   Run program to convert PMTL into MTL format.
   Send draft MTL to teams for review.

6. INSTRUMENT TEAMS
Return any final corrections to FLM.

7. INVESTIGATOR WORKING GROUP
Review and approve MTL.

8. PROCEED WITH SCIENCE PLAN GENERATION

3.3.4 Mission Target List (MTL)

The MTL file contains information on all potential targets to be scheduled for a given launch assumption. The requested times and priorities are folded in with target visibility information to construct a desired timeline of science observations. Note that if mission-specific roll angles, coordinate offsets from the PTL, etc., are needed, they need to get into the MTL and its associated files for proper tracking.

MTL file format:

ASCII data, field delimiter = space:

Contents	Format	Bytes	Comments	Unspecified Value
Resp Instrument	A1,1X	01-02	H,U,W,J	-
Type (PI,GI,Cal)	A1,1X	03-04	P,G,C	-
Sci. Prog. No.	A3,1X	05-08	3-digit ASCII code	-
Obs ID	I4,A1,I1,1X	09-15	xxxx-y (xxxx from PTL; y = roll, offset or pri)	9999-9
Name_1	A8,1X	16-24	8 chars	_
Name_2	A8,1X	25-33	8 chars	_
RA(1950)	I2,1X,I2,1X, F6.3,1X	34-46	hh mm ss.sss	99 99 99.999
DEC(1950)	A1,I2,1X,I2, 1X,F5.2,1X	47-59	sdd mm ss.ss	+99 99 99.99
Coord Source	I3,1X	60-63	xxx	999
Coord Accuracy	F5.2,1X	64-69	ss.ss	99.99
Roll request	F6.2,1X	70-76	ddd.dd (deg)	999.99 [Note 2]
Roll flag	I1,1X	77-78	0=none,1=abs, 2=+/-180,3=mod	9 90
Offset flag	I1,1X	79-80	1 if coords yet to be finalized	9
Time flag	I1,1X	81-82	1 if GMT req	9
Solar Sys flag	I1,1X	83-84	1 if moving tgt	9
Constraint	I1,1X	85-86	0=no constraint 1=night, 2=day, 3=SAA ok, 4=day->night, 5=night->day	9
Joint Priority	I1,1X	87-88	1=highest, 3=lowest	9 [Note 1]
Requested time	I5,1X	89-94	seconds	-9999
Comments	A38	95-132	[Note 2]	_

An example of the MTL file format is to be found in Appendix A.

Note 1: To provide flexibility in case of launch slips, targets that may become available can be placed in the MTL with a priority of 4.

Note 2: See section 3.3.4.1 for a full explanation of Roll Angle protocol and format for Comments.

Ancillary files:

MTLCOORD.DAT (contains actual references for coordinates).
NOTE: MTLCOORD.DAT is essentially the same as PTLCOORD.DAT, except that it may contain additional mission-specific references with regards to coordinate updates.
ASCII text file:
Reference
3,1X,A128

MTLCOM.DAT (contains comments longer than 45 characters).
ASCII text file:
Comment
I3,1X,A128

3.3.4.1 Roll Angle Protocol

It is sometimes desirable for science or calibration purposes to request a specific roll angle for an observation. In these cases, the value of the desired roll angle (in degrees eastward from north) is listed in the MTL file and the appropriate Roll flag is set. (This information gets carried forward into the SCIPLAN file from the MTL.) In the current planning flow, we reserve time after the initial SCIPLAN is produced to allow any roll angles (and coordinates) to be updated before the SCIPLAN is finalized. Any updates made at that time should be made both in the MTL and in the SCIPLAN file. These files MUST be kept consistent.

To permit the greatest flexibility in choosing IPS objective loads, it is also important to specify a "tolerance" on the requested roll angles. This is done by placing an appropriate comment in the rightmost field of the MTL file, using the following format: RT=N (where N is the acceptable angular tolerance on the requested roll angle in degrees [plus or minus] from the specified value). If no tolerance is given, the tolerance will default to +/-1 degree. The RT comment should be the FIRST comment listed; since other comments are informational only, the roll comment should take precedence over any existing comments (if space is a concern).

Roll angles are most often requested by HUT or WUPPE to place the long dimensions of their apertures in a certain orientation on the sky. In most of these cases, the absolute angle is not important, and the requested roll can be changed by +/-180 degrees (roll flag=2). If there is a case where an exact roll angle is required as specified, the roll flag will be set to 1. In certain instances, WUPPE needs to request angles "modulo 90 degrees", in which case the roll flag is set to 3. In general, UIT does not request roll angles (except at the specific request of HUT or WUPPE), although they desire, whenever possible, to have the same roll angle on multiple visits to the same target.

3.3.5 Science Plan (SCIPLAN)

The SCIPLAN is one of the main deliveries from the science teams to the MSFC planners. It specifies the desired (nominal) coordinates, roll angles, and sequence of science observations for a given launch assumption. After delivery to MSFC, subsequent versions of the SCIPLAN file provide the science teams with their best estimate of "reality" as to what is actually scheduled for their science observations. (That is, as the MSFC planners do their work, and sometimes modify the original file, returned versions of the SCIPLAN file can be used to tell us where the actual observation plan stands at any given time.)

SCIPLAN file format:

ASCII data, field delimiter = space:

Contents	Format	Bytes	Comments	Unspecified Value
Resp Instrument	A1,1X	01-02	H,U,W,J	_
Type(PI,GI,Cal)	A1,1X	03-04	P,G,C	_
Sci. Prog. No.	A3,1X	05-08	3-digit ASCII code	_
Obs ID	I4,A1,I2,1X	09-16	xxxx-yz (xxxx from PTL; y=roll, offset, or pri;z=revisit)	9999-99
Name_1	A8,1X	17-25	8 chars	_
Name_2	A8,1X	26-34	8 chars	_
RA(1950)	I2,1X,I2,1X, F6.3,1X	35-47	hh mm ss.sss	99 99 99.999
DEC(1950)	A1,I2,1X,I2, 1X,F5.2,1X	48-60	sdd mm ss.ss	+99 99 99.99
Coord Source	I3,1X	61-64	xxx(OBJ# if 98xx target)	999
Coord Accuracy	F5.2,1X	65-70	ss.ss	99.99
Roll request	F6.2,1X	71-77	ddd.dd (degrees)	999.99 [Note 1]
Roll flag	I1,1X	78-79	0=none,1=abs, 2=+/180, 3=modulo 90	9
Offset flag	I1,1X	80-81	1 if coordinates yet to be finalized	9
Time flag	I1,1X	82-83	1 if GMT requirement	9
Solar Sys flag	I1,1X	84-85	1 if moving target	9
Constraint	I1,1X	86-87	0=no constr, 1=all night, 2 = all day, 3= >1% SAA ok, 4 = day->night, 5=night->day	9
Joint Priority	I1,1X	88-89	1=highest, 3=lowest	9
Requested time	I5,1X	90-96	seconds	-9999
Scheduled time	I5,1X	97-102	seconds	-9999

MET start time	F8.4,1X	103-111	Decimal hours	0.0000
MET stop time	F8.4,1X	112-120	Decimal hours	0.0000
Comments	A11	121-132	[Note 1]	_

An example of the SCIPLAN file format is to be found in Appendix A.

Note 1: For Roll angle protocol, refer to section 3.3.4.1.

3.3.6 HUT Sequence File (HSF) Format

The HUT team maintains a large database file system, with one ASCII file for each potential observation. However, while these files are used for internal team planning purposes, they are not useful for general mission planning activities.

What is useful are the ASCII versions of the MMU load files, which we will call the HUT Sequence Files. These are generated by the HUT program "BUILDSEQ", and are the files transferred to the FLM for the production of the JOTP book. In order to be used in the JOTP software, the file must have the following characteristics: the data must be left-justified in the file; the data must have format I5, except for the target name, which is A20; the file must use tabs as field-delimiters. These files contain everything needed except the Target Procedure names, which come from the SEQNUM file. An example HSF is given below, with explanatory notes at the right. More information about these files is available in the document, "Building Sequence Files for the Hopkins Ultraviolet Telescope," which is available from the HUT team.

Example HUT Sequence File (MMU Load):

70	Sequence number	(4 < n < 512)
CYGLOOPB	Target name	(up to 20 characters)
835	Guide star 1 dZ	(tenths of arcsec)
-156	Guide star 1 dY	
-1665	Guide star 2 dZ	
969	Guide star 2 dY	
-780	Guide star 3 dZ	
-787	Guide star 3 dY	
0	Observation Type	(note 2)
5	Door configuration	(note 3)
2	Locate mode	(note 4)
1	Filter	(note 5)
13	Target magnitude	(-6 < m < 21)
12	Guide star magnitude	(-6 < m < 21)
7354	Planned time	(between 0 and 32767 sec)
7354	Primary observation interval	(0 to 32767 sec)
4	Primary SP mode	(note 6)
0	Primary SP mask	(note 7)
6	Primary slit	(note 8)
0	Secondary observation interval	(0 to 32767 sec)
1	Secondary SP mode	(note 6)
0	Secondary SP mask	(note 7)

2	Secondary slit	(note 8)
0	Initial position interval	(0 to 32767 sec)
5250	Initial expected rate	(0 to 32767 cts/10sec)
0	Offset 1 interval	(0 to 32767 sec)
0	Offset 1 dZ	(tenths of arcsec)
0	Offset 1 dY	(tenths of arcsec)
0	Offset 1 expected rate	(0 to 32767 cts/10sec)
0	Offset 2 interval	(0 to 32767 sec; 0 quit)
0	Offset 2 dZ from 1	(tenths of arcsec)
0	Offset 2 dY from 1	(tenths of arcsec)
0	Offset 2 expected rate	(0 to 32767 cts/10sec)
0	Offset 3 interval	(0 to 32767 sec; 0 quit)
0	Offset 3 dZ from 2	(tenths of arcsec)
0	Offset 3 dY form 2	(tenths of arcsec)
0	Offset 3 expected rate	(0 to 32767 cts/10sec)
0	Mirror step interval	(0 to 32767 sec)
0	Mirror step dZ	(tenths of arcsec)
0	Mirror step dY	(tenths of arcsec)
0	Mirror step Z count	(0 to 32767)
0	Mirror step Y count	(0 to 32767)

3.3.7 WUPPE Sequence File (WSF) Format

This file is produced by WUPPE for internal use and is also used by the FLM in the production of the JOTP Book. In order to be used by the JOTP software, it must use tabs as field-delimiters. The format is shown below.

WUPPE Sequence File Parameters:

Database Parameter	Function	Flt Display
num	Sequence number	Sequence Number = num
pseq	Identifier = ID.n	(Not used, ID is JOTF ID)
name	Astronomical name	Obj Name = name
comment		(Not used)
time	Planned time (secs)	PL MIN = time / 60
spc	Spectrometer mag	SPC MAG= spc
cam	Camera mag	TV MAG = cam
aper	Observe aperture	APERTURE= aper
filt	Filter	FILTER = filt
sig	Planned log rate	PL LOG-R = sig
pol	Expected pol (%)	PL LOG-POL = log(pol)
		flags (if listed)
nloc	Skip Locate	NOLC = *
fld	Locate in field	FLD = *
cur	Use cursor in locate	CURS = *
nocn	No centroid in locate	NOCN = *
pic	Do DFLD in locate	PIC = *
nogd	No guide in observe	NOGD = *
off	Offset guide in obs	OFFS = *

emline	Scale, Rate from max	(Not reported)	
roll	JOTF roll (deg)	(Not used)	
chain	Next sequence num		
locr	RA loc offset (arcsec)	OFFS LOC Y =	- locr cos(roll) - locd sin(roll)
locd	Dec loc offset(arcsec)	OFFS LOC P =	+ locd cos(roll) - locr sin(roll)
obsr	RA obs offset (arcsec)	OFFS OBS Y =	- obsr cos(roll) - obsd sin(roll)
obsd	Dec obs offset(arcsec)	OFFS OBS P =	+ obsd cos(roll) - obsr sin(roll)

Example of WSF:

num	139
pseq	4301.10.1
name	NGC1976
comment	Orion HII region
time	420
spc	10
cam	5
aper	7
filt	4
sig	3.1
pol	1
flags	cur,nogd,fld,pic
locr	-90.
locd	90.
obsr	-90.
obsd	300.
roll	95.0
chain	321

3.3.8 UIT Sequence File (USF) Format

The UIT sequence file is produced for internal use and is also used by the FLM in production of the JOTP Book. In order to be used by the JOTP software, the format below must be followed.

Format	Content
A5	Sequence No.
A3	Filter No.
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
A3	Filter No.
F8.3	Exposure Time

F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
A3	Filter No.
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
A3	Filter No.
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
A3	Filter No.
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
F8.3	Exposure Time
I3	No. of frames, Camera A
I3	No. of frames, Camera B
I3	Total number of exposures
A30	Comments

Comments:

Sequence Numbers less than 100 are in our UV EPROMs and won't be part of the MMU load.
998 and 999 are no-operation exposure sequences with the door open and closed respectively.

Example of USF:

```
102  a2     5.000  25.000  1.000    0.000a5     5.000  25.000
1.000
0.000b3     5.000  25.000   1.000    0.000b5     5.000  25.000
1.000
0.000       0.000  0.000   0.000    0.000  7  7 12   0.0
```
Intermediate-band continuum

Example formatted to show all data:

seq	102
filt1	a2
t1a	5.000
t1b	25.000
t1c	1.000
t1d	0.
filt2	a5
t2a	5.000
t2b	25.000
t2c	1.000
t2d	0.

filt3	b3
t3a	5.000
t3b	25.000
t3c	1.000
t3d	0.
filt4	b5
t4a	5.000
t4b	25.000
t4c	1.000
t4d	0.
filt5	
t5a	0.
t5b	0.
t5c	0.
t5d	0.
afrms	7
bfrms	7
totexp	12
num	0.
comments	Intermediate-band continuum

3.3.9 Target Procedures (TPs)

Target procedures are individual files which provide step-by-step instructions for the crew on-orbit. They are used as input files to the Joint Operations Target Procedures (JOTP) Book, and up to two TPs from each science team can be used per target, in addition to a nominal TP. This totals a maximum of seven TPs which the JOTP software must merge, and proper formatting is vital.

TP file format:

ASCII data, field delimiter = tab
ABSOLUTELY NO SPACES PERMITTED BETWEEN FIELDS!

Contents	Format	Comments
Step number	F6.4	Must have all six digits. If less than six, add leading or trailing zeros as appropriate.
Alt	A1	* = insert or replace nominal step; % = delete nominal step.
DSP	A3	3-letter DDU display mnemonic
Command	A25	Procedure step. 25-character hard limit. If there is a left parenthesis, there must be a right (close) parenthesis ON THE SAME LINE; else use brackets. (This is for post-script formatting.)

Descriptions and examples of science team TPs are in subsections following.

3.3.9.1 HUT Target Procedures

HUT Target Procedures (TPs; for historical reasons also sometimes called ALTs) are special instructions needed to modify the normal set up or observing procedure followed by default for most observations. These procedures are needed for handling contingencies that might occur (e.g. a cataclysmic variable star that may be found in its high state), for instrument safety (e.g. door state changes due to unanticipated count rates), or calibration activities. Also, if predicted count rates are close to the maximum allowed for a given SP mode, TPs are available to have the operators change the SP mode to what it should be based on the actual count rate obtained. Likewise, acquisition procedures might have to be changed on selected targets for a variety of reasons. Finally, only two TPs can be specified for each observation, but occasionally more than two TPs are needed. This has been handled by creating some TPs that are really just combinations of two others. Because of the numerous potential reasons for needing target procedures, including individual target specific reasons, it is likely that a few new TPs will be needed after the final SCIPLAN is in place.

Below we provide text descriptions of a few sample TPs, along with the TPs as currently written and used in the Astro-2 Basic timeline and JOTP book. More detailed information on HUT TPs can be found in Appendix C of the document "Building Sequence Files for the Hopkins Ultraviolet Telescope," which is available from the HUT team.

C_LR5.TP

Used when setting up at door state 3 or 4 (2550 cm**2), but predicted rate is just a bit over 2500/sec.

If observed rate is < 5000/2s, tells PS to open to door state 5 (full aperture). This one magnitude change does not require special camera precautions.

Number	alt	dsp	command
08.161	*	JOB	*IF HUT Rate < 5000/2s
08.162	*	HOP	* ITEM 42_5 (door 5)

SMALAP.TP

Used whenever an observation is in door state 2 (50 cm**2).

Because of possible pressure buildup in the telescope, leaves VIP on and detector off until the observing slit is in place. (Rotation of slit wheel allows high pressure in telescope to get into spectrograph.) Also protects TV camera at the end of the observation by putting the ND6 filter in place before QUIT, so that the doors do not open to the SLEW configuration with the camera set for the small aperture.

Also, to save time at the SETUP, moves the small aperture mechanism to the 50 cm**2 position during preceding SLEW. Then, when SETUP is commanded, large doors close, and small aperture is already in position for the observation.

Number	alt	dsp	command
01.000	*	JAC	VIP ON until at obs slit
01.101	*	HDC	ITEM 64_2 (smalap to 50)
05.000	*	JAC	Chk Stat - -LOC RDY
05.101	*	TV	Verify HUT acq on TV
08.101	*	JOB	When HUT aperture = 7
08.102	*	JAC	ITEM 16_0
10.701	*	HDC	(just prior to QUIT)
10.702	*	HDC	ITEM 61_0 (ND6 filt)
10.703	*	HDC	Check 61_0_0
10.704	*	JAC	ITEM 16_1
13.000	%		

SS-CYG.TP

Used for observations of SS-CYG (3227).

Magnitude of target is quite uncertain (could be outburst). If source is bright, PS will want to preview an alternate sequence which sets up for a lower door state. Because that lower door state is 50 cm**2, first get pump back on, as in normal small aperture observations. Then go to alternate target section of JOTP Book, where pages have been prepared for CV contingency observations. Manually edit sequence number, re-preview and re-setup and go as per alternate procedures on that page.

Number	alt	dsp	command
04.701	*	TV	*IF src is very bright
04.702	*	JAC	* ITEM 16_1
04.703	*	JAC	* Go to alternate target
04.704	*	JAC	* edit HUT WUPPE seq num

3.3.9.2 UIT Target Procedures

There are three major groups of UIT Target Procedures: ones which protect UIT during pointings at target which are too bright for it to observe (V-BRT and V-BRT2); ones for special calibration operations (CALSQ1, CALSQ2, and CALSQ3): and ones which are workarounds for a limitation of UIT-- it can handle a maximum planned time for an exposure sequence of 2184 sec (LTSTRT, TWONUL, TWO164 and its ilk, and THREE and FOUR). Two of the most common kinds of procedures, V-BRT and TWO164, are described and listed here.

V-BRT is arguably the most important UIT Target Procedure because it will kill UIT if not implemented properly. Many WUPPE scientific targets, and some HUT ones, are bright enough to damage UIT if it points at them even when UIT is turned off! So, UIT's door must be closed during the slew before arriving at the target, and opened only after the slew away begins. V-BRT is always used with exposure sequence 99, which is not in UIT's sequence load. This gives the PS the added warning of an error message reporting an 'invalid exposure sequence', which should remind the PS to check the door.

V-BRT.TP

Number	alt	dsp	command
00.301	*		(At beginning of slew)
00.302	*	UAC	*IF UIT Door O*
00.303	*		*ITEM 44, Chk Door C*
00.304	*		Expect UIT SET, OBS err
05.000	*	JAC	Chk Stat -LOC -LOC STB
13.901	*		(During slew)
13.902	*	UAC	*IF next obj not V-BRT
13.903	*		*ITEM 43, Chk Door O*

TWOxxx (e.g. TWONUL or TWO213) are schemes which cause UIT to divide a pointing that is longer than 2184 seconds into _two_ (get it?) exposure sequences. In these, the PS is to manually enter a time remaining of 2180 sec (step 8.601). UIT will then make pictures for 2180 seconds and go to standby mode (STB). When that happens, we may choose to do nothing (TWONUL), or to do one of several other exposure sequences (164, 178, 179, or 211 through 219, done by selecting TWO164, TWO178, TWO179, or TWO211 through TWO219, respectively, in the remaining time. There are three significant alterations of standard procedure: the first sequence must have 2180 seconds manually entered; then, after UIT goes to standby, an item 90 is needed to set up the desired sequence; and, immediately afterward, 'SETUP' and 'BEGIN' commands are entered to execute the second desired sequence using the time remaining (which need not be manually entered). Step 9.301, 'NO PREVW before UIT Begin' cryptically reminds the PS not to 'preview' the setup and sequence for the following target until UIT has started its second sequence. If that happened, UIT would be set up for the wrong (i.e. next target's) sequence.

TWO164.TP

Number	alt	dsp	command
07.901	*	JAC	config without UIT
08.601	*	UOB	UIT ITEM 7_2180
09.301	*	JOB	NO PREVW before UIT Begin
09.602	*	JOB	When UIT stat=STB
09.603	*	UOB	UIT ITEM 90_164 (nxsq=164)
09.604	*	JOB	UIT SETUP
09.605	*	JOB	UIT BEGIN
09.606	*	JOB	config with UIT

3.3.9.3 WUPPE Target Procedures

The named WUPPE Target Procedures (formerly called ALTs) alert the crew as well as the POCC OPS personnel to situations in which the sequences planned for a particular target deviate from a simple, automatic acquisition and observation. Most do deviate. Mission planners and the WUPPE replan position during the mission also need to be sensitive to the possible operational impacts of the need for special procedures.

The primary form which WUPPE TPs take in practice is seen in the various " MANOPS flags" which are either turned on or off individually to create a specialized procedure. The flags appear on the WED page (WED = WUPPE Edit, a standard Spacelab Experiment Computer (EC)display page) . They are preset in the WUPPE starlist loaded into DEP PROM (Dedicated Experiment Processor Programmable Read Only Memory) prelaunch. They may also be modified wholesale during flight by the load command CMD LOD DWUP01. The file DWUP01 is read from the MMU. It may either be a prelaunch version which may or may not differ from the one present in PROM at launch or it may have been uplinked at some time during the mission. The flags may also be toggled individually via item entries 40 through 46 on the WED page. Either the wholesale load or individual edits on WED may be performed either by the crew or by ground commanding. The flags are as follows:

NOLC	No Locate	Skip the normal locate step
FLD	Field	Start the locate step in ZOD mode "field"
CURS	Cursor	Start the locate step with cursor on
NOCN	No Centroid	User cursor position not star centroid
PIC	Picture	Down line grey scale field picture at start
NOGD	No Guide	Do not centroid during observation
OFFS	Off Set	Centroid on locate object during observe

The number of possible combinations of these flags is clearly very large, but not all possible combinations make sense. A few examples of those that do follows:

Examples of WUPPE TPs

WUPPE TP	flags set (for first sequence	MANOPS flag	Comments
APCHK	nogd,cur	1	NGC7023, Pleiades
BRIGHT	nloc	1	Very bright target: Safe ZOD
FLDLOC	cur,fld	1	Crowded field locate
FNTLOC	cur,nogd,nocn	0	Locate on faint star (e.g. class 8 objs)
HIILOC	cur,nogd,nocn	0	Locate on HII region
HOMUN	cur,nogd	1	Eta Car H
HOMUN2	cur,nogd	1	Eta Car H Lyot calibration
JFA	cur,fld	1	Joint Focus/Alignment
NOLOC	nloc,nogd,nocn	0	Do not locate on target (e.g. class 5 & 9 objs)
NUCLOC	cur,nogd,nocn	0	Locate on nucleus of galaxy (e.g. class 6 & 7 objs)

3.3.10 SEQNUM File

The SEQNUM file is a list of pointers to entries in the sequence files, one pointer for each object.

The SEQNUM file provides a cross reference for the sequence numbers from all three instruments, the names of any target procedures that will be required (including IMCS), and whether any manual operations will be needed for each planned observation. "Manual Ops" means when the PS expects to use the cursor to specify HUT or WUP mirror offsets (i.e. while the other instruments are operating normally). This mode is used very infrequently. A "Track" flag indicates the tracking software is required to observe this object. The UIT dt parameter indicates the UIT Early Quit Time. The Add/Update flag denotes whether the target sequence data has been modified and how.

The FLM will send out a time-ordered list of JOTFIDs in the SEQNUM file format (a template) and request inputs to the SEQNUM file from the science teams by a given deadline after the SCIPLAN. The science teams will fill in the appropriate fields in the template and return it. The FLM will then concatenate the responses into one file. This is the actual SEQNUM file.

As noted above, the SEQNUM file should be in time order.

SEQNUM File Format:

ASCII data, field delimiter=space

Contents	Format	Bytes	Comments	Unspecified Value
Blank	1X	01	blank	
Obs ID	I4,A1,I2,1X	02-09	xxxx-yz	-999-99
Name_1	A8,1X	10-18	8 chars,from PTL	_
HUT Seq No.	I3,1X	19-22	xxx	-99
WUP Seq No.	I3,1X	23-26	xxx	-99
UIT Seq No.	I3,1X	27-30	xxx	-99
Manual Ops	I1,1X	31-32	=1 if man ops, req'd else 0	9
Track	I1,1X	33-34	=1 if track s/w, req'd else 0	9
UIT dt	I3,1X	35-38	xxx (secs) delta quit time	-99
HUT TP 1	A6,1X	39-45	xxxxxx	_
HUT TP 2	A6,1X	46-52	xxxxxx	_
WUP TP 1	A6,1X	53-59	xxxxxx	_
WUP TP 2	A6,1X	60-66	xxxxxx	_
UIT TP	A6,1X	67-73	xxxxxx	_
IMC TP	A6,1X	74-80	xxxxxx	_
Add/Update Flag	A1	81	A or U	blank

An example of SEQNUM is to be found in Appendix A.

3.3.11 OBJSUM File

The OBJSUM file is an ASCII listing of all the IPS objective loads. It contains activation loads (IPS testing), IDIN objective loads, and all scheduled (SCIPLAN) target loads. These are the loads that are called out in the PCAP and in the IPOL List file and that are loaded on board. The maximum number of loads the MMU can hold is 999. The OBJSUM file, created by the Orbit, is generated pre-mission and any changes or additions that need to be made are included in each 12 hour replan shift.

OBJSUM File Format:

ASCII Data, field delimiter = space

Contents	Format	Bytes	Comments
Obj No.	1X,I3,1X	01-05	Objective Load Number
Type	A4,2X	06-11	IPS Mode
EXP No.	I1,1X	12-13	Experiment Number
D	A8,1X	14-22	wwww-xyz
Target Name	A8,1X	23-31	8 chars
RA (1950)	F8.4,1X	32-40	ddd.dddd (degrees)
DEC (1950)	F8.4,1X	41-49	sdd.dddd (degrees)
POS Angle	F8.3,3X	50-60	ddd.ddd (degrees)
OBJ Roll	F8.3,3X	61-71	sdd.ddd (degrees)
B	I1,2X	72-74	Number of boresight guide stars
R	I1,2X	75-77	Number of right tracker guide stars
L	I1,2X	78-80	Number of left tracker guide stars

An example of OBJSUM is found in Appendix A.

3.3.12 Joint Observation Target File (JOTF)

The ASCII JOTF file is a representation of the MMU JOTF file which goes on board. This file lists each observation chronologically (by GMT) and any associated instrument sequences from the SEQNUM file. It also contains moving target information if necessary. The JOTF file, created by the Orbit, is loaded on board pre-mission and is updated for every 12 hour replan shift.

JOTF.LIS file format:

ASCII data, field delimiter = space

Contents	Format	Bytes	Comments
Target	1X,A7,1X	01-09	xxxx-yz
Name	A8,1X	10-18	8 chars
RA Start	F8.4,1X	19-27	ddd.dddd (degrees)
Dec Start	F8.4,1X	28-36	sdd.dddd (degrees)
Roll	F7.2,1X	37-44	ddd.dd (degrees)
Planned Obs	I5,1X	45-50	seconds
Target Constraint	I3,1X	51-54	0=no constraint 1=night, 2=day, 3=SAA, 4=day->night, 5=night->day
HUT Seq No.	I3,2X	55-59	xxx
WUP Seq No.	I3,2X	60-64	xxx
UIT Seq No.	I3,2X	65-69	xxx
Delta	I3,1X	70-73	seconds
Stat Word	I1,I1,1X	74-76	1=Manual OPS, 1=Target Track
Dist Start	F5.2,1X	77-82	AU
Start Time	I3,'/',A8,1X	83-95	dd/hh:mm:ss

RA Stop	F7.2,1X	96-103	decimal degrees
Dec Stop	F7.2,1X	104-111	decimal degrees
Dist Stop	F7.2,1X	112-119	AU
Stop Time	I3,'/',A8	120-131	dd/hh:mm:ss

An example of a JOTF.LIS file is found in Appendix A.

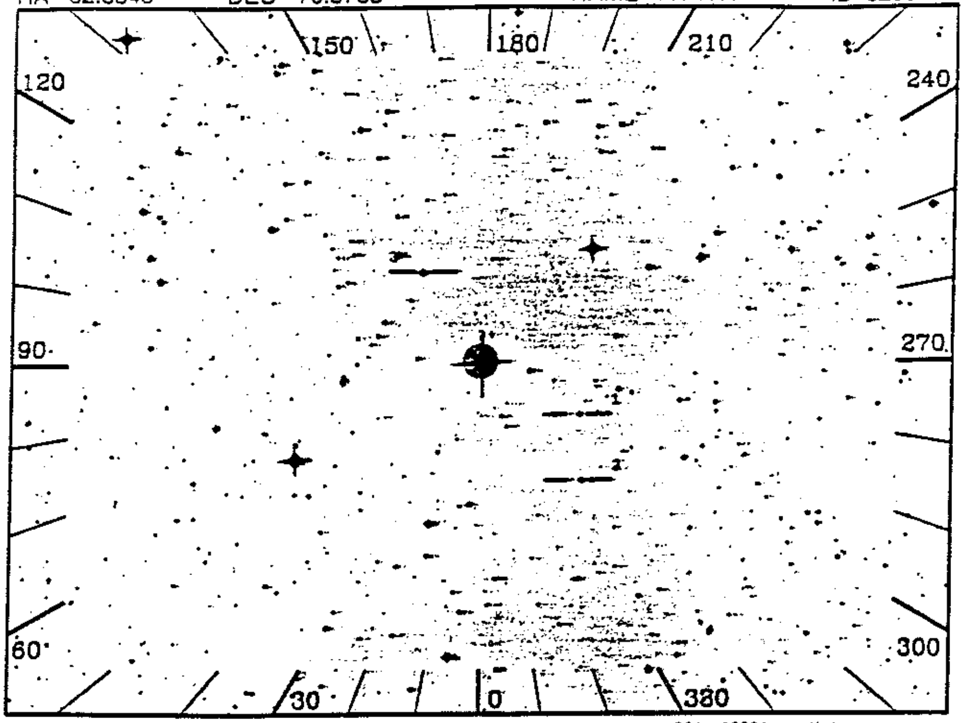
3.3.13 Target Book Interface

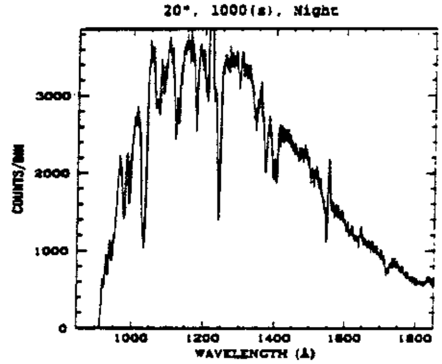
For Astro-2, a separate Target Book and Joint Operations Target Procedures (JOTP) book replace what was called the "Target Book" during Astro-1. The Astro-2 Target Book is intended by-and-large NOT to contain information that is "pointing specific", but rather "target specific." (This is not entirely true, for reasons that are given below.) Hence, there is no reason to show multiple Target Book pages for an MTL entry with multiple pointings unless some basic parameter (like roll angle or choice of guide stars) has also changed.

The method of generating the Target Book is also much different for Astro-2, taking advantage of both new technology and the availability of digitized all-sky data available from the Space Telescope Science Institute. The procedure is spear-headed by HUT team members because of their proximity to STScI and their need to obtain detailed guide star information for use by HUT in planning sequence files. For each target of interest (basically the MTL file), HUT requests digitized data for a field surrounding each target from the STScI Guide Star personnel. These data are returned to HUT in FITS format, and then processed for use in the target book. For the Astro-2 Basic T/L, software was written to generate Target Book pages as "postscript" files, combining the digitized image data with input files from HUT and WUPPE and the guide star information from HUT database files, and generating the proper headings and page formats. These postscript files are printed on a high quality 600 dots per inch laser printer at JHU. After verification, these pages are submitted to the CPE at MSFC for incorporation into the Target Book. An example Target Book page is shown in Figure 3.3.13-1.

Because HUT guide stars are indicated on the Target Book pages, any circumstance that would cause a target to have different guide stars (either on a revisit to a target or due to target variability) need to be accommodated by the Target Book. Also, the target book may contain pages for targets that are not in the current timeline, but may be added under certain circumstances during real-time operations. It is hoped that this will eliminate the need to uplink target book pages in real-time during the mission.

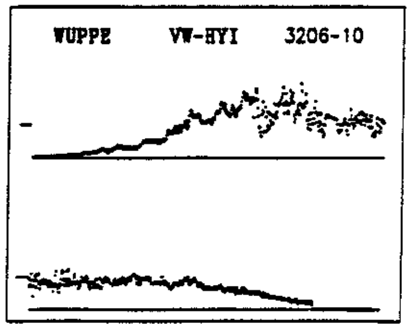
RA 62.3846 DEC -70.5753 NAME VW-HYI ID 3206-1





OBJECT: 3206 VW-HYI
KEYWORDS: Dwarf Nova, CV, outburst monitor
COMMENTS:
Dwarf Nova which undergoes irregularly spaced outbursts roughly every 20 days. Magnitude variation can be as large as V=13.4 to 8.5. (Photo shows the high state.) Object will be observed at regular intervals to monitor for outburst and track evolution of spectrum.
Alternate HUT sequences are available depending on brightness of object.

ID: 3206-10
Names: VW-HYI
Type: DN, SU UMa
% Pol: unknown
Max V mag: 8.5
Min V mag: 13.8
Ave Recurrence time: 29d
Comments: duration about 4d. HUT Prime.
If in outburst, use Halfwave sequence.
For dwarf novae in outburst, models predict a polarization of a few percent in the UV for an average inclination of 60 degrees.
The rise to maximum in the UV follows the rise in the visual.



JA-1782 3-1 TGT/ASTRO2/PRE

Figure 3.3.13-1 - Example Target Book Page

3.3.14 Joint Operations Target Procedures (JOTP) Book Interface

The Joint Operations Target Procedures Book is, as previously stated, a partial replacement of the old Astro-1 Target Book. Together, the new Target Book and JOTP Book comprise the same information as the old Astro-1 Target Book, but in a more user-friendly and less work-intensive fashion.

Unlike the Astro-2 Target Book discussed in the previous section, the JOTP book entries are pointing-specific. That is to say, a second pointing at the same target will require a new JOTP entry. It requires a number of input files from both the science teams and the PRT, and utilizes several pieces of software run by the FLM.

After the SCIPLAN is complete (see sections 2.3.1 & 3.3.5) and the orbits have determined roll angles, the FLM runs a program which utilizes the IPOL.LIS file (see section 3.3.1.6) to create a special SCIPLAN containing the desired version of the roll angle (O_Roll). Another program uses the SCIPLAN to create a template for the SEQNUM file. This template is then sent to the science teams to be fleshed out. (HUT has its own software which builds the template and fills it in.) Each team fills out the portion of the template specific to itself and returns its version to the FLM. When all four versions have been received, the FLM then runs a program called MSTRSEQNUM which splices all four versions of the SEQNUM file together into one master file. (See section 3.3.10.)

At the same time the science teams have been building the target procedures necessary for each target. (See section 3.3.9.) When they are complete, they are: 1) Emailed to the FLM, or 2) placed in a directory to which the FLM has access, the FLM is notified, and then FTP's the files into the appropriate subdirectory for each science team. (NOTE: the IMCS TPs are placed into the [ASTRO2FLM.JOTP.UIT] subdirectory, as the JOTP s/w considers them as UIT TPs.) Handled in the same way, and developing at the same time, are the sequence files. (See sections 3.3.6, 3.3.7, & 3.3.8.) Once all these files have been received, the FLM now has all the information necessary to build the JOTP pages.

Extraction software is run on each sequence file as required to strip out unnecessary data, then the main JOTP program is run on the stripped files. This produces an ASCII file which may be edited as necessary, then put through the PS program for conversion to postscript format and printed. An example JOTP page is shown in Figure 3.3.14-1. Meanwhile, the CPE has been building the framework of the JOTP Book, and, after sorting by section, the pages produced by the FLM are handed to the CPE for inclusion in the framework, and the book is published.

During realtime mission operations, it is expected that this procedure will be followed (probably each shift) if there is a necessity to change the parameters of, or add new, pointings. It is anticipated, however, that in realtime, the process would be a much-condensed one, since there would be fewer targets (shift-by-shift), and probably shorter files, per procedure run.

```
1 RA   142.5243      DEC    70.0525      ROLL    103.30      ID    2819-10
2 TIME 2773          MANOPS                                  NAME  24UMA
        SEQ  | LOC OBS  MAG   RT   D | A FM OF | A FM OF | A FM OF | TP1   TP2
3     H   76 | src sim  5  5  164 5  | 7 1 --- | - - --- | - - --- |
4 P   W  244 | aut aut  5  7 4.6     | 8 6 --- | -- - ---| -- - ---| SAA3
5     U   99 | DT    0 | NO-OP with DOOR CLOSED                      | V-BRT
 6   U        (At beginning of slew)
 7   U UAC    *IF UIT Door O*
 8   U        *ITEM 44,  Chk Door C*
 9   U        Expect UIT SET, OBS err
10     JAC    ITEM 16_0
11            Config H W U
12            ------------------------
13     JAC    All SETUP
14   U        Chk Stat -LOC -LOC STB
15            IMC BEGIN
16            HUT ITEM 5
17            All BEGIN
18   W        NOTE: DO NOT preview nxt
19   W         tgt till last WUP obs
20     JOB    Observe
21   W        Wait for time avail=0
22   W JAC    UIT QUIT
23            ------------------------
24   W        NOTE: SAA OBS-NO IPS HLD
25   W WOB    ITEM 8  (Pause)
26   W        ITEM 2  (Setup)
27   W        Chk WUP Stat -LOC
28   W        ITEM 7_t  (t=SAAout/mnvr)
29   W JOB    Observe
30   W JAC    All PREVIEW
31   W WOB    Wait for time rem obj=0
32   W JAC    All QUIT
33            ITEM 16_1(2)
34   U        (During slew)
35   U UAC    *IF next obj not V-BRT
36   U        *ITEM 43, Chk Door O*

JA-1784                        2-4                        JOTP/ASTRO-2/PPF
```

Figure 3.3.14-1 - Example JOTP Book Page - Preliminary Version

3.4 File Change Procedures

3.4.1 General Comments

The PROGRAM and BASIC/FINAL directories in the FLM account are updated according to a pre-planned baseline schedule. A new subdirectory is created every time a new launch time is defined which requires a complete re-negotiation of targets.

Each PI group makes new versions of their files and "CHANGE" files in their own directories and leaves mail to FLM. FLM verifies changes. FLM assembles a pre-baseline copy of the directory (PROGRAM.REV, version.REV) with a combined CHANGE file and new HISTORY file which is the sum of previous CHANGE files. FLM leaves mail for group; review to take TBD days.

If approved:

.REV	--> baseline
baseline	--> .OLD
.OLD	--> tape

3.4.2 Keeping Track of Changes: The 'Change' and 'History' Files

The CHANGE file is ASCII text. The first two lines of an entry in the CHANGE file gives the entry ID number, the date the change was received, who proposed the change, who executed the change, and the date the change was implemented. The next several lines (no limit) contain specific information describing the change, often taken directly from the mail message received from the group originating the change and any related comments from the other groups. The last line of an entry is a line of dashes.

Example of an entry in CHANGE.DOC:

ENTRY 6
07-22-87 HUT/BOWERS GANNAWAY-OSBORN 08-12-87

Here are some more coordinates from Chuck. Please note that reference 20 has been updated with a more complete (and published version).

- Harry

ID	Name1	Name2	RA (hhmmss.sss)	Dec (ddmmss.ss)	Acc. (sec.)	Source
2806	ALF-CENB	128621	14 35 51.63	-60 37 39.30	0.1T	18,36
3105	RW-AUR		05 04 37.7	30 20 14	3"T	19
3112	RU-LUP		15 53 24.0	-37 41 00	3"T	19
3204	EF-ERI		03 11 59.86	-22 46 47.4	1.5T	20
3211	VV-PUP		08 12 52.21	-18 54 02.3	1.5T	20
3214	AN-UMA		11 01 35.61	45 19 26.4	0.5T	21
3215	YY-DRA		11 40 48.83	71 57 58.7	0.5T	21
3217	EX-HYA		12 49 42.66	-28 58 40.6	0.5T	21
3218	UX-UMA		13 34 42.10	52 10 04.2	0.5T	21

3220	T-CRB		15	57	24.505	26	03	39.04		1
3221	V2051OPH		17	05	13.91	-25	44	38.2		20
3222	DQ-HER		18	06	05.30	45	51	01.2	0.5T	21
4121	NGC7027		21	05	09.464	42	02	02.65	0.43T	1
4123	NGC7662		23	23	29.4	42	15	36.0	1"	17
4205	R-MON		06	36	26.0	08	46	57	1"T	40
4301	NGC1976	ORION	05	32	58.9	-05	26	52.1	1"	1
5109	NGC6752		19	06	26.8	-60	03	59.5	0.60T	4
6137	NGC6822		19	42	07.1	-14	55	39.0	0.91T	4
6138	M32	NGC221	00	39	57.7	40	35	29.3	1.17T	4
6219	NGC3359		10	43	20.7	63	29	12	5"T	43
7206	NGC3077		09	59	21.5	68	58	31	4"T	43
7502	NGC404		01	06	39.3	35	27	10	4"T	45
7506	NGC4636		12	40	17.3	02	57	42	7"T	49
305	3C219		09	17	50.655	45	51	43.94		71
8307	M87	NGC4486	12	28	17.556	12	40	02.0	.055s,0.3"	80
8312	3C402		19	40	22.5	50	29	29		9
8403	MKN586	205+024	02	05	14.51	02	28	42.5		10
8408	3C110		04	14	49.18	-06	01	04.3		12
8413	TON490		10	11	05.65	25	04	11.0		13
8415	1115+080		11	15	41.5	08	02	24		10
8419	1202+281		12	02	08.9	28	10	54		14
8420	1211+143		12	11	44.8	14	19	53		14
8422	TON1530A	1222+228	12	22	56.58	22	51	49.0		31
8423	1225+317		12	25	55.9	31	45	13.0		10
8431	1411+422		14	11	50.1	44	14	13	.91T	4
8436	MKN290		15	34	45.4	58	04	00		15
8443	TON1530B	1222+228	12	22	56.5	22	51	49	0.83T	4
9303	AB2052		15	14	12	07	12	26	20"T	58

Source References:

----

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9. ApJ 144, 469, (1966).
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18. Fastie, W. (ST GTO proposal)
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21. ApJS 53, 523 (CV's) (1983).
31. ApJS 43, 57.
36. Henry, R.C.
40. ApJ 174, 401, (1972).
43. A&AS 12, 89, (1973).
45. ApJS 31, 187, (1976).
49. A&AS 3, 325, (1971).
58. ApJ 293, 94, (1985).
69. Astrofizika, Vol. 3, Feb. 1967.
71. AJ 68, 421.
80. Biretta et. al., Ap. J. 274, L27 (1983).

-------------------------end-of-entry--------------------------------

The HISTORY file is ASCII text. Like the CHANGE file, the first two lines of an entry in the HISTORY file gives the entry ID number, the date the change was received, who proposed the change, who executed the change, and the date the change was implemented. The next several lines (no limit) contain specific information describing the change, often taken directly from the mail message received from the group originating the change and any related comments from the other groups. The last line of an entry is a line of dashes. Hence, the HISTORY file resembles the CHANGE file in appearance. The HISTORY file is basically a compilation of CHANGE files; when a milestone is reached (e.g. a new version of the timeline is published), the old CHANGE file entries pertaining to the previous timeline are moved into the HISTORY file.

4.0 Real-Time Replanning

The science plan and all the associated products are intended to provide the resources necessary to accomplish the scientific programs of the Astro Observatory as conceived roughly a year prior to launch. However, a wide variety of circumstances can occur at various times which will lead to deviations from the pre-mission plan. It is thus necessary to have in place procedures and resources which will make it possible to restructure the existing mission plan and to recover as much of the scientific program as possible. Those procedures and resources are the subject of this section.

There comes a time, with the Shuttle fueled and on the pad, when there is no other option but to fix problems as they come. Weather and technical problems which delay launch by hours or days are all too familiar to veterans from Astro-1. The real-time replanning capability is designed to permit changes to the timelines to accommodate such delays, as well as other problems such as technical or hardware difficulties, missed observations, or changing science priorities.

The science plan and the many other timeline products that are developed during the final timeline cycle are intended to be the plan that is executed during the mission. However, due to a myriad of things that can happen between final timeline publication and the execution of the mission, edits, and sometimes major reworks of the timeline, may be necessary.

The nominal plan for accomplishing these inevitable changes is the 12-hour replanning cycle. The timeline is divided into roughly 12-hour segments corresponding to the work shifts of the crew on orbit. Therefore, 12 hours of timeline is replanned every 12 hours. The medium for requesting changes is the Replan Request (RR) which is written, distributed, approved and tracked in the Operations Management Information System (OMIS) which resides on a dedicated VAX computer in the MSFC POCC.

4.1 Description of Nominal Replanning Cycle

To illustrate the replanning cycle (See Figure 4.1-1, which is a graphic representation of a typical Astro replan cycle) consider a crew shift that takes place between 34 and 46 hours Mission Elapsed Time (MET). The replanning cycle for this timeslice would officially begin as much as 16 hours prior, at 18 MET, with the RR deadline. At this time, the science teams and any other positions in the POCC that require a change in the timeline should submit their RRs in OMIS. Also at this time the PAP team receives an Orbiter state vector with which they update the ephemeris prediction and related data. In addition, JSC sends a report called the SSP (Space Shuttle Program) Constraints. This document contains the latest data on propellant and other consumables as well as information on any Orbiter system malfunctions or any anticipated SSP interruptions of the science timeline. With the new ephemeris and constraints in hand the PAP team spends the next 2 hours evaluating the RRs for feasibility so that the PAP or the PRE (Payload Replanning Engineer) may report the results at the SOPG at 20 MET. Often the Orbit Analysis Engineers (OAEs) will begin to implement the RRs in the mission planning files as they are evaluated if the RRs seem straightforward and non-controversial. This saves time and is especially helpful when there are a large number of RRs for a shift. In the historically unlikely case that an RR is disapproved the OAE has only to replace the originally scheduled observation.

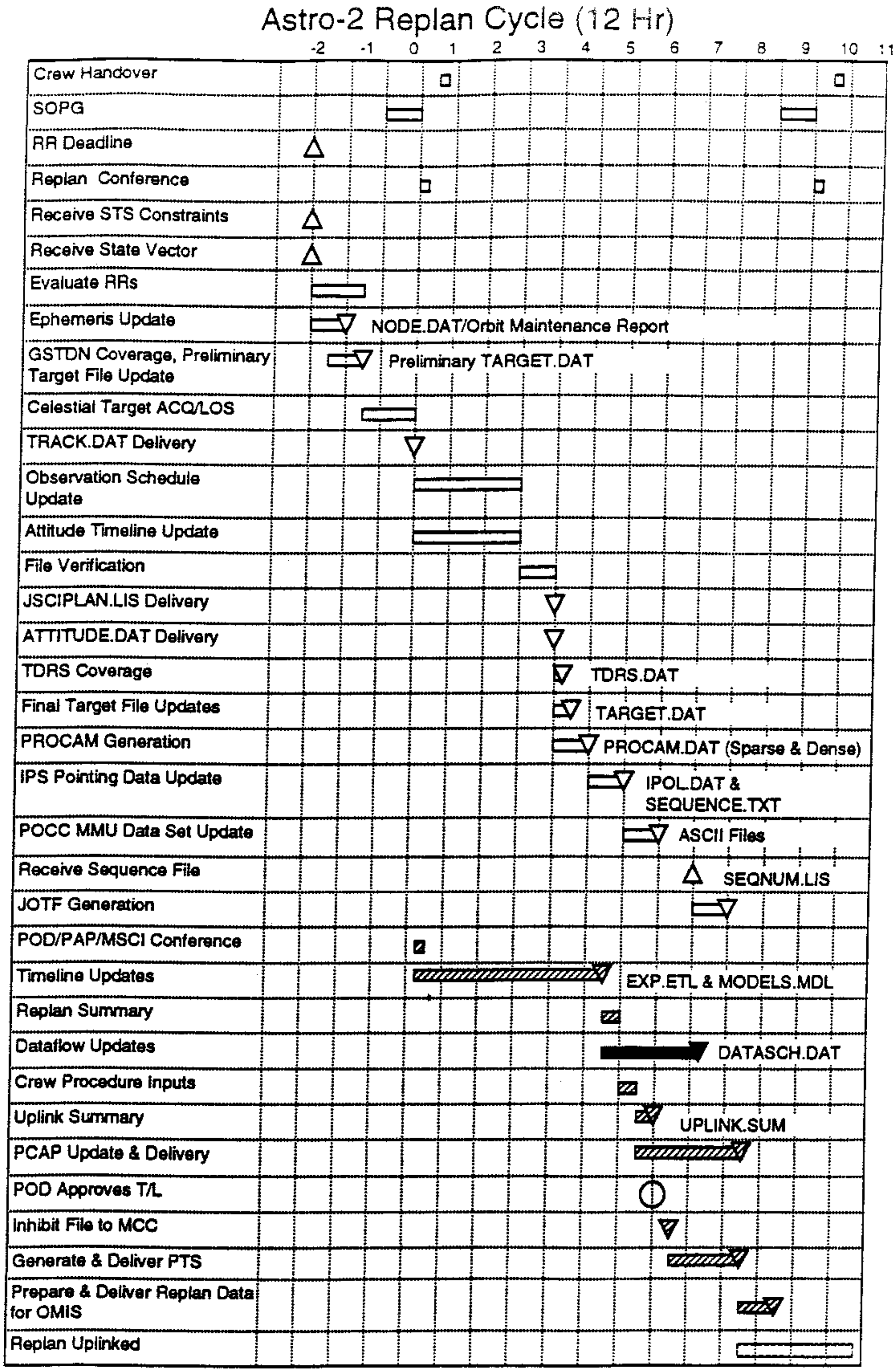

Figure 4.1-1 - Nominal Replan Cycle - Preliminary

One reason that few RRs, once submitted in OMIS, are disapproved is because the science teams conduct two RR coordination meetings in the SOA prior to submitting RRs for a shift. (These meetings are chaired in a rotating fashion by the science replanning representatives.) An SOPG-6 hr. meeting is held at which each team's representative reports his team's replanning priorities for the timeslice in question and an overall "plan of attack" is formulated. After this meeting each individual team works out the specifics of its particular target changes and arrives at a team consensus on the plan. Then, at an SOPG-2.5 hr. meeting the plans are finalized so that the RRs can be submitted by SOPG-2. Therefore, few surprises occur at the SOPG which necessitate a change to, or disapproval of, an RR.

At times during Astro-1, it was necessary for the MSCI to attend the planning meetings to assist in negotiating the replanning issues. With block scheduling, any negotiations should be minimal and the meetings should take on more of an advisory or informational nature. This is because with block scheduling, each team is more free to plan its highest priority targets into its next block, affecting (basically) its own targets. However, since two or three instruments will (hopefully) always be observing and sequence files may have to be updated, the teams still need to coordinate their activities closely.

When the SOPG is completed (21 MET) replanning begins in earnest. The OAEs incorporate the science target viewing scheme dictated in the RRs into the schedule file. New attitudes are designed if necessary and a new attitude timeline is written. The new maneuver times are put into the schedule file and a science plan is written. If preliminary TDRS coverage generated from the new attitude timeline looks sufficient to the Data Replanners (DREPs), the OAE delivers attitude, schedule, target, TDRS and SCIPLAN files to the mission interface directory on the MIPS VAX computer. The DREPs and TLEs then begin their work. The TLEs create the mission timeline file scheduling crew activities, commanding windows and unattended operations as necessary. They work with the DREP to plan video events as needed. Meanwhile, the DREP completes the new data schedule.

After the OAEs deliver the files listed above they continue by working attitude changes with Houston POINTING, creating the PROCAM file (contains various pointing information), make necessary IPS guidestar and objective load changes and create a new IPS Pointing List (IPOL) file and a new sequence list file. The FLM uses the sequence list to update the SEQNUM file. Also, if needed, the FLM updates the moving targets file. From the IPOL, SEQNUM, MOVE and SCIPLAN files the JOTF file is re-created and uplinked to the Spacelab Mass Memory Unit (MMU). Other MMU files containing updated ephemeris-related and TDRS data as well as any new or revised objective loads are also prepared and uplinked by the MMU Manager (MUM). In addition, any crew procedure changes are prepared by the CPE and the FLM creates any new JOTP book pages that might be needed. Finally, the OAEs create any new manual target acquisition plots necessitated by the replan.

For the crew shift 34 to 46 hrs MET, the TLEs send the PCAP and PTS to JSC at ~30 MET. Payload timeline changes from MSFC are mingled with Orbiter crew timeline changes from the MCC and all necessary information is uplinked to the crew at approximately 32 MET. At nearly the same time, the Cadre and science teams in the POCC have access to the full set of replanned timeline products in OMIS and hardcopies of the PCAP, PTS and Replan Summary are distributed in the POCC. Also at this time the next SOPG is beginning! The 12-hour replanning cycles continues thus until the last science-gathering shift of the mission is replanned.

4.2 Off-Nominal Conditions

4.2.1 Launch Delays on the Pad

Any number of conditions can occur that would cause the launch to be delayed from its nominal time (e.g. weather, temporary hardware problems, aircraft interference, etc.). The impact of such delays is largely proportional to the length of the delay, which can be anywhere from minutes to two hours (or more in the most extreme cases), depending on the actual launch window available.

Launch delays affect a mission plan in two major ways. The first effect is that launch delays change the nominal orbit plane with respect to the sky. Since the details of target visibilities from low earth orbit depend on the orientation of this plane, the target "acq/loss" times all change. In many cases, these changes are small enough so that they do not cause major problems with the planned observations, except that the new information must be calculated and uplinked to the crew. However, with certain targets near the original orbit pole, visibility can change dramatically, especially with respect to the day/night boundaries of the orbit. Also, a new problem for Astro-2 is that launch delays will affect some targets through the "Ram angle" constraint. The best strategy for handling these situations is simply to run tests on the final timeline pre-mission to identify the targets so affected, and to have corrective measures in hand for implementation in real-time replanning.

The second effect of launch slips is due to the SAA. The nominal SAA passes are fixed in Mission Elapsed Time (MET), and hence will slide in time with any launch slip. This affects the positioning of the nominal SAA passes with respect to the day/night boundaries, and hence with respect to the planned observations. Assuming the mission is planned such that SAAs are initially centered on the day portion of the orbits, the effect of launch delays is such that the SAAs shift toward the day-into-night terminator. The best strategy for dealing with this effect is to take it into account in pre-mission timeline planning. Avoid planning short observations directly after an SAA pass, and when possible plan observations directly before SAAs that still have some visibility (and hence, can be extended if the SAA slips). Since WUPPE plans to observe through SAAs wherever possible (and HUT may be more aggressive, depending on on-orbit testing), the significance of this effect may be somewhat diminished for Astro-2. However, it should still be kept in mind when planning the SCIPLAN.

One procedure that can be investigated pre-mission and implemented in real-time (i.e. after a launch slip has occurred) is to apply a "bias" to the entire timeline. A bias is simply a constant offset, usually implemented in integral minutes of time for simplicity, that "globally" corrects the start/stop times of planned observations for the change in orbit (to the extent that they can be). This basically amounts to "getting all the time back you can" from such a simple procedure, and then working the more serious problems as time permits, on a shift-by-shift basis. The bias procedure usually amounts to a minute or two of time saved per observations, which can amount to hours of total integration time over a given timeline.

The bias to apply to a given timeline during Astro-1 was derived experimentally by, for an assumed launch delay, running the JHU program 'slipanalysis' repeatedly on a timeline assuming various biases and determining how much total time was lost. The "best" bias produced a timeline with the least losses. (Note that the bias procedure can also be applied for day-to-day launch delays on the pad.) Although the best bias as derived above is experimentally determined, the sense and magnitude of the bias correction can be seen in the following summary table from Astro-1 Dec. 2, 1990, 0628 GMT timeline:

Launch Delay	Bias
20 m	-1 m
40 m	-3 m
60 m	-4 m
80 m	-4 m
100 m	-5 m
120 m	-7 m
140 m	-8 m
160 m	-9 m
180 m	-10 m

The sense of the correction is in the opposite direction for day-to-day delays on the pad, and is roughly +1 m for every two days of delay.

4.2.2 Off-Nominal Orbit Insertion

In the event of a off-nominal orbit insertion, a number of factors will have to be considered. These include altitude, orbit eccentricity, and amount of fuel remaining. The instruments have a nominal operating altitude, and if the Orbiter is below that altitude, or in a highly eccentric orbit which dips below that altitude, it may be highly desirable to raise and circularize the orbit. In the event that an abort-to-orbit has occurred, fuel reserves will be low, and altitude becomes a tradeoff versus time on-orbit. These factors are still being considered at the time of this writing.

4.2.3 IPS Problems/Contingencies

The entire timeline of science observations as described in this document is generated under the assumption that the Instrument Pointing System (IPS) and other Spacelab hardware is operating nominally. The activation time period (roughly the first 24 hours on orbit), and in particular the successful testing of the IPS, is crucial to the success of the mission downstream.

In recognition of this importance, much effort has gone into the analysis of IPS problems from Astro-1 and improved functionality of the IPS for Astro-2. Part of this process, which is still in discussion as of this writing, is an improved process by which the IPS will be checked-out on orbit, analyzed as to its functionality, and then turned over for science operations. This discussion is taking place within the IPS Task Team, made up of members of the IPS Working Group and the CI/MPT. Initial discussions include the idea of an "Early handover" if IPS checkout proceeds nominally, and a period of time for "IPS Contingency Checkout" if problems still need to be worked at the nominal handover time.

Appendix A

EXAMPLES OF MISSION INTERFACE FILES

Example of PM.DAT (Proper Motion File):

ID	Name1	PM RA	PM Dec	Ref
0101	ALF-AUR	0.0803	-0.423	SAO
2416	DEL-HER	-0.0231	-0.157	SAO
2506	LB3303	0.06	-0.05	Gliese, Catalog of Nearby Stars (1969)
2508	LD879-14	0.233	-1.50	Luyten, Catalogue of Stars With PM >0.5"/yr (1976)

Example of MTF.DAT (Moving Target File):

ID	RA Start	Dec Start	Dist Start	RA Stop	Dec Stop	Dist Stop
1101-10	304.2033	-18.7272	1.12	304.2	-18.73	1.12
1102-10	303.9552	-18.9486	1.11	303.95	-18.95	1.11
1103-10	303.8298	-19.0609	1.10	303.83	-19.06	1.10
1104-10	303.6716	-19.2026	1.10	303.67	-19.21	1.10
1105-10	303.6398	-19.2311	1.09	303.63	-19.24	1.09
1106-10	303.6079	-19.2597	1.09	303.60	-19.26	1.09

Example of PTL (Program Target List):

I	ID	Name1	Name2	RA	Dec	Src	Acc	O	R	T	S	M	WSP	HSP	USP	GSP	Comments
H	0001	HZ43	_	13 14 00.64	+29 21 48.2	0	99.99	0	1	0	0	1	_	_	_	007	Msn A;poss 0600 tgt
H	0101	ALF-AUR	HD34029	05 12 59.466	+45 56 58.04	1	0.03	0	0	0	0	1	_	H10	_	_	Mission A
U	0301	BR-EARTH	_	11 22 21.50	+04 01 48.7	0	99.99	0	0	0	1	0	_	_	U15	_	Mission A
W	0601	BET-TAU	HD35497	05 23 07.710	+28 34 01.74	1	0.03	0	1	0	0	1	W00	_	_	_	Mission A

Example of PTLCOORD.DAT:

No.	Coordinate Reference
1	SAO Catalog.600
4	CFA Measurements.
8	Smith, G. 1983, MNRAS, 204, 151.

Example of PMTL (Pre-Mission Target List):

I	T	ID	Name1	Name2	RA	Dec	S	Day	Night	WUPPE R	WUPPE O	WUPPE T	WUPPE C	WUPPE P	WUPPE Time	HUT R	HUT O	HUT T	HUT C	HUT P	HUT Time	UIT R	UIT O	UIT T	UIT C	UIT P	UIT Time
H	G	0001-0	HZ43	_	13 14 00.64	+29 21 48.2	0	1800	1380																		
H	P	0101-0	ALF-AUR	HD34029	05 12 59.47	+45 56 58.0	0	2160	1740																		
U	P	0301-0	BR-EARTH	_	11 22 21.50	+04 01 48.7	0	1200	1920																		
W	P	0601-0	BET-TAU	HD35497	05 23 07.71	+28 34 01.7	0	1620	1740																		

Example of MTL (Mission Target List):

I	T	SPN	ID	Name1	Name2	RA	Dec	Src	Acc	Roll	R	O	T	S	C	P	ReqTm	Comments
H	G	007	0001-0	HZ43	_	13 14 00.64	+29 21 48.2	0	99.99	-99.99	9	9	9	0	9	9	-9999	Mission A
H	P	H01	0101-0	ALF-AUR	HD34029	05 12 59.47	+45 56 58.0	1	99.99	-99.99	9	9	9	0	9	9	-9999	Mission A
U	P	U01	0301-0	BR-EARTH	_	11 22 21.50	+04 01 48.7	0	99.99	-99.99	9	9	9	0	9	9	-9999	Mission A
W	P	W01	0601-0	BET-TAU	HD35497	05 23 07.71	+28 34 01.7	1	99.99	-99.99	9	9	9	0	9	9	-9999	Mission A

Example of SCIPLAN (Science Plan of Science Timeline File):

I	T	SPN	ID	Name1	Name2	RA	Dec	Src	Acc	Roll	R	O	T	S	C	P	ReqTm	SchTm	METstart	METstop	Comments
H	G	007	0001-00	HZ43	_	13 14 00.64	+29 21 48.2	0	99.99	-99.99	9	9	9	0	9	9	-9999	-9999	0.0000	0.0000	Mission A
H	P	H01	0101-00	ALF-AUR	HD34029	05 12 59.47	+45 56 58.0	1	99.99	-99.99	9	9	9	0	9	9	-9999	-9999	0.0000	0.0000	Mission A
U	P	U01	0301-00	BR-EARTH	_	11 22 21.50	+04 01 48.7	0	99.99	-99.99	9	9	9	0	9	9	-9999	-9999	0.0000	0.0000	Mission A
W	P	W01	0601-00	BET-TAU	HD35497	05 23 07.71	+28 34 01.7	1	99.99	-99.99	9	9	9	0	9	9	-9999	-9999	0.0000	0.0000	Mission A

Example of SEQNUM:

ID	Name1	HUT	WUP	UIT	M	T	DQT	H_ALT1	H_ALT2	W_ALT1	W_ALT2	U_ALT1	IMCALT
0001-00	HZ43	053	107	999	0	9	-99	JFA3	_	_	_	V_BRT	_
0101-00	ALF-AUR	050	303	999	0	9	-99	_	_	_	_	_	_
0301-00	BR-EARTH	040	099	998	0	9	-99	LCDATA	EARTHA	NOWUP	_	BRIGHT	NOIMC
0601-00	BET-TAU	043	104	999	0	9	-99	SMALAP	_	_	_	V_BRT	_
0602-00	+33D2642	-99	-99	-99	9	9	-99	_	_	_	_	_	_

Example of OBJSUM:

Obj No	Type	EXP No	Science Target ID	Name	RA	Dec	Roll Angles Pos Angle	Obj Roll	Stars in FOV B	R	L
215	IDOP	2	5130-100	NGC6752	286.6110	-60.0670	135.001	89.999	0	2	1
216	IDOP	2	8411-100	0953+41	148.4510	41.4940	227.274	-2.274	1	3	1
217	IDOP	2	3601-100	OMI-CET	34.2040	-3.2040	194.766	30.234	0	1	3
218	IDOP	2	8204-100	NGC1275	49.1230	41.3310	225.000	0.000	1	2	1
219	IDOP	2	1102-100	HALLEY02	303.4520	-19.0500	302.500	-77.500	1	1	0
220	IDOP	2	6121-100	LMC-B	81.3760	-69.6790	30.027	-165.027	2	0	3
221	IDOP	2	8307-100	M87	187.0730	12.6670	164.993	60.007	0	1	3

Example of JOTF.LIS:

TARGET	NAME	RIGHT ASC-ST (DEG)	DECL START (DEG)	ROLL (DEG)	PLAN OBS. (SEC)	TARG CONST	HUT SEQ #	WUP SEQ #	UIT SEQ #	DELTA	STAT WORD	DIST STRT (AU)	TIME START (GMT)	RIGHT ASC-STP (DEG)	DECL STOP (DEG)	DIST STOP (AU)	TIME STOP (GMT)
0001-11	BR-EARTH	170.5896	4.0302	42.98	1403	2	40	99	998	10	10	0.00	66/17:33:18	0.00	0.00	0.00	66/17:56:41
0001-12	BR-EARTH	170.5896	4.0302	42.98	1298	2	41	99	156	10	10	0.00	72/21:55:33	0.00	0.00	0.00	72/22:17:11
0001-20	BR-EARTH	170.5896	4.0302	42.98	1423	2	42	99	156	10	00	0.00	67/22:51:08	0.00	0.00	0.00	67/23:14:50
0002-10	BET-TAU	80.7821	28.5672	110.00	323	2	43	104	999	10	10	0.00	66/09:00:30	0.00	0.00	0.00	66/09:05:53
0003-00	HZ43	198.5027	29.3634	78.46	1848	2	53	107	999	10	00	0.00	66/04:55:00	0.00	0.00	0.00	66/05:25:48

APPENDIX B: ROLL ANGLE DEFINTIONS

There are several different uses of the term "roll angle" for Astro-2 Mission Planning. The purpose of this appendix is to list and define the various roll angles used.

B.1 MSFC Celestial Roll Angle

This roll angle is used to locate IPS guide stars on the celestial sphere relative to the science star being observed by the IPS instrument cluster. This is a dihedral angle measured between the meridian plane containing the science star and the celestial north pole, and another plane containing the science star and the guide star. The zero position is in the meridian plane directly north of the guide star. The positive direction is to the EAST - or in the direction of increasing right ascension. This angle is also referred to as the "Position Angle", and it is frequently used to refer to the position of the right skewed star tracker (RST).

B.2 Dornier Roll Angle

The roll angle as defined by Dornier is measured in the same manner as that described in Section B.1 (MSFC Celestial Roll Angle) except that the positive direction is in the opposite sense; e.g. a Position Angle of 30 degrees would be 330 degrees in Dornier's measurement.

MSFC Celestial Roll Angle	=	360	-	Dornier Celstial Roll Angle

B.3 PI-Specified Roll Angle

When the IPS is in the cradle position in the orbiter, the HUT and WUPPE rectangular apertures are parallel to the orbiter Y axis ("Wing" plane). The IPS S-system is also parallel to the orbiter Y axis in this position, although positive is in the opposite direction to that of the orbiter Y axis. With the S-system aligned with the standard inertial system (the reference position), the rectangular apertures would be aligned perpendicular to the local meridian plane. The end of the aperture toward the +Ys axis would have a "Position Angle" (see B.1) of 90 degrees. So, when one sees a "roll-angle" specifed on the MTL or SCIPLAN file, this is really the desired position angle of the +Ys axis of the rectangular aperture, and it is frequently referred to as the "PI Roll". PI Roll angles are the same thing as the classical definition of "astronomical roll angle," i.e. North=0 degrees, and positive angles are measured eastward.

B.4 Objective Load Roll Angles

These roll angles are measured in the same sense as that defined by Dornier. At an Objective Load Roll Angle of 0 degrees (the "zero roll" position of the IPS S-system illustrated in Figure 18 of NASA TM-100336, Guide Star Selection for Stellar Mode, by L. Mullins and L. Wooten) the +Ys axis points EAST, and the +Zs axis points NORTH. A positive roll moves the +Zs axis to the WEST. Thus, an Objective Load Roll is related to the PI roll by:

Objective Load Roll = 90 - PI roll

To center a specific guide star associated with a given science target in one of the star trackers, however, a bias must be added to the objective load roll angle due to the fact that in the "zero roll" position of the IPS S-system the skewed star trackers are lying in a plane inclined 45 degrees to the local meridian plane. The left skewed tracker (LST) is 45 degrees east of north and the right skewed tracker (RST) is 135 west of north. Thus, in the "zero position", the RST has a roll angle of 135 degrees as measured in the Dornier system. If there was a guide star in the meridian plane directly north of the science star and one wished to center it in the Field of View of the RST, then the roll angle that one would have to put in the objective load would be -135 degrees. Generally, if "CR" is the MSFC Celestial Roll Angle of any guide star in an annulus about the science star and one wished to center the RST on that guide star, then the Objective Load Roll Angle would be:

$$\text{Objective Load Roll(RST)} = -135 + (360 - \text{CR})$$

Of course, it is also possible to center the LST on that guide star. In that case, the Objective Load Roll Angle would be 180 degrees from the above value, or:

$$\text{Objective Load Roll(LST)} = +45 + (360 - \text{CR})$$

If a PI Roll has been specified in the MTL or SCIPLAN file, this restricts positions that can be searched for guide stars. Using the relation shown above in equation 2 between PI Roll and Objective Load Roll, the MSFC Celestial Roll (CR) of potential guide stars would be:

$$\text{CR(RST)} = -135 + (\text{PI Roll} + 270)$$

and,

$$\text{CR(LST)} = +45 + (\text{PI Roll} + 270)$$

B.5 IPS Gimbal Roll Angle

This roll angle is a mechanical roll about the boresight (IPS X axis) which can vary between the limits of 0-180 degrees (positive or negative) from the cradle position of the IPS. Mechanical stops impose these limits.

There are 3 IPS Gimbal angles: 1) Elevation (EL), which is a movement about the orbiter Y axis ("wing" plane). This elevates the IPS boresight relative to the orbiter Y axis. 2) Cross-elevation (XL), which swings the IPS boresight from the orbiter X-Z plane toward the orbiter wings. When the IPSis in a "straight up" position relative to the orbiter body, the EL is 90 degrees and the XL is 0 degrees. 3) Roll (RL), which is mentioned above. Since the orbiter can have many different attitudes while viewing the same science target, there is no direct correlation between the IPS Gimbal Roll and the desired celestial roll.

APPENDIX C: Handling Moving Targets and High Proper Motion Objects

The material provided in this Appendix is generally a carry-over from Astro-1, and included here for reference purposes. In detailed discussions after Astro-1, the CI/MPT reviewed the situation with regards to moving targets and high proper motion targets and how best to accommodate these factors.

The CI/MPT stopped short of actually suggesting that the nominal capability to make these corrections (as described below) be removed from the "system" altogether. However, the implementation of making corrections for high proper motion objects or moving targets in some "automatic" way a) was not verified to the CI/MPT's satisfaction (or recollection) during Astro-1, b) was deemed a "cumbersome at best" way of dealing with these factors, and c) was not deemed as necessary for Astro-2. Although the concept of being able to put a single coordinate for a moving target or a high proper motion target in the planning files and have this coordinate updated in an "automatic" way for the time of observation was good in principle, in practice it causes many complications.

The "moving target" issue probably has its origins back in the Astro-Halley mission days, where a large number of pointings at Halley's comet were planned. Comets have a substantial motion against the background sky even during the course of a single observation, and hence the need to have the IPS track a moving target was deemed necessary. Subsequent to this, the idea was applied to planetary observations (e.g. JUPITER or SATURN), even though the motion of these targets during a given shuttle pointing is much smaller.

The real-time replanning capabilities demonstrated during Astro-1 allow us to take a much more straightforward approach to this problem. For observations of solar system objects on Astro-2, the best available coordinates for each object will be used for science planning, and the targets will be planned as if they were "fixed" targets. Then updated coordinates for each pointing will be submitted as part of the normal real-time replanning cycle during the mission. Any motion of these targets during a given shuttle pointing can easily be handled by the PS using the Manual Pointing Controller (MPC), as was demonstrated during Astro-1.

For high proper motion objects, we also advocate a much more straightforward approach (which basically corresponds to what was actually done on Astro-1). If proper motions are known for an object, the team responsible for the target entry in the planning files should make the correction, and place the revised in the planning files through the normal coordinate update process.

Below, for reference, are the Astro-1 file description information.

C.1 MOVE-Moving Target Program

```
Input:   ID#, Julian Day
Output:  Distance (AU), RA, Dec (true of date, coordinates 1950)

Program looks in PTL
     if "solar system flag" is set
               look in SOLAR.DAT file
               if "proper motion flag" set
                    use supplied subroutine
               else
                    use listed orbit elements, standard program
```

```
        else
                 if "proper motion flag" set
                     look in PM.DAT file
                     run standard program
        endif
    output in MOVE.DAT
```

SOLAR.DAT (orbital parameter file for solar system objects):

```
VENUS
0.718418       DISTANCE AT PERIHELION
0.006797       ECCENTRICITY
2447019.5      TIME OF PERIHELION PASSAGE
  3.3941       INCLINATION
 76.2297       ASCENDING NODE
 54.6379       ARGUMENT OF PERIHELION
-4.3           ABSOLUTE TOTAL MAGNITUDE
 5.0           MAGNITUDE FACTOR
JUPITER
4.950888       DISTANCE AT PERIHELION
0.048419       ECCENTRICITY
2442629.5      TIME OF PERIHELION PASSAGE
  1.3059       INCLINATION
 99.9433       ASCENDING NODE
273.5736       ARGUMENT OF PERIHELION
-8.9           ABSOLUTE TOTAL MAGNITUDE
 5.0           MAGNITUDE FACTOR
MARS
1.381511       DISTANCE AT PERIHELION
0.093313       ECCENTRICITY
2440515.8      TIME OF PERIHELION PASSAGE
  1.8500       INCLINATION
 49.1719       ASCENDING NODE
285.9667       ARGUMENT OF PERIHELION
-0.9           ABSOLUTE TOTAL MAGNITUDE
 5.0           MAGNITUDE FACTOR
SATURN
9.007372       DISTANCE AT PERIHELION
0.055717       ECCENTRICITY
2442058.5      TIME OF PERIHELION PASSAGE
  2.4904       INCLINATION
113.2203       ASCENDING NODE
338.8481       ARGUMENT OF PERIHELION
-9.1           ABSOLUTE TOTAL MAGNITUDE
 5.0           MAGNITUDE FACTOR
URANUS
18.27695       DISTANCE AT PERIHELION
0.047182       ECCENTRICITY
2439346.5      TIME OF PERIHELION PASSAGE
  0.7730       INCLINATION
 73.7453       ASCENDING NODE
```

```
 96.1031        ARGUMENT OF PERIHELION
-6.9            ABSOLUTE TOTAL MAGNITUDE
 5.0            MAGNITUDE FACTOR
NEPTUNE
29.80028        DISTANCE AT PERIHELION
0.008563        ECCENTRICITY
2468191.5       TIME OF PERIHELION PASSAGE
  1.7747        INCLINATION
131.2294        ASCENDING NODE
272.9567        ARGUMENT OF PERIHELION
-7.1            ABSOLUTE TOTAL MAGNITUDE
 5.0            MAGNITUDE FACTOR
4VESTA
2.1513797       DISTANCE AT PERIHELION
0.0891086       ECCENTRICITY
2446315.4       TIME OF PERIHELION PASSAGE
  7.14288       INCLINATION
103.43591       ASCENDING NODE
150.32219       ARGUMENT OF PERIHELION
 4.3            ABSOLUTE TOTAL MAGNITUDE
 5.0            MAGNITUDE FACTOR
2PALLAS
2.1260558       DISTANCE AT PERIHELION
0.2330664       ECCENTRICITY
2446518.8       TIME OF PERIHELION PASSAGE
 34.79180       INCLINATION
172.66249       ASCENDING NODE
309.96096       ARGUMENT OF PERIHELION
 5.0            ABSOLUTE TOTAL MAGNITUDE
 5.0            MAGNITUDE FACTOR
1CERES
2.5485041       DISTANCE AT PERIHELION
0.0785650       ECCENTRICITY
2446466.4       TIME OF PERIHELION PASSAGE
 10.60646       INCLINATION
 80.05225       ASCENDING NODE
 73.07274       ARGUMENT OF PERIHELION
 4.5            ABSOLUTE TOTAL MAGNITUDE
 5.0            MAGNITUDE FACTOR
29AMPHI
2.3660550       DISTANCE AT PERIHELION
0.0737089       ECCENTRICITY
2446982.3       TIME OF PERIHELION PASSAGE
  6.10549       INCLINATION
355.98126       ASCENDING NODE
 63.48599       ARGUMENT OF PERIHELION
 7.1            ABSOLUTE TOTAL MAGNITUDE
 5.0            MAGNITUDE FACTOR
```

PM.DAT (proper motion file containing the pm in RA and Dec in arcsec/year for a given target):

Proper Motion Data File Format:

ASCII Data - field delimiter = space

Contents	Format	Bytes	Comments
--------	------	-----	--------
Target ID	I4,1X	01-05	xxxx
Name1	A8,1X	06-14	8 chars
PM (RA) (arcsec/yr)	F7.4,1X	15-22	proper motion in RA
PM (Dec) (arcsec/yr)	F6.3,1X	23-29	proper motion in Dec
Reference data	A103	30-132	source of the proper motion

An example of PM.DAT is to be found in Appendix A.

MOVE OUTPUT (MOVE.DAT):

```
                    JUPITER

                    PERIHELION DISTANCE       4.951
                    ECCENTRICITY              0.04842
                    ARGUMENT OF PERIHELION  273.574
                    INCLINATION               1.306
                    ASCENDING NODE           99.943
                    MAGNITUDE CONSTANT        5.00
                    ABSOLUTE MAGNITUDE       -8.90
                    JD AT PERIHELION    2442629.5000
                    SEMIMAJOR AXIS            5.20
                    PERIOD                   11.87
                    APHELION DISTANCE         5.45


                    JUPITER

  DATE       RA(1950)   DEC(1950)     RA        DEC       DELTA   R
2446495.50   22 21 43  -11  8 14   22 23 39  -10 57 14    5.98   5.01

  MAG  PHASE
-1.52   2.3

                    JUPITER

  DATE       RA(1950)   DEC(1950)     RA        DEC       DELTA   R
2446505.50   22 30 42  -10 17 22   22 32 37  -10  6 11    5.94   5.01

  MAG  PHASE
```

-1.53   3.7

C.2 Moving Target File (MTF)

MTF file format:

ASCII data, no field delimiter

Contents	Format	Bytes	Comments
OBS ID	1X,A7	01-08	xxxx-yz
*RA Start (1950) (degrees)	F12.6	09-20	ddd.dddddd
Dec Start (1950) (degrees)	F12.6	21-32	sdd.dddddd
Dist Start	F12.6	33-44	AU
RA Stop (1950) (degrees)	F12.6	45-56	ddd.ddddd
Dec Stop (1950) (degrees)	F12.6	57-68	sdd.dddddd
Dist Stop	F12.6	69-80	AU

* Coordinates are true of date

An example of the MTF is found in Appendix A.

APPENDIX D: Launch Date Specific Mission Planning Constraints

```
JSC H/O TIMES
-------------

0/10:45
0/22:00
1/11:15
1/23:15
2/11:00
2/23:00
3/11:15
3/23:15
4/11:15
4/23:00
5/11:15
5/23:15
6/11:15
6/23:00
7/11:15
7/23:15
8/11:15
8/23:15
9/11:00
9/23:15
10/11:15
10/23:15
11/12:15
12/00:00
12/13:00
13/01:00
```

APPENDIX E: List of Acronyms and Abbreviations

ACRONYM	DESCRIPTION
A&AS	Astronomy & Astrophysics Supplement
AJ	Astronomical Journal
ALTs	Alternate Procedures
ApJ	Astrophysical Journal
ApJS	Astrophysical Journal Supplement
AU	Astronomical Unit
CCTV	Closed Circuit Television
CI	Continuous Improvement
CI/MPT	Continuous Improvement / Mission Planning Team
CMD LOD	Command Load (Experiment Computer command)
CPE	Crew Procedures Engineer
CR	Celestial Roll angle
DEP	Dedicated Experiment Processor
DREP	Data Replanner
EC	Experiment Computer
EFORD	Experiment Functional Objectives Requirements Document
EL	IPS Elevation
EOM	End Of Mission
FCS	Flight Control System
FES	Flash Evaporator System
FITS	Flexible Image Transport System
FLM	File Manager
GI	Guest Investigator
HSF	HUT Sequence File
HUT	Hopkins Ultraviolet Telescope
ID	Identification
IDIN	"Initial Identification" IPS procedure
IDOP	"Operational Identification" IPS procedure
IIA	Integration & Interface Agreement
IMCS	Image Motion Compensation System
IMCAST	IMCS test
IMCCAL	IMCS test
IMCGYRO	IMCS test
IPOL	IPS Pointing List
IPRD	Integrated Payload Requirements Document
IPS	Instrument Pointing System
IPSADF	IPS test
IWG	Investigators Working Group
JD	Julian Date
JHU	Johns Hopkins University
JIS	Joint Integrated Simulation
JOIP	Joint Operations Interface Procedures
JOTF	Joint Observation Target File
JOTP	Joint Observation Target Procedures Book
JSC	Johnson Space Center
LINER	Low Ionization Nuclear Emission Region
LST	Left Star Tracker
MET	Mission Elapsed Time
MMU	Mass Memory Unit

MPHIRD	Mission Planning Handbook and Interface Requirements Document
MSCI	Mission Scientist
MSFC	Marshall Space Flight Center
MTF	Moving Target File
MTL	Mission Target List
NASA	National Aeronautics and Space Administration
OAE	Orbit Analysis Engineer, or ORBIT
OCR	Operations Change Request
ORBIT	See OAE
OSP	Optical Sensor Package
OSPCAL	OSP Calibration test
OVV	Optically Violent Variable
PAO	Public Affairs Office
PAP	Payload Activity Planner
PCAP	Payload Crew Activities Plan
PI	Principal Investigator
PIP	Payload Integration Plan
PMRR	Pre-mission Replanning Request
PMTL	Pre-MTL file
POCC	Payload Operations Control Center
POG	Payload Operations Guidelines
POH	Payload Operations Handbook
PROM	Programmable Read Only Memory
PRT	Payload Replanning Team
PTL	Program Target List
PTS	Payload Timeline Summary
RA,DEC	Celestial coordinates: Right Ascension and Declination
RAAN2	Right Ascension of the Ascending Node on the 2nd Orbit
Rev	Revolution (1 orbit)
RL	IPS Roll angle
RR	Replanning Request
RST	Right Star Tracker
SAA	South Atlantic Anomaly
SCIPLAN	Science Plan
SEQNUM	Sequence Number
SMC	Small Magellanic Cloud
SOPG	Science Operations Planning Group
STS	Space Transportation System
STScI	Space Telescope Science Institute
TAL	Trans-Atlantic Landing
TDRS(S)	Tracking and Data Relay Satellite (System)
TIG	Time of Ignition
T/L	Timeline
UIT	Ultraviolet Imaging Telescope
USF	UIT Sequence File
VIP	Vacuum Ion Pump
WED	WUPPE Edit (Experiment Computer display page)
WSF	WUPPE Sequence File
WUPPE	Wisconsin Ultraviolet Photo-Polarimeter Experiment
XL	IPS Cross Elevation
ZOD	Zero Order Detector