CHAPTER 2:

Planning Observations in Two-Gyro Mode

2.1 Introduction

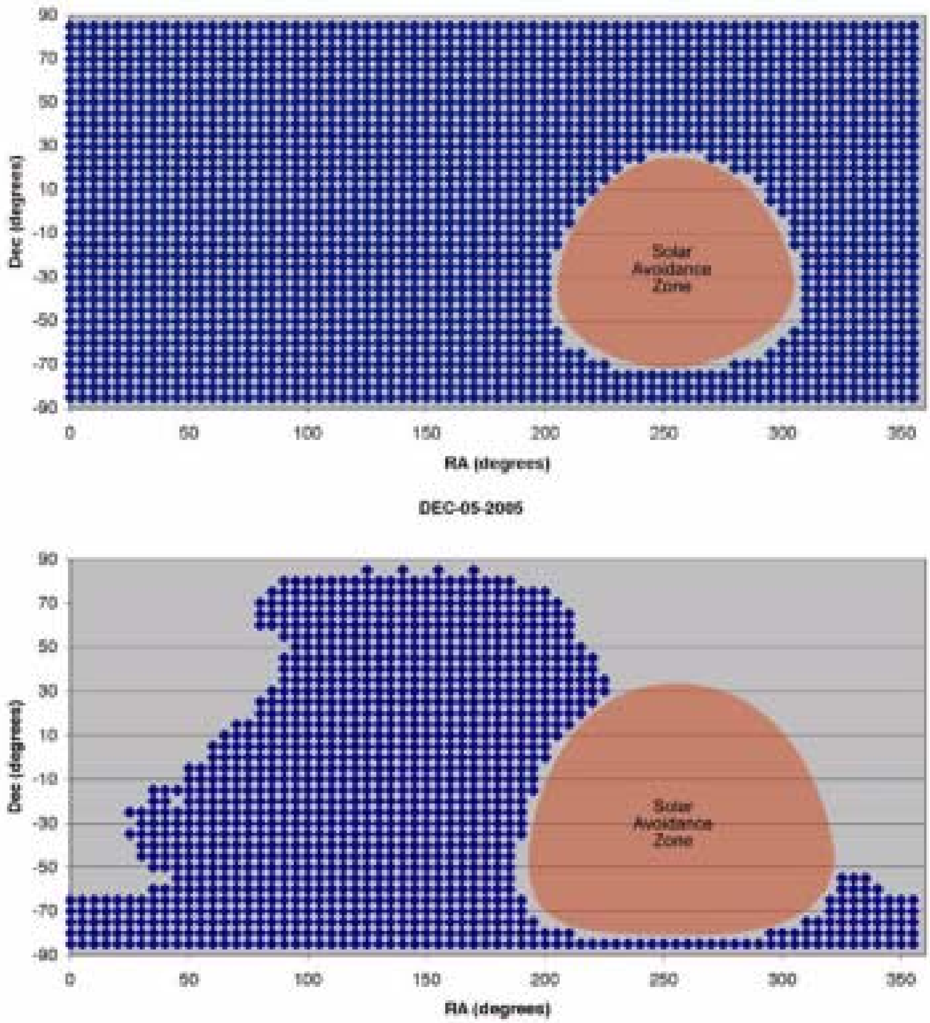
Observers will face some changes in the way they design their observing programs in Cycle 15 and future cycles. The conversion to two-gyro operations impacts how observations are scheduled and the visibility periods available for scientific observations. This chapter describes the scheduling constraints encountered during two-gyro operations and provides information necessary for observers to successfully complete their Phase I proposal submissions. The material in this chapter has been distilled from a more extensive discussion of the differences between two-gyro and three-gyro operations found in a previous version of this Handbook (v1.0, Ch. 6)

2.2 All-Sky Availability of Fixed Targets

2.2.1 Overview

The schedulability of an HST observation depends upon many factors and differs considerably between three-gyro and two-gyro operations. To briefly highlight some of these differences, it is useful to compare the accessible regions of the sky in the two modes on a given day of the year.

Figure 2.1: Sky Availability on 5 December 2005



Caption: Sky availability for 5 December 2005 in both three-gyro mode (top panel) and two-gyro mode (bottom panel).

Figure 2.1 shows the sky availability for a single day assuming attitude control with either three gyros (top panel) or two gyros (bottom panel).

Blue regions indicate areas of the sky that can be observed on the date shown, while grey areas of the sky are not observable at that time. The unobservable region of sky is much larger in two-gyro mode than in three-gyro mode because of constraints imposed to achieve guide star acquisitions and to ensure the safety of the observatory. On any given day there is a region of the sky that cannot be observed in either two-gyro or three-gyro mode because of solar avoidance constraints. In three-gyro mode, all regions of the sky outside the solar avoidance zone (50 degree radius) are accessible on any day. The solar avoidance zone for two-gyro mode is larger, with a 60 degree radius. A large region of the sky ahead of the solar avoidance zone (at larger right ascensions than the Sun) is also unobservable in two-gyro mode because of constraints imposed by the process of correcting slew errors and achieving fine guiding lock. Thus, in two-gyro mode most targets can only be observed when they are on the trailing side of the Sun as it moves along the ecliptic. Over the course of the year, all areas of the sky are available in two-gyro mode, but the total time available in any given direction is less than in three-gyro mode.

2.2.2 All-sky Availability Movie

A short narrated movie showing the sky availability during the course of a year can be found on the web at:

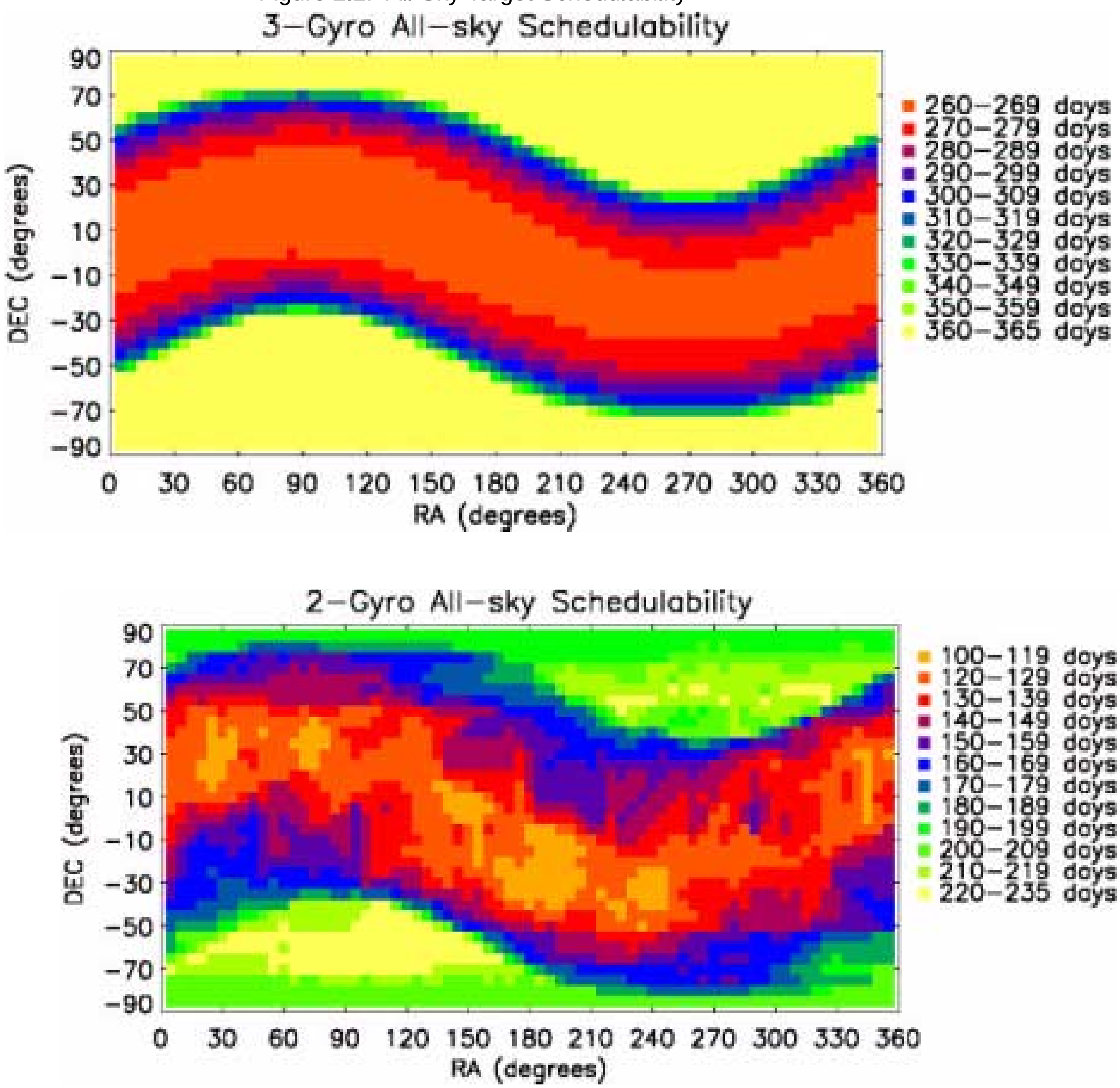
http://www.stsci.edu/hst/HST_overview/TwoGyroMode/2GyroMovies/2gyro.html

This movie compares the three-gyro and two-gyro availabilities in one-week increments in a format similar to the figure above. It shows the variable nature of the sky availability in two-gyro mode and the features discussed previously. It also shows that the availability near the equatorial poles is periodic and alternating. This availability pattern at high declinations is tied to the precession of the HST orbit.

2.2.3 Number of Available Days During the Course of a Year

It is useful to consider how many days per year a target of fixed position can be observed by HST. The top panel of Figure 2.2 shows the number of days in a cycle that any position in the sky is observable by HST with three-gyro pointing capabilities. This plot is essentially an encapsulation of the contents of the sky availability movie described above. The color-coding of this figure indicates the number of days for which at least one orbit (defined here to be a contiguous time block of at least 30 minutes) is available to observe a fixed target. In this figure, the allowable Sun angle range is 50-180 degrees. The fewest number of schedulable days occurs over a small swath of sky near the ecliptic, with availability increasing toward the equatorial poles. The minimum number of days available is approximately 260. A large portion of the sky at greater than 50 degrees ecliptic latitude has at least one schedulable orbit over the entire cycle duration. Be aware that this plot does not convey the information necessary to judge uninterrupted availability as occurs in the continuous viewing zones (CVZs). CVZ opportunities depend on a variety of additional factors that are described elsewhere (see the *HST Primer* and Section 2.6).

Figure 2.2: All-Sky Target Schedulability



The bottom panel of Figure 2.2 shows the number of days in a cycle that any position in the sky is observable with HST operating in two-gyro mode. Here, the allowable Sun angle range is restricted to 60-180 degrees. Note that the absolute level of the color scaling is different than it is in the three-gyro case shown in the top panel. There are several things worth noting about this panel when comparing it to the three-gyro results. First, and most importantly, the total number of schedulable days at all positions in the sky decreases substantially in two-gyro mode. Second, the smooth progression in availability seen in the top panel becomes slightly less regular, with pockets of reduced availability occurring across the sky. The overall trend for greater availability increasing toward the equatorial poles remains, but even some high declination pointings have fewer than half as many schedulable days as in three-gyro mode.

2.3 Scheduling Considerations and Visibility Periods for Fixed Targets

2.3.1 Overview

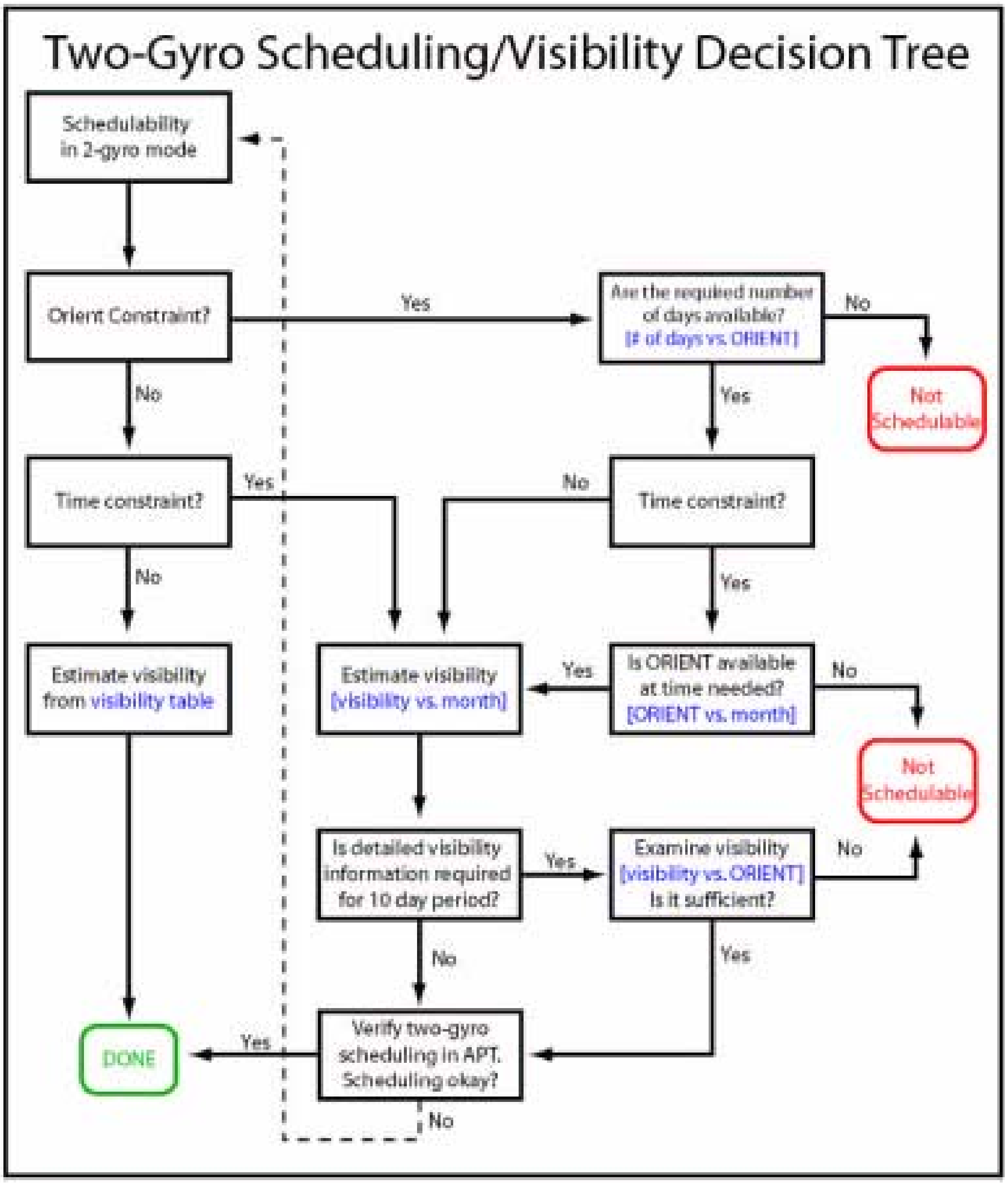
The primary observational constraints on the schedulability of most fixed targets in two-gyro mode are the position of the target in the sky, the required orientation or roll angle of the observatory (if any), and the required timing of the observation (if any). Orientation constraints are usually specified with the `ORIENT` special requirement and often involve a restricted range of allowable roll angles that correspond to a particular time period that HST is able to achieve this orientation. Timing requirements may be specified either implicitly through the `ORIENT` special requirement or explicitly through timing special requirements (e.g., `BETWEEN`, `AFTER`, etc.). In some cases, an observation may not be schedulable in two-gyro mode because of the restrictions imposed by orientation and/or timing special requirements.

Minimizing the number of special requirements on your observations will improve schedulability.

The operational definition of orbital visibility period for two-gyro operations is the same as it was for three-gyro operations. Orbital visibility is the unocculted time available during the orbit for guide star acquisitions (6 minutes), target acquisitions, science exposures, calibration exposures, and instrument overheads.

Figure 2.3 provides a graphical description of the general decision process involved in determining the schedulability and orbital visibility periods for fixed targets observed in two-gyro mode. The decision process for unconstrained observations involves minimal effort, whereas constrained observations require more careful consideration of the times of year that an observation can be scheduled. We discuss both types of observations below.

Figure 2.3: Two-Gyro Scheduling and Visibility Decision Tree



2.3.2 Unconstrained Fixed-Target Observations

If you do not need to specify the orientation of the observatory or the time of year of the observation, then the impact on scheduling is minimized and the observation will be schedulable at some time during the year. The orbital visibility of an unconstrained fixed-target is determined primarily by its declination. Table 2.1 lists the two-gyro orbital visibility periods as a function of declination. These average values are sufficient for Phase I orbit calculations.

Table 2.1: Standard Two-Gyro Fixed-Target Orbital Visibility Periods

Declination (degrees)	Orbital Visibility[1] (minutes)	LOW Visibility[2] (minutes)	SHADOW Visibility[3] (minutes)
0–5	52	47	25
5–15	52	47	25
15–25	53	48	25
25–35	53	48	25
35–45	53	48	25
45–55	54	45	25
55–65	54	45	25
65–75	55	43	25
≥75	57	42	25
Any CVZ	96	incompatible	incompatible

1. The orbital visibility periods in this table are the typical unocculted times available for guide star acquisitions and instrument-related activities.
2. LOW visibility refers to low-sky observations specified with the LOW special requirement.
3. SHADOW visibility refers to Earth-shadow observations specified with the SHADOW special requirement.

If your observation has no timing or orientation special requirements, the orbital visibility period can be found in Table 2.1, and you do not need to use the scheduling plots found later in this chapter or on the Two-Gyro Science Mode web site.

2.3.3 Constrained Fixed-Target Observations

If your science goals require specification of either the orientation of the observatory and/or the timing of the observation, determinations of the schedulability and orbital visibility period are slightly more complicated. An on-line tool to help you determine when a fixed target can be scheduled during Cycle 15 is available on the Two-Gyro Science web page at:

http://www.stsci.edu/hst/HST_overview/TwoGyroMode/AllSkyInformation

Enter the coordinates of your target into the web form, and the tool provides several graphical products that can be used to assess when and for how long the target is visible. The calculations used to construct this output were performed on a $5^\circ x 5^\circ$ grid on the sky. The output returned is appropriate for the grid point nearest the input coordinates. Thus, any input position is within 3.5 degrees of a grid point. This sampling is sufficient to provide accurate scheduling and visibility information for any position on the sky for the Phase I proposal process. The models used as input to produce this information rely upon realistic representations of the constraints expected for two-gyro operations. For clarity, Moon avoidance constraints are not included in these results; this does not alter the schedulability of a fixed-target or its orbital visibility significantly. Complete models including all constraints will be available for Phase II proposal processing.

The products returned by the Available Science Time and Orientation web tool include:

1. A plot and table of the total number of days per year that each orientation is available.
2. A plot and table of when each orientation is available during Cycle 15 and the first half of Cycle 16.
3. A plot and table of the target visibility as a function of date during Cycle 15 and the first half of Cycle 16.

The plots contain information about the schedulability of the target and how much time per orbit is available for the observation. Examples of each of these plots and tables are discussed below.

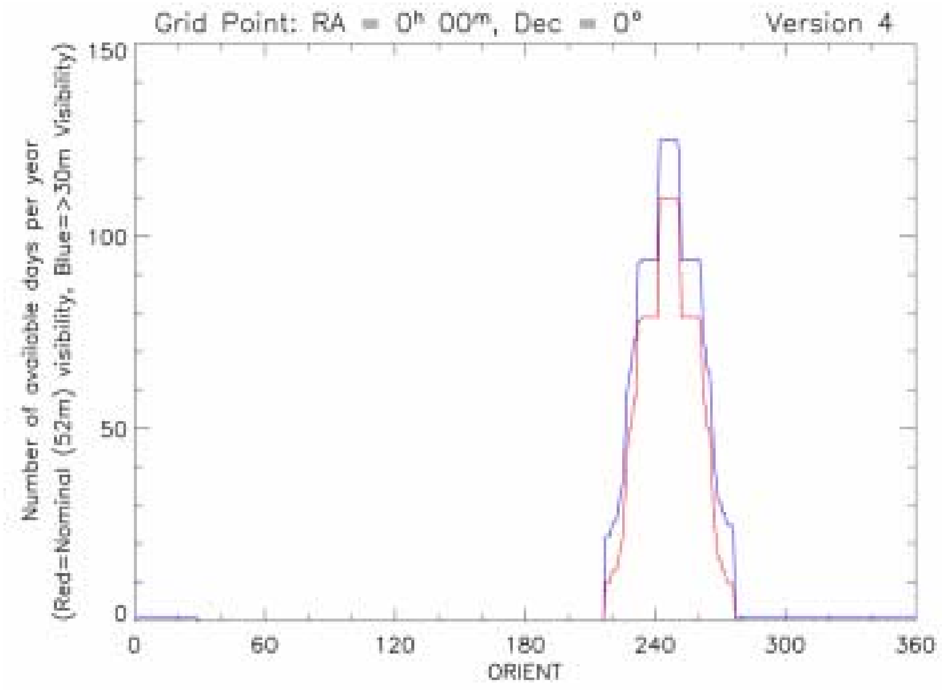
Plot Example: Number of Available Days as a Function of Orientation

The number of days that a particular HST orientation (roll angle) can be achieved in two-gyro mode in Cycle 15 is shown as a function of orientation for a low-latitude location ($\alpha = 0^\circ$, $\delta = 0^\circ$) in Figure 2.4 and for a high-latitude location ($\alpha = 0^\circ$, $\delta = +70^\circ$) in Figure 2.5. An available day is defined to be one in which at least one orbit with the nominal visibility listed in Table 2.1 exists (red curve in the figures). Some days may have only short visibility periods; for reference, the number of days with visibilities 30minutes is also plotted in the figures (blue curve). A portion of the table returned by the web tool for the low latitude example is provided in Table 2.2.

The number of days of availability may be quite limited for some orientations, especially at low declinations, as a result of Sun angle constraints. The range of available orientations expands at higher latitudes, with the number of days of availability increasing for some orientations and decreasing for others. In some cases, the number of days available may be zero.

In the low latitude example in Figure 2.4, there is a restricted range of orientations over which the target is observable. There is minimal availability for orientations from 0˚-30˚ and from 280˚-360˚. There is a large window available for orientations centered around 245˚, and using orbits with less than the nominal (52 minute) visibility does not increase the availability significantly. Note that, unlike three-gyro operations, it is not possible to observe at orientations with a 180˚ separation.

Figure 2.4: Orientation Availability for a Low-Latitude Target Near $\alpha = 0^\circ$, $\delta = 0^\circ$

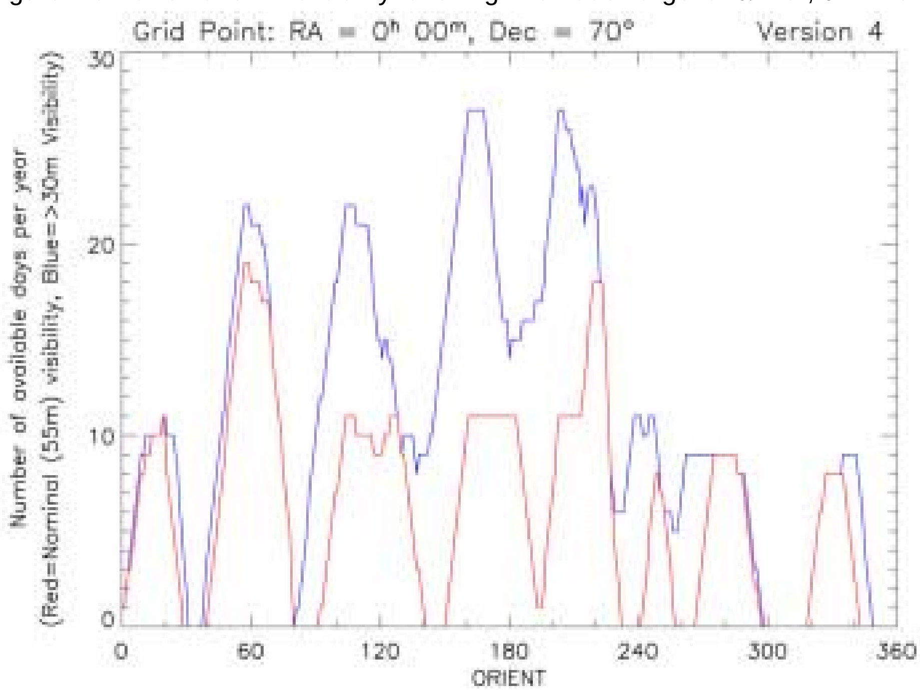


In the high latitude example in Figure 2.5, many orientations are available for five or more days, with notable exceptions occurring over restricted ranges in orientation where the availability dips to zero. Unlike the low latitude case, there are several orientations (e.g., 180˚) for which the use of orbits with less than nominal (55 minute) visibility increases the availability; in some cases, the target is available only with these short orbits. However, scheduling these short orbits results in efficient use of the telescope. Requests for short orbits must be well-justified scientifically and are expected to be available only in exceptional cases.

Table 2.2: A Portion of the Tabular Output for the Data Shown in Figure 2.4

Grid Point: RA = $0^h\ 00^m$, Dec = 0˚		
Orientation Angle (deg)	**Number of Days Available (>30 min)**	**Number of Days Available (>52 min)**
:	:	:
262	73	58
263	71	56
264	65	50
265	65	50
266	54	39
267	41	26
268	37	22
269	31	16
270	31	16
271	28	13
272	28	13
:	:	:

Figure 2.5: Orientation Availability for a High-Latitude Target at α = 0˚, δ = +70˚

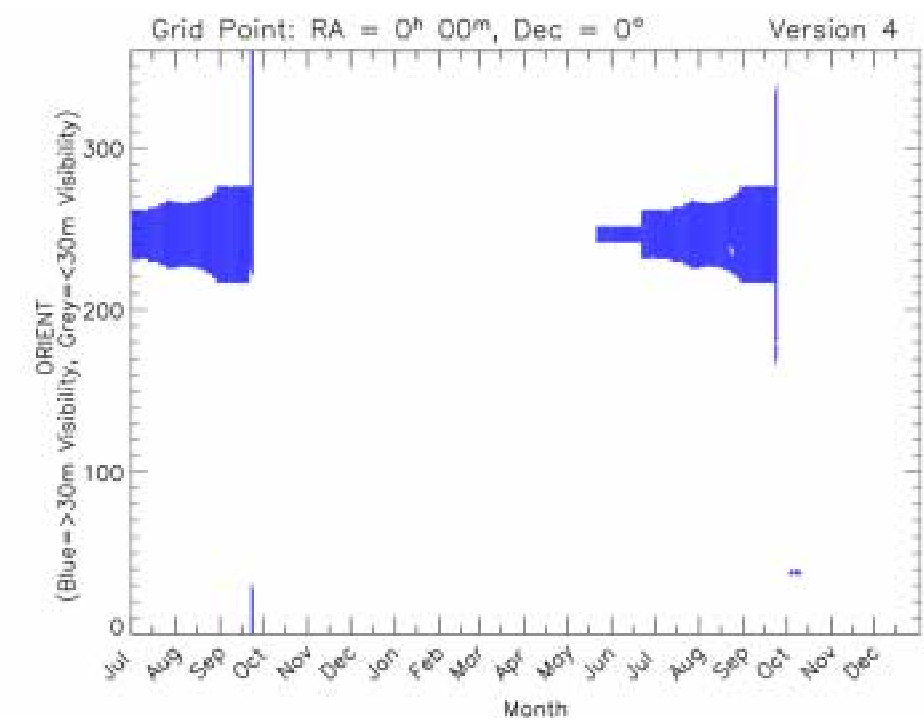


Plot Example: Availability of Roll Angles in Cycle 15

If a sufficient number of days exists to observe a target, the next step in determining its schedulability is to check when the target could be scheduled. If there are roll angle (`ORIENT`) constraints, you should check when the particular orientation is available by examining the web tool plot illustrating `ORIENT` versus time. Example plots are shown in Figure 2.6 and Figure 2.7, and a sample of the tabular output is shown in Table 2.3. The time axis on these plots extends for 18 months from the start of Cycle 15 (1 July 2006 to 31-Dec-2007) so that observers can judge whether observations that may begin in Cycle 15 could be concluded in the first half of Cycle 16. The blue regions of the figures indicate what orientations are available for the specified date when there is at least one orbit with 30 minutes of visibility. The gold regions indicate less than 30 minutes of visibility for some ORIENTs on that date. Note that most orientations are available only for limited periods of time.

Consider first the low-latitude pointing in Figure 2.6. The February-May time period is unavailable because of Sun avoidance restrictions. The Sun-leading region of the sky (October-February) is also inaccessible in two-gyro mode because of the need for fixed-head star tracker (FHST) visibility prior to fine-lock. Thus, in 2006, available orientations are limited to the June-September timeframe. A somewhat larger range of orientations is accessible for a very restricted range of dates in late September 2006 and 2007 when the target is located near the anti-Sun direction.

Figure 2.6: Low-Latitude Target Roll Angles Available During Cycle 15

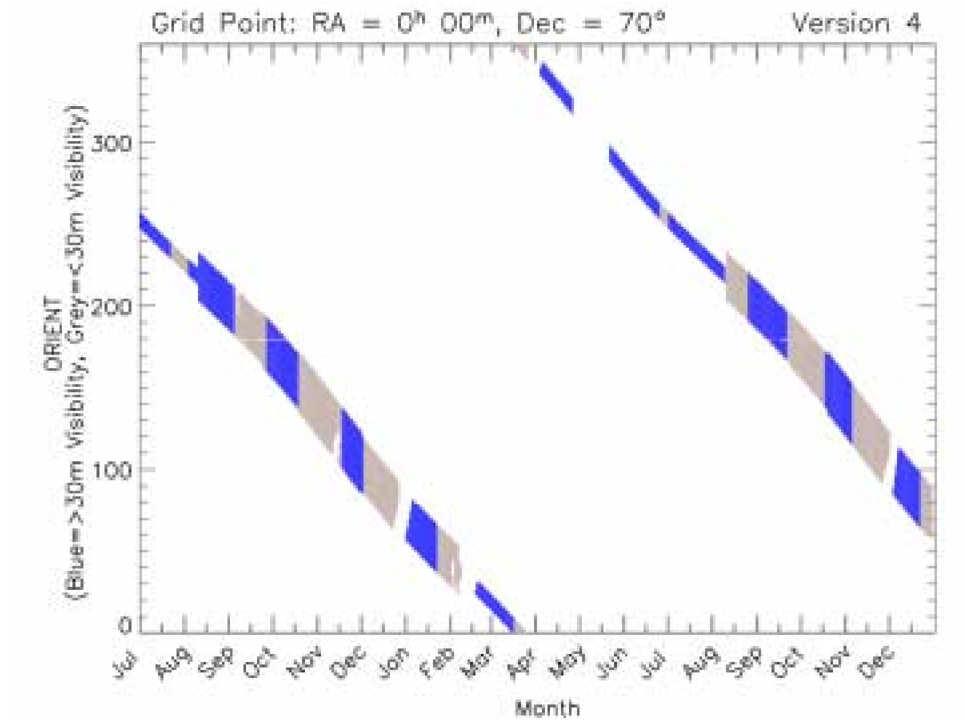


For the high latitude pointing in Figure 2.7, the availability of roll angles in two-gyro mode is broken into several time intervals separated by periods where the object is unobservable. These breaks in availability occur primarily because precession of the HST orbit causes the Earth to block the FHSTs, which are needed for guide star acquisitions.

Table 2.3: A Portion of the Tabular Output for the Data Shown in Figure 2.6

Grid Point: RA = $0^h\ 00^m$, Dec = 0°	
Date	**Available Orientations**
:	:
20-Sep-2006	216.6 - 276.6
21-Sep-2006	216.6 - 276.
22-Sep-2006	225.6 - 276.6
23-Sep-2006	223.0 - 31.0
24-Sep-2006	221.0 - 28.0
22-May-2007	241.6 - 251.6
23-May-2007	241.6 - 251.6
24-May-2007	241.6 - 251.6
25-May-2007	241.6 - 251.6
:	:

Figure 2.7: High-Latitude Target Roll Angles Available in Cycle 15



Plot Example: Target Visibility as a Function of Date

For constrained observations, the orbit visibility may change dramatically throughout the year, unlike unconstrained observations, the visibility cannot be described as a simple function of declination alone (e.g., Table 2.1). The web tool displays the visibility information in graphical form in a plot of target visibility versus time for an 18 month period beginning at the start of Cycle 15 (1 July 2006 to 31-Dec-2007). Plots for the low- and high-latitude sight lines are shown in Figure 2.8 and Figure 2.9. Sample tabular output for Figure 2.8 is shown in Table 2.4. The orbital visibilities in these plots are shown with blue points indicating the maximum visibility available, and by green lines indicating the full range of visibilities for the orientations available. In some instances, the maximum visibility depicted by the blue line may be identical to the minimum visibility in which case there is no green line, just a blue point.

The horizontal black line at 30 minutes in Figure 2.8 and Figure 2.9 indicates the minimum orbital visibility that will be allowed for Phase I proposals in Cycle 15 without special scientific justification. Most observations can be scheduled at times when the orbital visibility exceeds this amount, and those few that cannot will likely have other restrictions that will preclude such observations. For example, in the high-latitude example, the visibility window on 11 September 2006 is only 10 minutes. Therefore, a target at this location in the sky will not be scheduled on this date.

Figure 2.8: Orbital Visibility for a Low-Latitude Target in Cycle 15

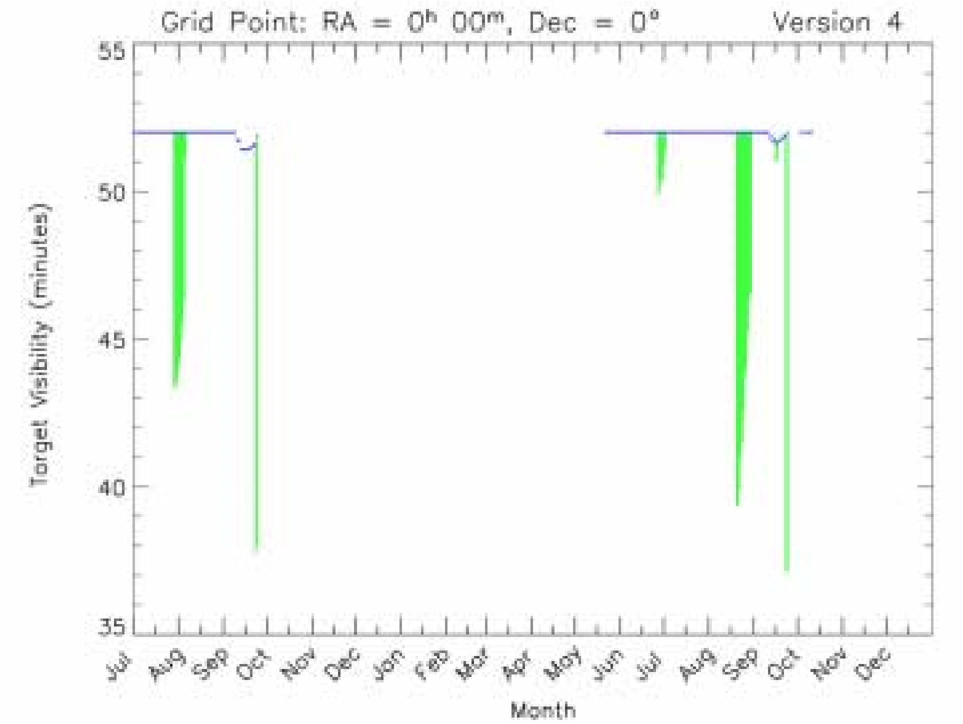
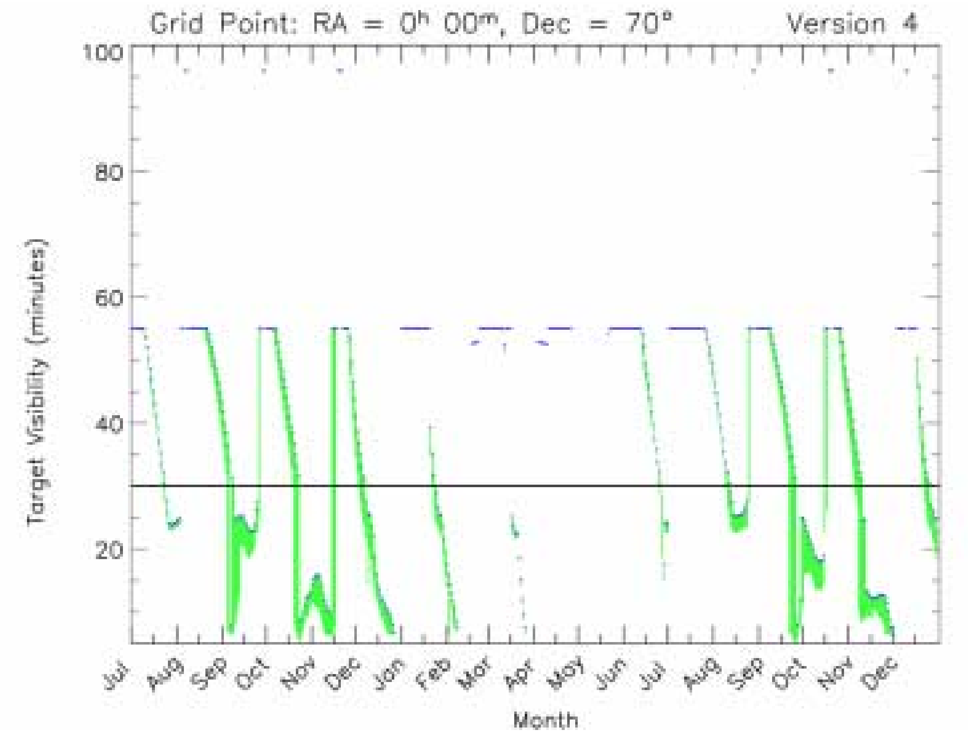


Table 2.4: A Portion of the Tabular Output for the Data Shown in Figure 2.8

Grid Point: RA = $0^h\ 00^m$, Dec = 0°		
Date	Science Time Available (minutes)	
	Two-Gyro (minimum)	Two-Gyro (maximum)
:	:	:
26-Jul-2006	52.0	52.0
27-Jul-2006	52.0	52.0
28-Jul-2006	52.0	52.0
29-Jul-2006	43.3	52.0
30-Jul-2006	43.4	52.0
31-Jul-2006	43.6	52.0
01-Aug-2006	44.0	52.0
02-Aug-2006	44.3	52.0
03-Aug-2006	44.9	52.0
04-Aug-2006	45.5	52.0
:	:	:

Figure 2.9: Orbital Visibility for a High-Latitude Target in Cycle 15



In calculating the orbit visibility period in two-gyro mode for Cycle 15, observers should adopt the maximum visibility estimate indicated by the blue points in the visibility plots unless they have both `ORIENT` and timing restrictions, in which case they need to examine the more detailed visibility plots described in the next section. The HST scheduling system will make every effort to schedule observations when the visibility is optimized.

Detailed Target Visibility Considerations

In some cases it may be necessary to have a more detailed look at the target visibility for various orientations on a particular date to assess whether a highly constrained observation is feasible. The Detailed Visibility Tool on the Two-Gyro Science Mode web page can be used to determine the target visibility. You can enter the target coordinates and the desired date of the observation, and the tool will return a plot and table of the science time available as a function of orientation for the 11 day interval centered on the input date.

Figure 2.10 contains an example of the detailed visibility plot for the low-latitude sight line example on a set of dates centered on 20 August 2007. The resulting visibilities are color coded by date. The information is shown in tabular form in Table 2.5. Observers requiring a specific orientation on a specific date should specify the appropriate visibility indicated by these plots (or tables) in their Phase I proposals.

Figure 2.10: Detailed Visibility Plot for a Low-Latitude Target

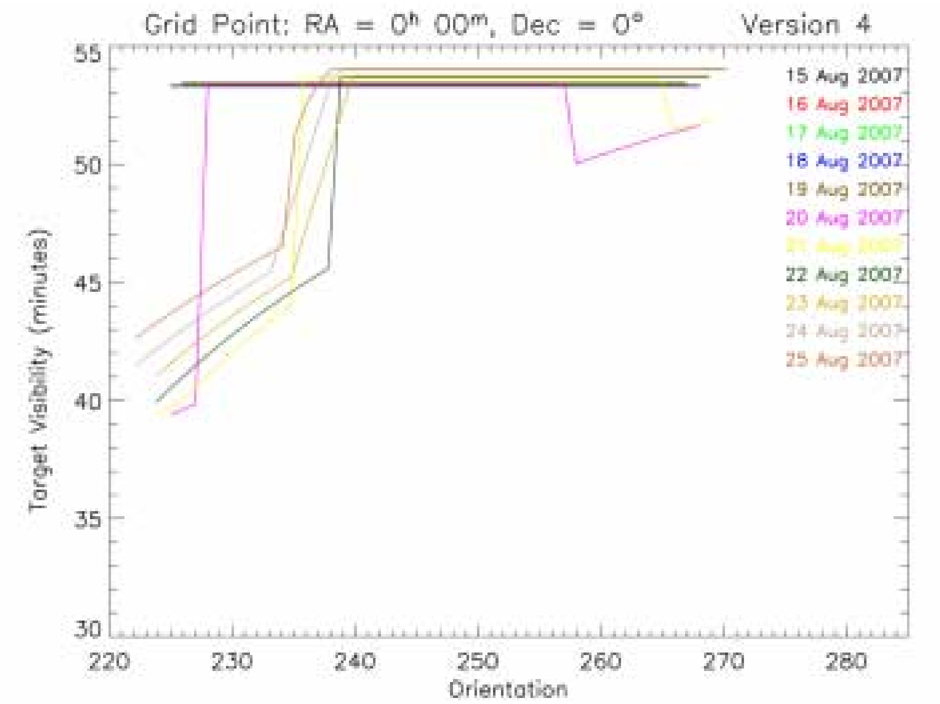


Table 2.5: A portion of the Tabular Output for the Data Shown in Figure 2.10

Orient	Year 2007				Orbital Visibility (minutes)						
	Aug 15	Aug 16	Aug 17	Aug 18	Aug 19	Aug 20	Aug 21	Aug 22	Aug 23	Aug 24	Aug 25
222	0	0	0	0	0	0	0	0	0	41	43
223	0	0	0	0	0	0	0	0	0	42	43
224	0	0	0	0	0	0	39	40	41	42	43
225	0	0	0	53	53	39	40	40	41	43	44
226	53	53	53	53	53	40	40	41	42	43	44
227	53	53	53	53	53	40	40	41	42	43	44
235	53	53	53	53	53	53	44	45	45	0	51
:	:	:	:	:	:	:	:	:	:	:	:
266	53	53	53	53	53	51	51	54	54	54	54
267	53	53	53	53	53	52	52	54	54	54	54
268	0	0	0	53	53	52	52	54	54	54	54
269	0	0	0	0	0	0	52	54	54	54	54
270	0	0	0	0	0	0	0	0	0	54	54

2.3.4 Examples

In this section we provide some examples of how to determine the schedulability and visibility period for different types of observations in two-gyro mode.

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Example 1: Time-series observations of the Hubble Deep Field
(HDF) and Hubble Ultra Deep Field (HUDF).
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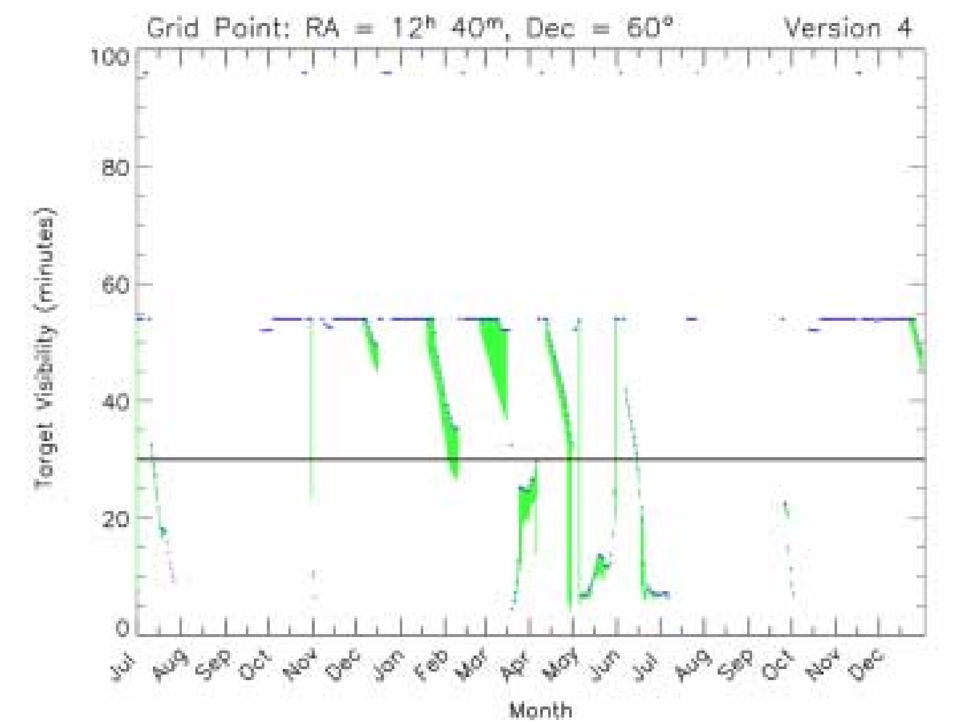
Observer #1 wants to search for supernovae in the HDF and HUDF by repeating a set of ACS observations every ~45 days for as many consecutive 45-day intervals as possible. The fields are tiled with multiple pointings, each of which has five 400 second integrations designed to fit in a single orbit. The total time required to tile either field is 15 orbits (~1 day). Orientation is not critical, as the field can be tiled in a manner that allows nearly full coverage of the field regardless of orientation. The HDF and HUDF are located at $\alpha = 12^h\ 32^m$, $\delta = +62°18'$ and $\alpha = 3^h\ 32^m$, $\delta = -27°\ 55'$, respectively.

Figure 2.11: Time Available per Orbit for the HDF in Cycle 15



Let's consider first the HDF. Using the on-line tool available at the Two-Gyro Science web site, we examine the scheduling and visibility plots available for the $\alpha = 12^h\ 40^m$, $\delta = 60°$ grid point. The plot of number of available days versus orientation shows that there are many days in Cycle 15 that the HDF is observable in two-gyro mode provided that the orientation is greater than ~130 degrees. Since Observer #1 does not have an orientation constraint, we skip the plot of orientation versus month and proceed directly to the plot of visibility versus month. From this plot (Figure 2.11), we see that good visibility is achievable for this program throughout much of the year.

This program could be conducted with a set of 4 observing opportunities spaced ~45 days apart (e.g., 01-Oct-2006, 14-Nov-2006, 29-Dec-2006, 12-Feb-2007). The science times available per orbit on these dates are listed in Table 2.6. A larger set of observations may be difficult to schedule since the next opportunity in this set (March 29) has very poor visibility. When dealing with visibilities that change rapidly over the course of a month, flexibility in time series spacing may improve the schedulability. For example, in this case allowing a 55 day separation from February 12 to April 8, instead of the 45 day spacing between February 12 and March 29, would increase the visibility sufficiently to make another epoch of observations possible.

Table 2.6: Two-Gyro Time for the HDF on Selected Dates in Cycle 15

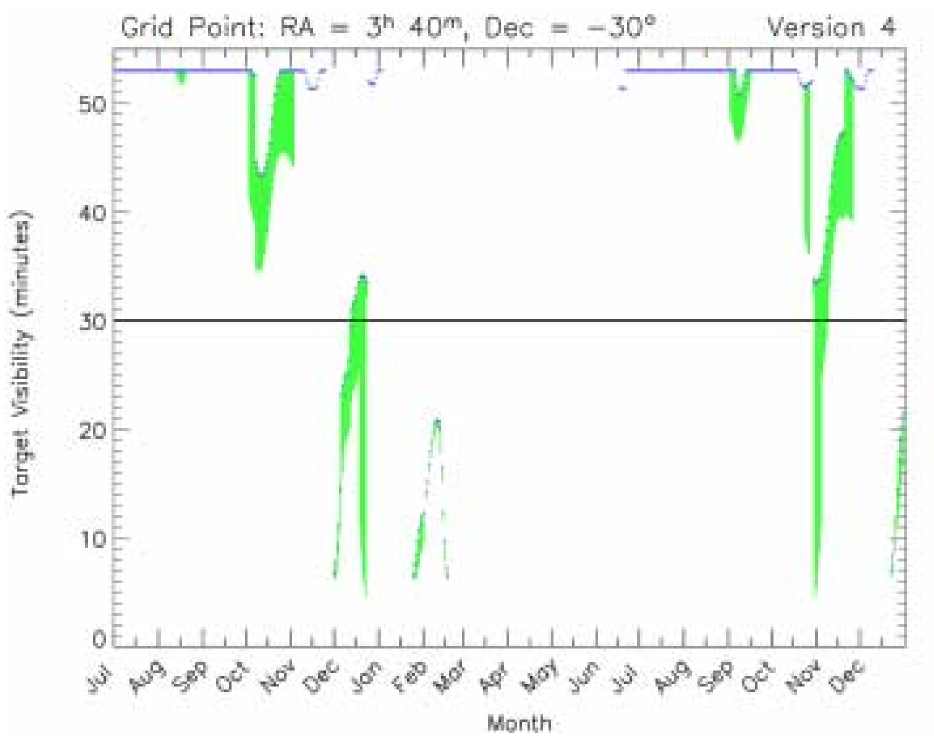
Observation Date	Time per Orbit (minutes)
01-Oct-2006	52
13-Nov-2006 14-Nov-2006 15-Nov-2006	53 52 54
28-Dec-2006 29-Dec-2006 30-Dec-2006	54 54 54
11-Feb-2007 12-Feb-2007 13-Feb-2007	54 54 96
28-Mar-2007 29-Mar-2007 30-Mar-2007	25 25 25

Now consider the HUDF. Using the on-line tool available at the Two-Gyro Science web site, we examine the scheduling and visibility plots available for the $\alpha = 3^h\ 40^m$, $\delta = -30^\circ$ grid point. The possibilities for scheduling a series of observations with a spacing of 45 days is more limited due to the gap from mid-December 2006 to June 2007. Starting the series as early as possible is the only way to obtain four observing opportunities.

Table 2.7: Two-Gyro Time for the HUDF on Selected Dates in Cycle 15

Observation Date	Time per Orbit (minutes)
01-Jul-2006	53
14-Aug-2006	53
28-Sep-2006	57
12-Nov-2006	52

Figure 2.12: Time Available per Orbit for the HUDF in Cycle 15



`Example 2: Time-series light curve observations of a supernova found in Example 1.`

Observer #1 finds a supernova in the HDF using the experiment outlined in Example 1 and wants to obtain the light curve of the supernova by obtaining photometric images of the supernova and surrounding field once a week for 7 weeks. The supernova was discovered after the fourth set of observations was obtained on 12 February 2007.

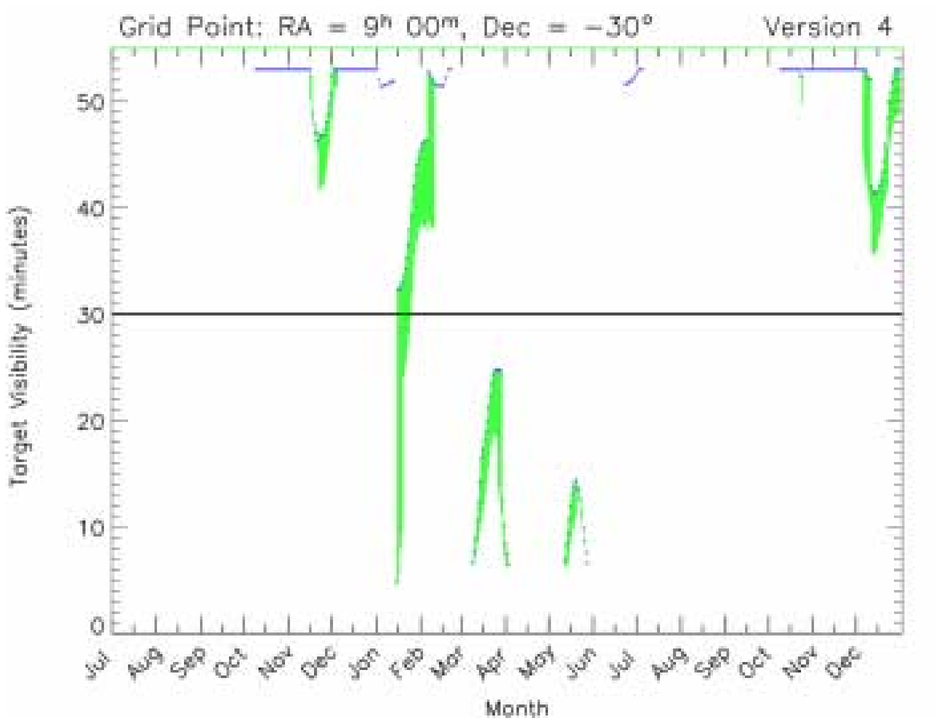
Using the visibility versus month plot generated for Example 1, Observer #1 notes that the orbital visibilities for the HDF and surrounding areas are good on February 19 and 26 (54 minutes) as well as March 5 and 12 (54 and 53 min, respectively). However, by March 19 the visibility has dropped to 33 minutes, and by March 26 it is only 25 minutes. Thus, it is not possible to follow the supernova light curve throughout the entire 45 day period as hoped.

If the supernova had been found after the second epoch observations of the HUDF (instead of the HDF), it would have been possible to follow the light curve for the full 45 day interval between 14 August 2006 and 2 October 2006 (see Figure 2.12).

```
Example 3: Time-constrained observations of recurrent nova T Pyx.
```

Observer #3 wants to observe the recurrent nova T Pyx ($\alpha = 9^h\ 05^m$, $\delta = -32^\circ\ 23'$) during its next outburst, which should begin in early October 2006. The objective is to study the evolution of the ejected shell using images (3 orbits with at least 46 minutes of visibility) obtained as soon as possible after outburst, followed by images 7, 21, 49, 84, 112, 140, and 365 days later. There are no orientation constraints on the observations. Observer #3 estimates the science time available using the web tool plot of visibility versus month shown in Figure 2.13 for the nearby position at $\alpha = 9^h\ 0^m$, $\delta = -30^\circ$ (see also Table 2.8).

Figure 2.13: Time Available for T Pyx in Cycle 15



Examination of this plot provides the following information (assuming a 9 October 2006 start) for the relative timing of the observations and the amount of science time available per orbit.

Table 2.8: Two-Gyro Time Available for T Pyx on Selected Cycle 15 Dates

Observation Date	Relative Timing (days)	Time per Orbit (minutes)
09-Oct-2006	0	53
16-Oct-2006	7	53
30-Oct-2006	21	53
27-Nov-2006	49	48
01-Jan-2007	84	53
29-Jan-2007	112	44
26-Feb-2007	140	0
09-Oct-2007	365	53

Two of the observations have less than the 46 minutes of visibility needed for this particular science investigation, and are therefore not suitable choices for this time series. The day 112 observation would need to be moved back to February 3, while the day 140 observation would need to be moved to February 22. Since these observations have moved closer together, Observer #3 decides to drop the day 140 observation. A possible revised series of observations is given in Table 2.9.

Table 2.9: Revised Two-Gyro Time Series for T Pyx in Cycle 15

Observation Date	Relative Timing (days)	Time per Orbit (minutes)
09-Oct-2006	0	53
16-Oct-2006	7	53
30-Oct-2006	21	53
27-Nov-2006	49	48
03-Feb-2007	117	46
09-Oct-2007	365	51

However, while the outburst is expected around the beginning of October, it could occur later in the month, so it is necessary to check how a later outburst would impact the observations. With start dates of October 16, 23, and 30, the following sequences listed in Table 2.10 are possible. Thus, if T Pyx goes into outburst anytime in October, the observations can be successfully obtained in two-gyro mode.

Table 2.10: Alternate Time Series for T Pyx in Cycle 15

Observation Date/Timing	Time per Orbit (minutes)	Observation Date/Timing	Time per Orbit (minutes)	Observation Date/Timing	Time per Orbit (minutes)
16-Oct-2006 / 0	53	23-Oct-2006 / 0	53	30-Oct-2006 / 0	53
23-Oct-2006 / 7	53	30-Oct-2006 / 7	53	06-Nov-2006 / 7	53
06-Nov-2006 / 21	53	13-Nov-2006 / 21	53	20-Nov-2006 / 21	47
04-Dec-2006 / 49	53	11-Dec-2006 / 49	53	18-Dec-2006 / 49	53
08-Jan-2007 / 84	52	...	...	...	...
05-Feb-2007 / 112	46	12-Feb-2007 / 112	52	19-Feb-2007 / 112	52
16-Oct-2007 / 365	53	23-Oct-2007 / 365	53	30-Oct-2007 / 365	53

```
Example 4: An orientation-constrained observation of the
Vela supernova remnant.
```

Observer #4 wants to take an ACS image of a portion of the Vela supernova remnant near the position of the star HD 72089 ($\alpha = 08^h\ 29^m$, $\delta = -45^\circ\ 33'$). A roll angle of 70 5 degrees must be used to keep the bright star off the detector. A second observation to observe a different part of the remnant requires an orientation 90 5 degrees from the first observation.

Entering the coordinates of HD 72089 into the scheduling tool on the web yields the following plots of the number of days each orientation is available (Figure 2.14) and orientation versus month (Figure 2.15) for the nearby position at $\alpha = 8^h\ 20^m$, $\delta = -45^\circ$. It is apparent from these plots that an orientation of 70 degrees cannot be achieved in two-gyro mode at any time in Cycle 15.

Realizing that the planned orientations are not viable, Observer #4 checks the availability of orientations 180 degrees from those originally envisioned. The inverse orientations at 250 degrees and 340 degrees are accessible in October 2006 and December 2006, respectively. Therefore, this observation is feasible in two-gyro mode as long as the requested orientations are changed to 250 5 degrees and 340 5 degrees. The availability of allowable orientations must be described appropriately in the Phase I proposal.

Figure 2.14: Cycle 15 Orientation Availability in the Direction of the Vela SNR

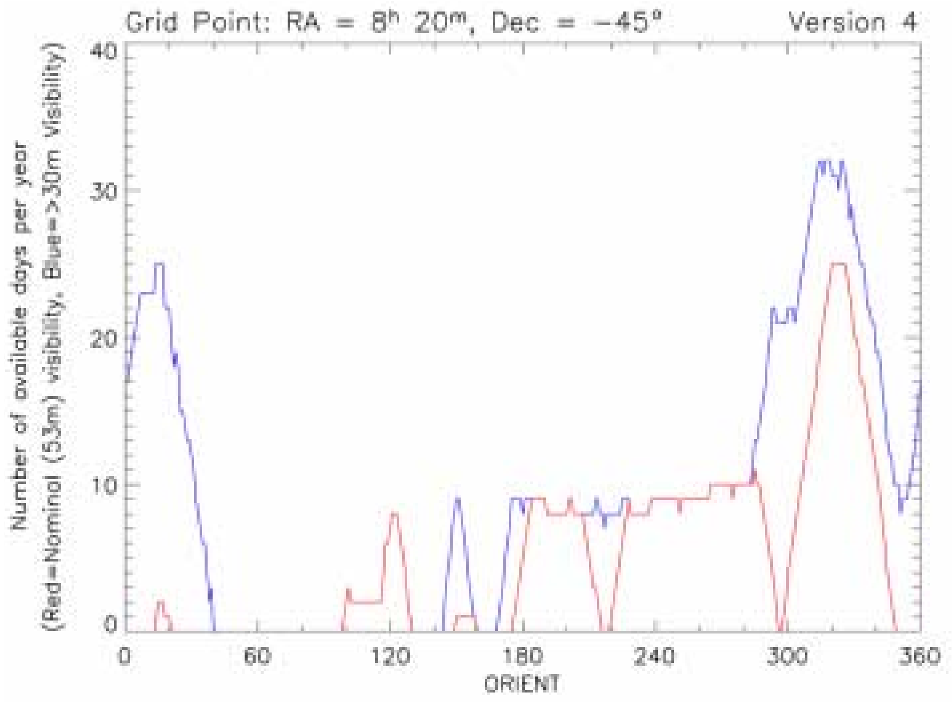
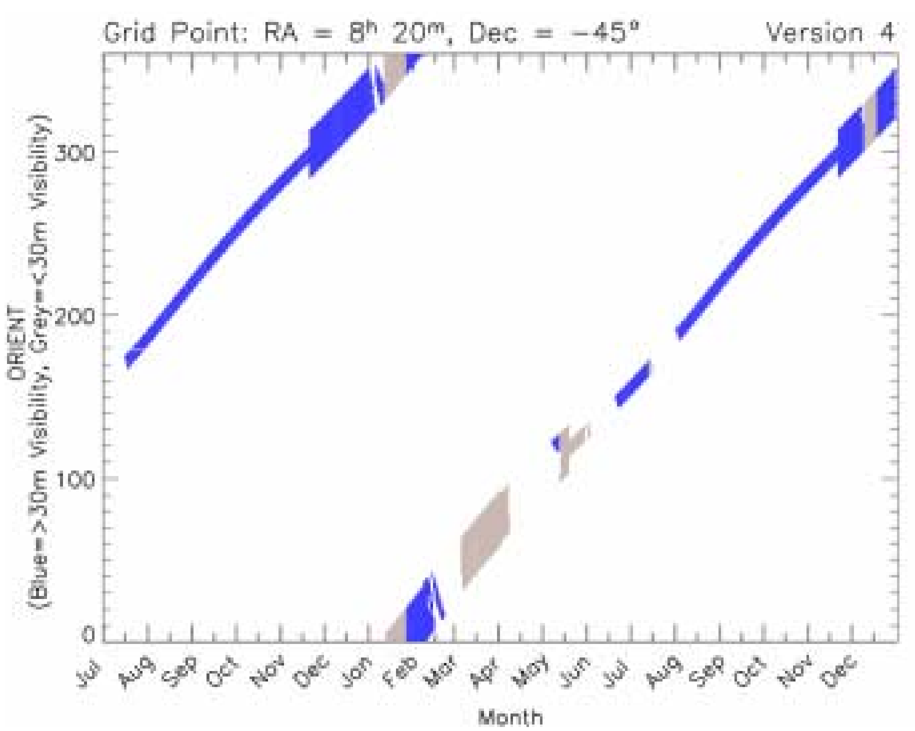


Figure 2.15: Cycle 15 Orientation Angles Versus Month Toward the Vela SNR



2.4 Verifying Scheduling Constraints for Phase I

The Astronomer's Proposal Tool (APT) package contains software to check the schedulability of targets in Phase I proposal forms. When filling out the APT form for their Phase I proposals, Cycle 15 proposers will be asked to verify the availability of their targets in two-gyro mode. Observers should perform this check after they have entered their observation information based upon the tables and plots discussed in the previous sections of this chapter.

2.5 Two-Gyro Orbit Calculations for Phase I

The visibility period for two-gyro observations should make use of the two-gyro visibility periods from the plots and tables described in this chapter. The tools for creating these plots and tables are available on the Two-Gyro Science Mode web site. Exposure times for two-gyro observations should be calculated with the appropriate two-gyro exposure time calculators (ETCs) for each instrument. In most cases, these are the same ETCs as were used for three-gyro mode since the instrument performance in both cases is nearly indistinguishable. Links to these ETCs can be found on the main web page for each instrument.

2.6 Continuous Viewing Zones

The continuous viewing zones (CVZs) are regions of the sky where HST can observe without interruptions caused by target occultation by the Earth. These zones are approximately 24 degrees in size centered on the orbital poles, which are 28.5 degrees from the celestial poles. Thus, targets located in declination bands near 61.5degrees may be in the CVZ at some time during the 56-day HST orbital precession cycle. The CVZ interval duration depends upon the telescope orbit, target position, and constraints imposed by Sun and Earth limb avoidance. South Atlantic Anomaly crossings limit the uninterrupted visibility of any target to no more than 5-6 orbits (see Section 2.3.2 in the *HST Primer*).

The CVZs in two-gyro mode will be the same size as those in three-gyro mode, but the durations may be shorter because of more restrictive pointing constraints. To determine whether constrained two-gyro observations qualify for CVZ time, observers should consult the visibility tables and plots, like those discussed above. Only those observations for which the orbital visibility is 96 minutes should be considered CVZ candidates.

2.7 Moving Targets

We expect that there will be no significant impact of two-gyro operations on moving target observations other than that gyro-only tracking and guide star handoffs are not available in two-gyro mode. Proposers wanting to observe moving targets should consult the Two-Gyro Science Mode web page for updates, which will be posted as information about observing moving targets in two-gyro mode becomes available.