

Maintaining Scheduling Efficiency in a Two-Instrument Environment: Reducing the Competition for SAA-Free Orbits

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January 29, 1999

ABSTRACT

An ad hoc working group met in October and November of 1998 to discuss the effect on HST scheduling efficiency of both STIS and WFPC2 competing for the same SAA-free orbits after NICMOS end-of-science. If nothing were done, the HST observing efficiency would decline from ~45% to ~27% from November 1998 to June 1999. We discussed possible changes in the ground system and in some of the observing programs to prevent this inevitable decline in observing efficiency if no action were taken. Out of the five options discussed, three have been implemented: reducing the size of the WFPC2 SAA-avoidance contour, restricting WFPC2 alignment times to 22 minutes or less whenever possible, and, unless scientifically justified, restrict all visit durations to no more than 5 orbits.

1. Observing Efficiency in a Two-Instrument Environment

During the 1997 servicing mission the opto-isolators on STIS and NICMOS were seen to trigger randomly during passage through the South Atlantic Anomaly (SAA). For STIS, this represented a health and safety danger since a triggering of an opto-isolator in the MAMA control electronics could cause an uncontrolled ramping of the MAMA high voltage. To minimize this risk, STScI operations currently impose the following restrictions on using the MAMA detectors:

- The low-voltage power supplies to the MAMA detectors are turned off each time HST passes through the SAA.
- Furthermore, to reduce the wear and tear of repeated on/off cycling, the MAMA high voltage power supplies are turned on only at the start of the period of SAA-free contiguous orbits each day and turned off at the conclusion of the SAA-free contiguous period.

As a result of these restrictions, STIS MAMA science and calibration observations can be taken only during contiguous SAA-free orbits. To increase the time available for MAMA observing, the operational STIS MAMA and CCD SAA-avoidance contour sizes were reduced and changes were made to the ground system management of MAMA operations. However, despite these changes, only an average of 7.3 contiguous SAA-free orbits are available per day. On a given week's calendar, a maximum of 41 SAA-free orbits (about 45% of the "observing" time) is available for actual MAMA observing.

With only two major instruments in the current HST complement (WFPC2 and STIS), this limitation on STIS observing posed rather severe scheduling constraints. This scheduling problem was exacerbated by the fact that a large fraction of the WFPC2 observations (~45%) also required SAA-free contiguous orbits. With 62% of all WFPC2 and STIS observations requiring SAA-free orbits, almost two-thirds of the entire observing pool competed for less than half of the available observing time. If no changes were made, not only would science programs drag out in time, but, more importantly, the Planning and Scheduling System would not have enough visits to fit into the SAA-intersected orbits to fill a given week's schedule. This would result in a rather severe drop in the observing efficiency of HST: from 45% in November 1998 to an estimated 27% by July 1999. Observations that were scheduled for execution in the long range plan would begin to fall off, and the time to complete Cycle 6, Cycle 7, and Cycle 8 observations would expand even further beyond their advertised end-of-cycle dates.

2. Options Considered and Actions Taken

A working group consisting of Stefi Baum, John Biretta, Wayne Kinzel, Danny Golombek, Anurhada Koratkar, Merle Reinhart, Brad Whitmore, and Jim Younger met several times during October and November of 1998 to identify and study possible ways to alleviate this problem.

2.1 Reduce the size of the WFPC2 SAA-avoidance contour

WFPC2 and FGS science use the largest SAA-avoidance contour of any HST instruments. This limits the scheduling flexibility of WFPC2 observations, since it means there are, on average, slightly shorter visibility periods available for WFPC2 visits than for other Science Instruments having smaller contours (such as STIS). Examination of the cosmic ray rates as a function of HST position suggested that the size of the WFPC2 SAA contour could be reduced while keeping the increase in cosmic ray hits within an acceptable range for normal observing.

Action taken

The WFPC2 group provided a new avoidance contour and it has been implemented in the ground system. The FGS and WFPC2 instruments now have separate SAA contours which has the added benefit of making any future changes simpler and easier to make.

Effect on operations and science

All of the remaining WFPC2 proposals have to be reprocessed through Transformation to take advantage of the new contour. The cost to WFPC2 science is relatively small, since most WFPC2 images will see little or no increase in cosmic ray flux. For most HST orbits, the spacecraft is in the new region (formerly included in the old WFPC2 SAA contour) for only 1 to 2 minutes, hence the number of extra cosmic ray hits is small. However, there are some HST orbits where the spacecraft is in the new region for 10 contiguous minutes, and long exposures taken in this circumstance will suffer a factor ~4 increase in cosmic ray hits and the data may be compromised. We estimated the fraction of seriously affected WFPC2 images at <0.1% (about 6 orbits), possibly resulting in a few HOPRs and repeated observations.

2.2 Restrict the alignment times of WFPC2 observations to less than 22 minutes

The smallest fundamental scheduling unit of the ground system is an alignment. Transformation (TRANS) forces a new alignment each time there is a change in pointing. Formerly, the default in the absence of a change in pointing was to allow an alignment to be up to a full visibility period (i.e., an orbit) in length.

Action taken

The default alignment period was changed in TRANS from the maximum visibility period (typically 45 minutes) to 22 minutes for WFPC2 observations, thus increasing the flexibility of scheduling WFPC2 visits in SAA-intersected orbits. We estimated that this will alleviate ~75% of the scheduling problem.

Note: A similar change to STIS observations was not made because of the limited lifetime of the STIS external shutter which is closed after each alignment.

Effect on operations and science

All of the remaining WFPC2 observations need to be reprocessed through TRANS to incorporate this change. The science cost of breaking WFPC2 visits into smaller alignments is a small increase to alignment overheads (2 to 3 minutes), which can result in an increase in the number of orbits for a given visit (usually 1).

The total number of orbits required to carry out the entire WFPC2 program would expand by roughly 10%, due to some spillage into additional orbits beyond the original program allocation. A similar cost will not be incurred in Cycle 8, because GOs submit their proposals using the modified RPS2/TRANS which would automatically split their alignments. However, the shortened alignments will allow for more tightly packing of the overall schedule which should offset this slippage. It is possible that the overall scheduling efficiency of HST actually will improve.

2.3 Break long visits requiring SAA-free orbits into two or more visits

Very long visits are difficult to schedule for all instruments. Accordingly, the maximum size allowed for a single visit, except in special circumstances, has been steadily decreased for all instruments over time, and the ad hoc group recommended that it be reduced to 5 orbits.

As of November, 1998, the scheduling pool had roughly 63 WFPC2 visits and 31 STIS visits longer than 5 orbits. Many of these “long visits” come from Cycle 6, a time before shorter visit limitations were imposed, and they must schedule in contiguous SAA-free orbits because these times are the only periods long enough to be free of SAA interruptions, even for WFPC2. If visits longer than 5 orbits are broken up into smaller visits, (e.g., a 6-orbit visit broken into two 3-orbit visits), they can be scheduled in SAA-intersected orbits and no longer will compete for MAMA observing time.

Action taken

In December 1998, STScI sent letters to all affected GOs (44 for WFPC2 and 15 for STIS) requesting that they break up these long visits into smaller ones, and to insert Special Requirements if they wanted the observations executed within a certain period of time (e.g., GROUP

WITHIN 60 DAYS) or with the same orientation. This would alleviate ~35% of the problem if this was done for all programs. We estimated that 50 to 75% of the GOs would make the changes, resulting in a net 20 to 25% net effect on the problem.

Effect on operations and science

Contact Scientists will have to review all revised programs (approximately 100 visits in 60 programs), and the Program Coordinators will have to reprocess them after they are resubmitted and get them back on the Long Range Plan (LRP). Scientifically, the primary difficulty with splitting the visits is pointing errors introduced when a full-acquisition occurs instead of a re-acquisition. The full acquisitions are expected to introduce ~30 mas of pointing error (0.7 PC pixel), and this would corrupt fractional pixel dithers which are used by most of these long visits.

There are, however, many cases where the sequence of exposures could be changed so as to minimize the effects of pointing errors. Therefore the GO would not only have to split up their long visits into shorter ones, but also would have to restructure some of the visits to minimize the pointing errors. The incentive for the GO to make these changes is that the expected execution date for their observations will be sooner, on average, than if they don't make the changes (i.e., they will remain in the LRP in their current locations rather than often being bumped out by STIS MAMA observations).

2.4 Change the default WFPC2 exposure adjustment in TRANS

The original plan was to change the default for the amount of time an exposure could be shortened to be the same as for STIS (20%). Unfortunately, this turned out not to be a useful option since some Cycle 6 and 7 WFPC2 programs were not designed with automated shortening in mind.

Action taken

No action was taken on this option.

2.5 Change default from SCHED30 to a more flexible scheduling factor

The current default for all instruments is SCHED30, that is, to require the ground system to schedule all visits in the 30% of times where the orbital visibility duration is maximized. However, in practice, use of the more flexible SCHED100 factor has very little effect on the duration of the orbit visibility for most declinations. We discussed an implementation in the ground system where a declination-dependent SCHED factor following a simple orbit time rule, such as the change from SCHED30 should be less than 5 or 10% of the SCHED30 visibility time.

This would not directly alleviate the specific problem imposed by competition with the MAMA observations, however it would increase the overall scheduling flexibility, by reducing competition for unique scheduling slots.

Action taken

No action was taken on this option, since other options considered were much more efficient in addressing the problem. This is an option that could be reconsidered in the future, if necessary.