Report of the Space Telescope Users' Committee (STUC) Meeting, 19-20 April 2006

STUC Members Present: D. Axon, M. Elvis (Chair), E. Emsellem, L. Ferrarese, M. Matteo, P. McCarthy, R. O'Dell, R. Schulte-Ladbeck, M. Tosi, M. Vestergaard, D. York.

Note: Each section below begins with a short summary of the presentation, and ends with comments by the STUC (*in italics*).

In opening the STUC was pleased to note that essentially all the requests for agenda items from the previous meeting were included in this meeting. Such responsiveness by NASA and STScI is gratifying.

STScI OUTLOOK (Matt Mountain)
The STScI Director outlined the state of the Hubble Space Telescope (HST) mission.

Recent science highlights include: (1) the Cycle 15 results, for which 733 proposals were received. A growing use of NICMOS for extragalactic research was a feature of Cycle 15. (2) The transition to 2-gyro mode operations has resulted in negligible image degradation when multi-drizzle is used. (3) The HUDF/GOODS survey has found over 500 z>6 galaxies, requiring strong galaxy evolution shows that HST can address the epoch of reionization. (4) Galactic results (e.g. the Orion Treasury image) and (5) solar system results (e.g. the new moon of Pluto) demonstrate the continuing breadth of HST science.

The NASA budget situation has changed dramatically since the last STUC meeting.
In order to fund the Shuttle return to flight, ISS (International Space Station) completion and the Crew Exploration Vehicle (CEV) as a replacement for the Shuttle, the NASA Administrator, Mike Griffin, has moved $3B from the science budget over the next 5 years. The Universe Division (soon to be the Astrophysics Division) is down 25% (in constant dollars) in funding by FY11, to about $1.3B/yr. However this is still a substantial sum, and science overall is still around 1/3 of the NASA budget. In order to carry out the astronomy program envisaged NASA is concentrating on completing the highest priority missions first, which in practice means the HST SM4 (servicing mission #4) and the James Webb Space Telescope (JWST). This has caused much controversy in the astronomy community as other missions have been cancelled or deferred to enable the completion of JWST. The Director felt that this has led to criticism of 'flagship' missions, such as JWST, that does not take into account the high productivity of these missions, their enabling of many diverse research programs, their demonstrated capability to produce surprising results, and their nurturing of a new generation of astrophysicists.

The Director asked the STUC's opinion on a proposal to manage the float in grant funds more precisely, as is done at NSF. Currently HST grant funding sits in the US Treasury for 2-3 years as universities are typically slow to bill STScI. The Institute proposes to work with the PIs receiving the largest grants in Cycle 15 to phase the commitment of

funds better. It is estimated that this could free up $6M in float funds this fiscal year that would then become available for SM4 activities.

The Director also asked STUC for advice on whether to move HST funding to a formula-based approach, like Spitzer, obviating the need for a phase II proposal, saving several weeks of work at STScI and no longer requiring a Financial Review Committee (FRC). There would also be the advantage that a formula is more transparent, and less open to the appearance of subjectivity.

STScI will be sponsoring a workshop on "*Astrophysics enabled by the Return to the Moon*" (December 5-7 2006 at STScI) to explore whether the new space infrastructure capabilities made available by the Moon-Mars initiative can be valuable for astronomy. The outcome of the workshop is envisaged to be a position paper that can be used as input to next decadal survey, which will begin work in about 2 years.

The Director has called for a review of Director's Discretionary (DD) time award procedures, following a possible duplicative DD observation.

The STUC fully endorses and encourages the Institute's and Project considerable work to maintain HST as a healthy, productive facility for years to come. This includes the efforts to make SM4 a complete success, continuation of improvements in data processing and reduction tools for existing and future HST instruments, and maintaining viable scientific and technical expertise at the Institute to support and employ the telescope effectively as a powerful science resource.

Improved float management for the large projects seems prudent.

The STUC sees the relatively small savings from a formula-based grant system as less important than the loss of flexibility in funding to cope with the wide range of data analysis challenges presented by HST programs. We see no problem with the perceived fairness of the FRC.

The "Astrophysics enabled by the return to the Moon" workshop is an interesting and timely exercise.

A review of DD policy seems wise.

PROJECT STATUS AND PROGRAM [Jennifer Wiseman, Preston Burch, Dave Leckrone]

Jennifer Wiseman, the HST Program Scientist, presented the NASA HQ view of HST.

The new NASA Science organisation chart has 5 divisions: Heliophysics, Earth sciences, Planetary, Astrophysics (R. Howard, acting head), and Management/Policy.

The NASA science budget is down overall by several $100M/yr in the FY07 (Fiscal Year 2007) budget compared with previous plans; this still represents a 1%-1.5% growth over FY06. Increased costs for ISS and Shuttle are more of a driver for the science budget in FY07 than the Moon/Mars initiative. These costs mean that, as NASA needs an 'executable program' for science (i.e. one that can be carried out within the budget), NASA has had to cancel or defer many missions, and has put SOFIA 'under review'. In addition the Research and Analysis (R&A) budget, which funds small guest observer programs, the Astrophysics Data Program (ADP) and used to fund the Long Term Space Astrophysics (LTSA) program, is down 15%. The Planet finding ('Navigation') missions and the 'Beyond Einstein' programs have suffered most. Specifically NASA has: delayed the Space Interferometer Mission (SIM) launch to be no earlier than (NET) 2015; deferred Terrestrial Planet Finder (TPF) indefinitely; and cancelled the Keck interferometry outrigger telescopes; The *Beyond Einstein* missions [LISA, Constellation-X and the Joint Dark Energy Mission (JDEM)] will be executed one-at-a-time rather than in parallel. However, the operation of the three operating Great Observatories is unchanged: Chandra is planned to operate to 2011; Spitzer through to the time of the loss of cryogen, plus an extended 'warm' phase.

The immediate outlook for new missions remains quite good. GLAST has been re-baselined due to issues with its main instrument (the Large Area Telescope, LAT) for launch no earlier than 9/07. NASA Herschel, Planck involvement continues. The planet finding Kepler and infrared survey WISE (Widefield Infrared Survey Explorer) missions are preparing for launch and will be operating 2007-2010. However, after 2013 only JWST and SIM are now in the plan, leading to a significant reduction in the number of missions.

The reactivated NASA advisory groups will meet next month. The Senior review of the operating small missions will occur next week, and it is quite likely that some missions will be closed down.

The STUC appreciates receiving a presentation from NASA HQ following our request at the previous meeting to have such a perspective. We hope that this practice can be followed at least annually.

Dave Leckrone, the HST Project Scientist at GSFC, presented reports on several issues.

A report of the Wide Field Camera 3 (WFC3) contamination program, prepared by David Hughes, was presented in response to an earlier STUC request SLIC (Super LIghtweight Carrier). The hydrocarbon coating on the pick-off mirror of WFPC1 was diagnosed, after the return of WFPC1 to Earth, to have come from a new FGS, not from the outside the spacecraft. Hence the contamination did not come from the instrument carrier or anywhere in the Shuttle cargo bay. The SLIC, which will carry WFC3 in the Shuttle bay on SM4, already almost passes the contamination tests before bake out. Bake out will reduce any contamination by orders of magnitude; moreover pathways for contaminants to reach the optic surfaces of WFC3 have been designed out.

It appears that the project is fully sensitive to this matter and is taking all prudent steps to assure that contamination is not a problem. STUC thanks Project for their responsiveness to our concern.

A preview of a presentation to be given at NASA HQ on the value of 'flagship' missions was given.

HST Program Status: [Preston Burch]

There has been no major change in the health of the HST spacecraft since the last STUC meeting in October 2005.
Battery tests are now underway. So far battery #6 has been tested and it showed no loss of capacity.

Servicing Mission #4 (SM4):
The project is working to preserve the option of a December 2007 launch for SM4. (Which puts us now at launch –20 months), and is pushing to have a crew named by June 2006. Delays would be unfortunate as they cost $12M/month and increase post-flight costs, so that a 6-month delay would have a total cost $130M. Moreover, the gyros drive the science lifetime and have a 50% chance of one gyro failure in mid-2008. Promising work is proceeding on a contingency 1-gyro mode, employing the magnetometers in a novel way. Even if science operations have to be suspended before SM4 due to gyro failures, it is the batteries which are the drivers on HST spacecraft life, and these are expected to be adequate until late 2009. So SM4 will remain viable for some time to come.

Note that SM-4 is not an approved mission but is dependent on the outcome of the next Shuttle flight, STS-121. STS-121 need not be perfect, but must be good enough to demonstrate that planned work will make the next flight fully acceptable. The ISS Columbus module is highly likely to use the first flight after STS-121. If so then SM-4 would be expected to take place April-May 2008.

The SM4 manifest priorities are:

1. HST mission life extension. [Gyros, batteries, FGS, insulation blankets];
2. Science instrument upgrades. [WFC3, COS];
3. Science instrument restoration [STIS]. Work on STIS repair planning is going well, with the first buoyancy tank tests with astronauts being successful.

The installation of both the Aft Shroud Cooling System (ASCS), and of the Data Handling cross-strap (DSC) have been eliminated from SM4. No reboost of HST is needed during SM4 as HST will 'fly over' solar cycle 24 without significant loss of altitude.

The 5-day EVA timeline for the astronauts to carry out all the servicing tasks on SM4 is crowded, but the deletion of the ASCS relieves the pressure. If fewer EVA days are available, e.g. to allow time for the inspection, and possible repair, of tiles on the Shuttle, there may be a need to choose e.g. between COS and WFC3 and STIS. NASA wants community input on priorities well in advance. For previous SMs STScI has used the STUC to provide instrument priorities.

Post-SM4 Operations plans assume a 5-year post-SM4 science observation mission for HST, followed by a 2-year data analysis phase. NASA must continue to monitor the spacecraft health and safety until reentry.

The STUC is pleased to see SM4 planning proceeding well, notably promising state of the STIS repair tests.

The STUC wonders what the cost of ASCS was. Are there 'lessons learned', or does the decision to build ASCS still seem prudent, given the information available at the time?

We would be like to hear about contingencies in the case of reduced EVAs at the next STUC meeting.

STUC would like to hear a discussion of what happens to STIS programs terminated by failure, if SM4 succeeds in reviving STIS?

CYCLE 15 RESULTS [Duccio Macchetto]

Cycle 15 had roughly a 4:1 oversubscription in all categories. The GO oversubscription has been lower since STIS died. The acceptance rate for GO programs was again roughly independent of program size. The ESA program share was about 15%. The main science categories were: cosmology (32%), unresolved stellar populations in galaxies (20%), resolved stellar populations in galaxies (18%), a total of 70% of the available HST observing time.

With 3 years of experience in hand the scientific productivity of Large and Treasury programs can now begin to bed assessed. Their publications/orbit rate is similar to regular GO programs. Citations are only just becoming useful for these big programs and they appear to garner 1.5-2 times more cites/orbit than normal GO programs

The Call for Proposals for Cycle 16 will be issued in the fall of 2006. The instruments available to propose for will depend on the outcome and timing of SM4. STScI needs to be ready with COS, WFC3 documentation and tools. The TAC will need to prepare for both pre- and post- SM4 instrument suites. Post-SM4 observing time will be 6 months only if SM4 happens in December 2007; the amount of time available with the new/restored instruments drops rapidly as SM4 is (hypothetically) delayed.

The STUC, several of whose members were participants in the Cycle 15 TAC, was pleased to find that the Cycle 15 instructions to applicants and to panel members were clearer than in the past, and the whole process was smoothly executed.

GREAT OBSERVATORIES WORKSHOP [Neill Reid]

A small workshop has been organized jointly with the Spitzer and Chandra mission centers to consider the science enabled by joint use of these three Great Observatories. This workshop will be held in Pasadena, May 22-24, 2006. (URL: http://ssc.spitzer.caltech.edu/mtgs/greatobs.) The workshop has its origins in the limited response to the opportunity for joint Hubble/Spitzer proposals in past proposal cycles. The goal if the workshop is to encourage future science programs with Hubble/Spitzer/Chandra, and to identify key science programs that these observatories should undertake in preparation for JWST, Herschel, Constellation-X, and future large ground-based facilities.

The STUC is pleased to hear that the workshop plans are well in hand, although it is unfortunate that the only feasible dates were during university exam time. We will be interested to see the results at the next meeting.

Space Telescope European Coordinating Facility (ECF): ROLE AND TASKS [Bob Fosbury]

Following an impromptu ECF presentation at the last STUC meeting (October 2005), and an invitation to present to the STUC more formally, the ECF Director, Bob Fosbury, gave an overview of the ECF and its plans. (As this is the first ECF report to the STUC, more detail is given than normal.)

The ECF was not part of the original ESA-NASA MOU (which covers ESA staff at STScI). The ECF was started separately in 1984 with joint ESA/ESO funding. It is based in Garching at the ESO HQ, with the original goal of helping European users become familiar with HST so that they could write good proposals, and use the tools to produce good science. At a 1996 mid-term review it was decided that these goals had been largely accomplished, and the ECF should concentrate on project support, thus giving ECF a more project-wide, less Eurocentric emphasis. Following this review a NASA/ESA MoU covering 2001-2005 added 7 staff temporarily. A new effort was added in European outreach (2 people, URL: www.spacetelescope.org) covering HST and other ESA missions.

The ECF archive is the only complete copy (including proprietary data) of the HST archive. This complete archive is necessary to carry out many of the ECF development projects. The same archive format has been adopted by VLT.

The ECF has contributed to developing: (1) dithering/drizzling; (2) model-based calibration for FOS, then applying the same approach for STIS (as well as to several ESO

instruments); (3) WFPC2 associations (co-adding with nonlinear iterative methods, a legacy from Leon Lucy in the aberration era. [Drizzling is linear version.]); (4) on-the-fly reprocessing; (5) NICMOS grism spectral extraction using the 'aXe' software; (6) the 15th anniversary Hubble DVD and books.

Currently the ECF is working on extending their work on slitless spectroscopy to create tools for ACS prism spectroscopy, and later to create similar tools for WFC3. The method requires astrometry based on direct imaging to be taken during the same visit. This project is the first to be carried out under an agreement with STScI, and the MoU is to be signed during the current visit of Bob Fosbury to STScI.

The ECF is also performing COS lamp lifetime testing due to concerns over potential lamp degradation and reduced lifetime.

For other software, the *FITS Liberator* tool, developed by the ECF, allows FITS files to be read directly into photoshop, and is widely used by educators and the public. The *Scisoft* collection of useful astronomy software, distributed jointly by the ECF and ESO, continues to be supported.

ESA is now undergoing a planning exercise for the ECF to create a plan through 2010.
Elements of this new plan are:
1. Develop new HST data products: End-to-end high-level data product production from calibration through to VO compliant Hubble Legacy Archive products (see HLA, below).
2. SM4 related tasks: The details are still under discussion, but the ECF is likely take slit spectroscopy, and some slit spectra and imaging tasks.
3. Outreach: emphasizing the connection with the VO as an enabling technology.
This plan needs science oversight and needs to be coordinated with STScI and the Hubble Legacy Archive (HLA, see below).
If SM4 does not take place then there will be a need to re-balance the ECF program.

The STUC warmly thanks Bob Fosbury for coming to STScI to deliver his detailed account of the role and tasks of ECF. STUC members are impressed by the achievements such a compact team has managed in the past, and the valuable contribution it represents to the overall HST project. STUC encourages the ECF to present its detailed plan for the next 4 years after the ESA/ESO review. STUC endorses the two components of this plan as presented, namely: (1) the end-to-end high level data production, and more specifically when it involves building on the unique expertise developed in slit and slitless spectroscopy at the ECF; (2) the Hubble European Public Outreach, which gives ESA the prominence due to it for its crucial support of the HST mission. The choice of important areas of data analysis that would otherwise go unsupported, and the careful coordination with STScI software plans, is impressive and we hope that ECF continues this work.

HUBBLE LEGACY ARCHIVE [Brad Whitmore]

STScI's goal is to optimize the scientific return from HST. In the 1990's the development of the HST archive & pipelines created a change in paradigm for optical astronomers. *(Though not for X-ray or UV astronomers, for whom Einstein and IUE had already established this way of working.)* In the 2000's there is the potential for another shift by means of the VO. The change in data access speed and convenience would be comparable to using ADS rather than a library to access the literature. VO could enable users to short-circuit the normal proposal-to-paper project cycle for some fraction of their science.

STScI is considering four developments:

1. Upgraded existing data products, incorporating much improved astrometry and artifact removal, and adding VO headers;
2. An Observation Footprint service for HST observations, using the JHU/SDSS tool as a prototype. A user could then easily determine which areas of sky had, e.g. NICMOS and ACS coverage;
3. An Image Cutout service, to readily obtain sub-sections of images containing a favorite object. The ACS IDT already produces cutout products for multicolor images.
4. Catalogs of objects found in HST images. An example, of a search for massive stars and stellar clusters in the Antennae galaxies using only concentration index, was quite successful. However different pipelines would be needed for different types of field.

User interfaces, such as OpenSkyQuery, or Aladdin for a graphical approach, are being investigated. All these services would interact with the STScI Data Archive and Distribution Service (DADS), as a client.

The HLA project goal for FY06 is to develop a beta version catalog by October 2006 for ACS and WFPC2.

There is an STScI HLA Steering Group. The current level of effort is ~3-4 FTE for 1 year. This will be reviewed based on progress at that point. HLA is a collaboration of STScI with the ECF and the Canadian Astronomy Data Center (CADC), and there will be a planning meeting in Garching on 4/5 May. The intent is to involve the community early in the planning phase.

The STUC strongly approves of the first goal of improving the quality of the existing data products, especially of the astrometry, but also of artifact removal (e.g. CR cleaning). This process represents a gathering of HST experience that otherwise could well be lost as teams inevitably move on. We were also pleased that this part of the presentation responds to STUC concerns from previous meetings (notably on astrometric accuracy and access speed).

The proposed Footprint and Cutout services seem valuable and unproblematic.

We are however skeptical of the current ideas concerning the creation of object catalogs. We agree that, in principle, these could be valuable, particularly in the VO era. However, reliable object detection in complex fields (crowded ones, or those with complex backgrounds) is a far from trivial process, and the subsequent derivation of accurate photometry for these objects is also not simple, even for point sources. We feel that the current state of readiness does not support the proposed schedule, of a beta release of some object catalogs in October 2006. At this stage such catalogs would have low reliability and/or completeness. It does not seem feasible or prudent to proceed with this plan. We urge STScI to concentrate on the first three items, and to defer catalog plans. We also recommend that STScI hold external reviews of HLA at critical points.

INSTRUMENTS UPDATE

- **OVERVIEW [Bill Sparks]**

All the on-board instruments are in good health.

ACS: There was a minor single event upset (SEU) in March. STScI provided input on ACS background rates vs. temperature to the decision not to manifest ASCS in SM4.
A new ACS data handbook is now ready.

NICMOS: operations continue satisfactorily. The processing pipeline has been updated. A photometric nonlinearity, mentioned briefly at the last STUC meeting, has been addressed (see below).

WFC3: The science oversight committee is examining both replacement filters and detector options. The Instrument Team is concentrating on filter characterization, chip alignment, and detector selection; New thermal/vacuum tests are being performed as the original series had to skip many calibration measurements.

COS: A drift in the optic select mechanism position will be corrected in software using 'TAGFLASH' data (taken routinely for wavelength calibration). The COS Exposure Time Calculator (ETC) will be completed in August 2006, and the Instrument Handbook has been started.

- **NICMOS [Roelof De Jong]**

The count rate dependent non-linearity mentioned at the previous STUC meeting has been addressed. [Note that this is not the normal 'full well' non-linearity, which is for *total* counts in an exposure, but rather a count *rate* problem.] The effect is a +/-10% photometric shift over the range 10-10,000 ADU/s, and is systematically larger at short wavelengths, and becomes small at 1.8 microns. At present there is no physical understanding of what the effect is due to, although the wavelength dependence must be a big clue.

A test using the calibration lamp on a star cluster field shows that the difference ['Lamp-On' – 'Lamp-off'] image shows stars – a clear symptom of count rate nonlinearity. A more detailed pixel-by-pixel map shows a clear, tight, power-law trend that is not

temperature dependent. This power-law relation allows a phenomenological correction to be applied. A Python script has been written to correct the effect. Tests show that this script works well, and it will be put into the standard NICMOS pipeline.

- **WFPC2 Chip #4 (WF4) RECOVERY [John Biretta]**

A "Repair" has been made to reduce an anomalously high dark current in the WF4 chip. This anomaly has been traced back for about 2 years, beginning in March 2002, and gradually worsening. When discovered (the week before the STUC meeting) in October 2005, 90% of the pixels had low bias, and 25% were completely blank. Some 2300 images are affected by low bias. Only the WF4 CCD was affected, WF1, WF2 and WF3 are operating nominally.

For existing data a two-step bias correction has been developed which is good to 1% for low bias images (which show up as streaks in readout direction). However, blank fields are not recoverable. The science impact is limited due to low WFPC2 usage since ACS was installed. However, targets covering a large area, and parallels, will lose 1/3 of their sky area.

"Repair": the effect is well correlated with a temperature rise in a WF4 circuit board, caused by a heater. Old data shows that the bias is extremely low (zero) when this board is hot (>18 C). As a result the heater set points have been changed to center on 15 C, and the bias now almost normal, with fewer than 10% blank fields. There are some small side effects: the WFPC2 optical bench is 2-3 C lower, leading to 50mas changes in chip alignments. The anomaly is likely to reappear as the (unknown) root cause failure progresses at ~0.1 C/month. At this rate WF4 can be further cooled to give normal bias for another 2-3 years.

STScI options are now:

(1) Issue a report so GOs can deal with it; (2) provide a pyIRAF task to apply the corrections; (3) put the correction into the pipeline. In this last case then a decision is needed soon to allow completion by late 2007.

- **STIS CLOSEOUT [Paul Goudfrooij]**

Work on the STIS closeout has progressed. Reports have been issued on: synphot, CTE, the spectral PSF. In addition, 11 Calibration workshop articles were published, and STAN newsletter articles were released. [STAN= ST Analysis Newsletter.] The STIS pipeline update issued 2 weeks back included: a CTE correction, and the inclusion of a PSF halo at long wavelengths (leading to 2% vs. 20% accuracy); variance weighted error array interpolation. All STIS data will be run through this improved pipeline by late summer. On-the-fly-reprocessing (OTFR) now supports 38 modes.

By June a blaze shift vs. order as a function of time for each grating will be installed. This will give 3-5% wavelength accuracy, a major improvement. These shifts will be implemented as associations of wavecals and fringe flats with science data, via static tables. [If STIS is revived these will be made OTF.]

The STIS closeout wish list includes: spectral trace generation pyIRAF tool; a 2-D rectification interpolation scheme (e.g. the K. Davidson algorithm) implemented as an off-line tool; spectroscopic multi-drizzle using the ECF physical-model-based echelle wavelength calibration.

The STUC congratulates both the NICMOS and WFPC2 instrument teams for first characterizing and then correcting the non-linearity issue (for NICMOS) and WF4 anomaly (for WFPC2).

For STIS we are pleased that STUC prioritizations were used in choosing where to make cuts, but note that the inputs requested from STUC members Axon and York do not seem to have been used. Overall though we are pleased with new pipeline and believe that the improvements, particularly of the blaze angle corrections to echelle wavelengths, are important. We are glad that this pipeline will be used for a revived post-SM4 STIS,

Regarding a fix for the WFPC2/WF4 anomaly, the STUC recommends that the instrument team first identify the proposals to which the 2300 affected exposures belong, and evaluates how many of these exposures make use of the WF4 data. In the assumption that the number of program/exposures needing to be corrected is manageably small (10-40 programs, a few hundred exposures), the STUC recommends a fix involving the quick development of a stand-alone pyraf task that can be applied by the users themselves as necessary. The STUC also recommends that exposures that are affected by the WF4 anomaly be accompanied by a flag in the archive. This solution is deemed preferable to a longer-term implementation of the fix within the calibration pipeline.

As a general comment, the STUC did not have a feeling of how resources are being allocated between different efforts (instrument software development/fixes, HLA, etc.), and would like to receive an overview at the next meeting. In view of the current budget situation, the STUC recommends that these efforts should be prioritized, and that achieving a perfect fix for some of the problems (for instance a fully integrated correction for the WF4 anomaly and some of the STIS close-out items, where a simpler fix might be available) might be considered low priority. We are pleased that the STUC prioritization of tasks was used by STIS team. We also would like to hear how the Institute will respond to the dropping of IRAF support by NOAO. What are the costs to STScI, and is pyraf a complete substitute?

Post-SM4 there will be 6 instruments will be in the HST focal plane. The STUC would like to hear about how STScI plans to cope with these observational riches, and how instruments should be prioritized in a time of tight budgets. We suggest that this issue could be the topic of a major review (e.g. 1 day) at the next STUC meeting. A primer on quasi-duplicative modes among instruments and usage levels of modes would be informative. We are happy to defer or minimize some of the more routine presentations in order to accommodate this review in the STUC agenda.

There is an issue with Multidrizzle when used to combine observations with large shifts. There should be an announcement to community noting this problem.

SCHEDULING EXPERIENCE IN TWO GYRO MODE [Rodger Doxsey]

2-gyro mode Scheduling results

Prior to the switch to 2-gyro mode the scheduling team predicted 68.5 orbits/week of on-target time in 2-gyro vs. a mean of 80 orbits/week in 3-gyro mode. In practice HST is achieving a mean of 73.3 orbits/week, with a 3.6% failure-to-acquire rate, vs. the 2% rate expected, giving a net mean of 70.6 orbits/week of successful targeting. In practice, this rate is highly variable (from 60 to 90 orbits/week) due to interactions with SAA restrictions.
Overall there has been a small change in scheduling efficiency (~45% reduced to ~40%).

The lower acquisition success rate (3.6% vs. 1% failures in 3-gyro mode) is largely due to FHST (fixed head star trackers) errors adding to the normal 'bad guide star' rate. The FHSTs are now needed 3 times per acquisition instead of once. GSFC is analyzing the causes of these failures, which seem to be due to several small effects, and some fixes are in progress. (A similar process of gradual improvement occurred with guide star acquisition in the 1990s).

A planned improvement to 2-gyro mode is to reduce the times reserved for each part of the acquisition process saving 8-10min (though it still takes ~20min to acquire). This will lead to increased sky availability by 10-15%, and some additional flexibility. The Bright Earth avoidance zone can be reduced too, which will also add roll flexibility.

The STUC congratulates the scheduling team for their extraordinary success in adapting quickly to 2-gyro mode operations and obtaining such a high scheduling rate of orbits/week. A super job!

Cycle 14: The scheduling team adjusted quickly to 2-gyro operations. They have carried out several Directors' Discretionary (DD) observations. There was a slow start on Cycle 14 observations due to the transition to 2-gyro mode, as expected. The prediction is for Cycle 14 observations to catch up by the end of the cycle. With the new viewing restrictions Large and Treasury programs create a bunching of observations. (E.g. the June-July time frame contains several Large and Treasury programs.)
ToOs (mostly of SN and GRBs) are more constrained in 2-gyro mode. GRB observations are activated by triggers from Swift, and STScI is studying how the pointing constraints of the two missions interact to lead to a possibly low GRB ToO rate. (E.g. the anti-sun position tends to be on edge of 2-gyro acquisition zone.)

Tiled observations are simpler to schedule if the tiling orientation maximizes availability. The Phase 1 calculation does not include guide star acquisition (which is a complicated

calculation). A 1-FGS guiding method, which would increase the numbers of acceptable fields with guide stars, is now in testing.

Further control system degradation can be mitigated. A 1-gyro mode design review will be held next month (May). Improved magnetometer analysis could make 1-gyro as good, or even better, than 2-gyro is now. An on-orbit test is being planned for February 2007 to test 1-gyro mode. If, in addition, an FGS were lost. a possibility of using a parallel instrument for roll control has been recognized, though not yet investigated in depth.

Scientific Productivity of SNAPS [Keith Noll]

SNAP programs and GO programs are equally productive scientifically, and produce similar numbers of papers/orbit and citations/paper. Indeed 3 of the 10 Top Ten most cited programs are SNAP programs. The SNAP program began in earnest in cycle 6, reaching ~20% of overall observing program, Cycle 14 has 23 approved SNAP programs, compared with 109 GO programs, and competition for SNAP time is as strong as for GO programs. Survey science is, unsurprisingly, prominent among SNAP programs.

Historically 50% of targets in each SNAP proposal are successfully observed, but the introduction of 2-gyro mode has led to a much reduced, ~25%, success rate. In part this is due to the deliberate oversubscription in Cycle 14 introduced as a contingency depending on how well 2-gyro mode would work. Hence in Cycle 15 SNAPs were reduced to 1000 targets (vs. 2000), to allow Cycle 14 SNAP programs to catch-up. (SNAP programs live for 2 cycles.) The Cycle 14 + Cycle 15 average will then be 1500 targets, which was the prior number used.

What should the priority of SNAP programs be? Currently this is a Zero-sum tradeoff: SNAPs are used only as fillers, the scheduling system's goal is to maximise GO efficiency, while the corresponding loss of SNAPs is not weighted. Is this the best scheme? Giving higher weight to SNAPs is not unreasonable, and is worth re-examining.
Is there a non-Zero sum solution? To obtain the most orbits/week on-target the optimum scheduler pool would be: single orbit observations, no observing constraints, target positions well distributed over the sky. This describes SNAP programs very well. Can we use this good fit to increase the overall average of 82 (out of 105) orbits/week on-target? Is this worth investigating? Unlike GO programs SNAPs incentives community to minimize observing time and constraints. A larger GO 'snap-like' pool could increase observing efficiency.

Scheduling directions in the future [Rodger Doxsey]

SNAPs are scheduled automatically. SNAP observations have been improved over time (allowing the use of guide stars, moving objects). The number and size of gaps in the program is now determined by success of GO scheduling, so better GO scheduling reduces the number of gaps, and hence the number of SNAPs scheduled. The switch to 2-gyro mode reduces SNAP opportunities, as HST needs an extra 20 min to acquire the target. Over time there has been a shift to scheduling shorter SNAPs; most are now 30-45min. Very few programs propose <15 min SNAPs.

There are some approaches that could increase the scheduled number of GO orbits:
- use 3 orbits to schedule 2 TAC orbits (instead of nothing);
- schedule nominal orbits in the continuous viewing zone (CVZ);
- make visits shorter than their nominal visibility time ('crafting').

The South Atlantic Anomaly (SAA) limits the number of schedulable orbits. There are 105 physical orbits per week, but 82 "TAC orbits" correspond to more physical orbits, due to using 3 physical orbits to schedule 2 TAC orbits when the SAA reduces the available observing time/orbit. With sufficient observations that hide the SAA available it could be, in principle, possible to use more physical orbits/week. The automatic SNAP scheduling rules have not examined for about 10 years. The scheduling team will re-examine the priority scheme, and look for ways to allow more SNAPs. For example, it is quite likely that idle time exists that 5-10 min SNAPs could make use of, or that using a pool of 800 SNAPs, rather than the current 200, will fill more gaps.

A return to 3-gyro mode post-SM4 would return SNAP opportunities to their pre-2-gyro mode level.

Only <1 orbit SNAPs cannot be written as GO programs and, though this seems not be widely known, GO programs can be for N orbits out of a larger pool of targets, just like SNAPs.

The STUC was pleased to learn that the SNAP program is scientifically productive and that these observations do boost the efficiency of HST generally. The current issues with the Cycle 14 SNAPs may represent a special case induced by the change to two-gyro mode and by the impressive improvements in overall efficiency by the scheduling team. Assuming that the Cycle 14 SNAPs approach the historical success rates by improving their execution in Cycle 15, we expect that future cycles will likely revert to their historical averages. Of course, should SM4 succeed as currently planned, future SNAP success rates and implementations should approach to the pre-Cycle 14 levels.
The STUC did note that the SNAP guidelines could be improved to (a) impress on users that very short SNAPs are easiest to accommodate into the schedule, (b) emphasize that the original rules for SNAPs do not allow observations longer than one orbit, and, (c) highlight the little used category of GO observations with a large pool of targets from which a number, randomly chosen, will be observed for a set number of awarded orbits.

The strong non-linearity of the scheduling process suggests that experiments could yield surprises and efficiency improvements. We urge the scheduling team to do experiments, e.g. including SNAPs near the beginning of the process, after the constrained observations are included, so long as these experiments do not interfere with the normal scheduling of the Observatory.

COS, WFC3 PIPELINE [Warren Hack]
Mostly the COS data will be taken in photon counting mode, except for bright sources where on-board binning will be performed. Photon based data allows for flexible data analysis including the removal of time-dependent backgrounds.

The CALCOS functionality defined at CDR is already implemented, and has been tested with data from the thermal vacuum tests and the 'TAGFLASH' data (which is taken for wavelength calibration). The blaze shift from STIS [see below] has also been included.

CALWF3 currently includes the basic functionality required at CDR. Code reuse from NICMOS and WFPC2 has speeded up development. CALWF3 has also been tested with data from the thermal vacuum tests. Additional work that is planned comprises: including the characteristics of the flight choice of IR detectors [see above], and adding WFC3 support to MultiDrizzle.

Development of the pipeline control system OPUS to accommodate COS and WFC3 that have been made are: (1) inclusion of the appropriate WCS keywords, and (2) the ability to perform 'Grand-MAMA' image generation for CALCOS. (The 'Grand-MAMA' image is a sum of all observations in detector pixel space in order to search for undue exposure of individual pixels.)

The COS, WF3 instrument teams could report at next STUC meeting on their ground and on-orbit calibration plans.

In response to a question from the STUC about whether there would be a plan to give priority to high resolution spectroscopy in the first SM4 cycle as this capability has been lost for few years, the Institute staff replied that they are aware of a pent-up demand for spectroscopic observations, but that they plan to continue to have the TAC rank proposals purely on science priority determined without special treatment. They assure the STUC that TAC panel members will be chosen to include a fair proportion of experts on spectroscopy.

The STUC was pleased to hear that COS, WFC3 software is well in hand. We would find an in-depth external review to validate these plans reassuring. We agree that a ranking of all proposals on science merit alone is appropriate.

We are happy to accept the offer to hear from the instrument teams on their calibration plans for COS, WFPC3 both on the ground and on-orbit, at the next STUC meeting.

WFC3 IR DETECTORS [Massimo Robberto]

The WFC3 IR detectors are 1k x 1k arrays operating at 150K, and this high temperature leads to a 1.7 μm long wavelength cutoff. Despite many batches of arrays being provided by Rockwell, there were quite serious problems with high background and with dark current. (These were reported on at several previous STUC meetings.)

Rockwell chips delivered in 2005 solve these problems. Thinning of the CdZnTe substrate has reduced the particle background effectively. (CdZnTe is used as an efficient high E particle detector.) Thinning is possible because the active layer for IR photon detection is only 8 μm thick. This thinning process has the bonus of substantially increasing the array QE at short wavelengths to some 80% in the 0.8-1.7 μm range, and opens a visible window down to 0.4mu. Within this double gain the low dark current

requirement (<0.4 e/s) is somewhat in conflict with a high QE, and several batches of chips are under test to determine an optimum choice. This will be based on the 'discovery efficiency' metric (s/n in given time at several wavelengths – J, H, 0.8μm) to select the flight detectors. More batches of chips are continuing to arrive from Rockwell and a final selection will be made in the next few weeks. The flight chips will not be ready in time for the thermal vacuum test in the Fall, and the old arrays (FPA64) will be used then. An extra set of thermal vacuum tests will be made before sending the completed instrument to GSFC in Spring (for December 2007 launch).

A problem surfaced by the JWST chips was also dealt with by improving the mechanical reliability at the junction of the chip to its support structure. Although the issue was less important for WFC3 due to the higher operating temperature, this fix removes a worrying issue.

The STUC is relieved to find the WFC3-IR detector issues under control and applauds those involved for working hard to find solutions.

The many batches of detectors created for WFC3 must have cost significant funding. Is there a way to use the non-flight chips, e.g. by a competition offering them to the community for ground based instrumentation?

LUNCH: *Once again the Azafran café at the Institute provided fine catering which was much appreciated by the STUC members. We liked escaping from the boardroom for lunch. We had hoped for more interaction with STScI staff however. Perhaps a buffet format could be tried at the next meeting, allowing STUC members to sit anywhere, and staff could be explicitly invited to mingle with STUC members?*

DATE OF NEXT MEETING: was set to be Wednesday-Thursday October 25-26 2006.

Summary of STUC Recommendations, April 2006

1. *We would be like to hear about contingencies in the case of reduced EVAs at the next STUC meeting.*

2. *STUC would like to hear a discussion of what happens to STIS programs terminated by failure, if SM4 succeeds in reviving STIS?*

3. *We will be interested to see the results of the Great Observatories workshop at the next meeting.*

4. *STUC encourages the ECF to present its detailed plan for the next 4 years to the STUC after the ESA/ESO review.*

5. *We would like to receive an overview of resource allocation between the various projects at the next meeting. In view of the current budget situation, the STUC recommends that these efforts should be prioritized.*

6. *We also would like to hear how the Institute will respond to the dropping of IRAF support by NOAO. What are the costs to STScI, and is pyraf a complete substitute?*

7. *Post-SM4 there will be 6 instruments in the HST focal plane. The STUC would like to hear about how STScI plans to cope with these observational riches, and how instruments should be prioritized in a time of tight budgets. We suggest that this issue could be the topic of a major review (e.g. 1 day) at the next STUC meeting. A primer on quasi-duplicative modes among instruments and usage levels of modes would be informative. We are happy to defer or minimize some of the more routine presentations in order to accommodate this review in the STUC agenda.*

8. *We are happy to accept the offer to hear from the instrument teams on their calibration plans for COS, WFPC3 both on the ground and on-orbit, at the next STUC meeting.*

9. *We had hoped for more interaction with STScI staff however. Perhaps a buffet format could be tried at the next meeting, allowing STUC members to sit anywhere, and staff could be explicitly invited to mingle with STUC members?*

END