

Report of the Hubble Space Telescope Users' Committee

April 10th/11th 2008

Present: Martin Barstow (acting chair), Peter Garnavich, Jim Green, Jean-Paul Kneib, Lori Lubin, Mario Mateo, Philip Nicholson, Robert O'Connell, Abhijit Saha, Alvio Renzini, Marianne Vestergaard.

Apologies: David Koo, Patrick McCarthy, Tommaso Treu

Executive Summary

The Space Telescope Users Committee (STUC) is pleased to report that significant progress has been made in the preparations for Servicing Mission 4 (SM4). The new instruments, COS and WFC3, are almost ready for flight and promise to deliver their planned capabilities. In particular, STUC members were very pleased to see that the WFC3 infrared channel now has a detector that is yielding impressively high quantum efficiency, well above those of previous devices. Planned repairs to STIS and ACS are well developed. We are optimistic that the careful planning in evidence for SM4 through out the project will lead to an expansion of the capabilities of Hubble to an unprecedented level.

Top level recommendations and observations:

- The STUC commends the Institute and the HST Project in reaching the levels of readiness for SM4 already achieved. We are pleased to see plans that leave Hubble with a full complement of operating instruments while ensuring that spacecraft health and safety issues are addressed to ensure full exploitation of the new and repaired scientific capabilities.
- STUC notes that there has been a change to the SM4 manifest priority order, such that the installation of FGS2RR is no longer mandatory for mission success, a decision that will give the astronauts more flexibility in the EVA schedule should the number of EVAs be curtailed for any reason. We are confident that the Institute and the HST Project have a full understanding of the likely longevity and of the FGS units and that this re-balancing of priorities is a sensible decision.
- STUC commends the efforts made by the WFC3 team to resolve the past problems encountered by this instrument and the tremendous progress made in bringing the instrument to flight readiness. We are particularly pleased at the level of performance that has been achieved with the infrared channel detector. We were concerned to hear that liquid contamination had left a residue on the UV/optical channel window comprising a population of lensing spots but reassured by the detailed analysis that indicates that there will be a minimal impact on the photometric accuracy of the instrument. We endorse the recommendation of the WFC3 SOC recommendation that there should be no attempt to clean the window prior to flight.
- We were concerned about the reported reduction by \$43M in projected budgets for HST operations in FY12 and FY13. While it has been possible to absorb other cuts within the Goddard HST program, a large fraction of these future cuts would have to be passed on to the grants programme and STScI operations, which would have an undue impact on the scientific exploitation of HST. We suggest that these cuts should be reconsidered, since they potentially undermine the considerable financial investment of SM4.
- We understand NASA's desire to maximise the public impact of SM4 by undertaking a press release of data from the new and repaired instruments simultaneously. However, we encourage the project to make use of the important opportunity of the January AAS meeting

to have a coordinated ERO release that will also allow GOs to present results from their own observations.

- STUC were asked to comment on the whether or not the current format for HST proposals should be changed. It was felt very strongly that the current total page limits and the limits on the scientific case were appropriate and that there was sufficient flexibility for including figures and references to satisfy proposers. Any changes, which would probably disturb the reviewing process and make life more difficult for the TAC and panel members should be avoided.
- STUC felt that the Multi Cycle Treasury Program idea was an important development with the potential to deliver exceptional legacy data sets and science in the latter years of the Hubble programme. However, it was felt that the programme should be more ambitious, and seek to spread projects over more than the two cycles currently envisaged. However, only truly exceptional projects should be supported and that the telescope time not utilised for this program unless the highest standards were achieved. There should be periodic review of any approved projects to ensure that promised scientific returns were delivered. STUC did not wish to see the time allocation for small/medium program reduced to support this initiative but for more orbits to be diverted from the existing Large and Treasury allocations. STUC was happy with the proposed plan for review and selection of the MCTP programs.
- The STUC wishes to acknowledge its deep appreciation of the highly valuable and unique contributions that ESA and ECF provide in terms of operations and calibrations support and outreach. These contributions are of prime importance for astronomers and non-astronomers of all ages not only in Europe but all over the world! These contributions are important because they cannot at present be covered by STScI efforts alone. Especially the ECF's public outreach program has such a unique and high impact on the community that it will be a severe loss if the program is terminated.

Minutes of the meeting:

STScI Outlook

Matt Mountain reported on some Hubble highlights, staffing at the Institute, Cycle 17, JWST status and ideas for a new 8-16m class UV/optical telescope. A new double lensed galaxy had been identified $z=7.6$, which would be a prime target for WFC3. Having a double lens eliminated some of the potential unknowns in the system allowing measurement of dark matter halo of galaxy. A map of dark matter in a supercluster had been produced from ACS images and NICOS images had revealed nascent planetary system in the process of disruption by ploughing into the ISM. A first detection of organic molecule (Methane) in an extrasolar planet was reported.

Recent hires had been made to support SM4 and JWST demands. Current staffing levels were higher than for many years, peaking about now, but falling again in subsequent years. The current launch date for SM4 is 28th August 2008, but Spaceflight.com was reporting a 4-6 week probable further delay.

JWST has just passed PDR with work progressing on real hardware (pathfinder mirrors being polished). New cost models were requiring all projects to carry a 30% contingency, a new constraint. An independent cost estimate placed JWST at \$4.1B to launch (70% confidence). The contingency will be moved out of the Future Missions line into the JWST budget to comply with congressional requirements. Increased pressures on cost required STScI cut \$20M out of \$70M SOC budget.

An exciting new project being studied was the Advanced Technology Large Aperture Space Telescope, 8-16m UV/optical telescope (Mark Postman PI). An important part of the study is to look at what astrophysics will be enabled by such a facility. Some initial ideas include characterising extrasolar planets and retracing star formation in galaxies.

Status of the Project and Program

Preston Burch briefed the committee on the status of the HST program. It is officially working to an August 28 launch date and is on schedule for that date. However, the latest information is that launch will slip to early October because of delays in delivering the external tank for the STS126 "launch on need" shuttle. The program has completed an assessment of SM4 EVA priorities in light of the estimated reliability and redundancy of the FGS units, gyros, and scientific instruments.

Given the high reliability of the FGS units, demonstrated over 18 years of HST operations, the program has recommended to NASA Headquarters that replacement of FGS2 remain at the same priority level for EVA but be removed from the list of "core priorities." With that change, the core priority list consists of the gyros, WFC3, COS, and the batteries. This will reduce the likelihood that the FGS2 unit will be installed in the event of an off-nominal mission that requires reduction in the number of HST servicing EVAs.

All planned EVA activities now appear to fit easily within the available EVA duration. The program is hoping that the ACS repair (currently split between two EVAs) can be combined into one EVA. ACS/HRC repair is less assured than ACS/WFC repair because it is not known where electrical damage occurred; it would take a major effort to provide the same level of confidence for repair of HRC and for WFC.

Good progress has been made in getting hardware ready for SM4. The COS alignment measurement anomaly was traced to the optical effects of the GN2 purge and is not an issue for ultimate on-orbit operations. WFC3 is in the middle of Thermal-Vac test 3, using its flight detectors in both its UVIS and IR channels, and should be out on schedule in about two weeks. Replacement parts for STIS and ACS are on schedule.

Spacecraft health is unchanged since the last STUC meeting. HST is operating in 2-gyro mode with one good gyro as spare. The one-gyro science operations mode was successfully tested on orbit, as was the "Kalman Filter Sunpoint" mode.

The primary long-term challenge to the program is the reduction in projected operating funds for HST in FY2010-2013 in the proposed 2009 NASA budget. The reduction is \$43M higher than had been negotiated in fall 2007. Burch stated that this much reduction, added to an earlier \$41M cut, threatens a "broken operation" inasmuch as it could not be absorbed by GSFC or Lockheed while maintaining safe spacecraft operations. The program's view is that cuts of this magnitude pose an unacceptable risk to HST.

Preston Burch and program scientist David Leckrone then outlined the status of planning for the SM4 servicing mission and in particular on the priorities assigned to the various installation and repair tasks. At the present time the completion of the external tank for the shuttle Endeavour (105), which is to act as backup for Atlantis (104) in the event of a serious on-orbit problem, is driving a schedule slip from an Aug 28 launch to launch on or about Oct 8. In the nominal plan, the astronauts will work on HST over 5 EVAs and complete the following tasks, in priority order: (1) replace all 3 RSU units (6 gyros), (2) install WFC3, (3) install COS, (4) replace all battery modules (6 batteries), (5) install a refurbished FGS2RR, (6) repair STIS, (7) repair ACS (WFC side only, but with hope that the new power supply will also permit the HRC to resume operation), and (8) replace one or more sets of external thermal blankets.

The STUC was pleased to see the level of thought which has gone into establishing detailed contingency plans for SM4, in the event that circumstances dictate a reduction in the number of EVAs. We note that, notwithstanding the above issue of flexibility, all of the contingency plans which involve at least 3 EVAs include replacement of FGS2R, which is showing signs of a degraded servo LED. We see no reason to second-guess these plans, and understand that the repair of both ACS and STIS will be done on a "best effort" basis, subject to on-orbit exigencies and the successful completion of higher-priority tasks.

Both WFC3 and COS appear to be almost ready for flight, with WFC3 still to undergo one more thermal/vacuum test in late April. The STUC was especially pleased to learn that the final flight detectors in WFC3 (UVIS-1' and IR-4) are the highest-quantum-efficiency units to have been

tested. Flight versions of two of the new electronics boards for ACS are still to be produced but an engineering model has achieved a gratifying low read noise level. New ACS power supply boards have completed testing and are ready for delivery. STIS replacement parts are in their final stages of preparation, with new low-voltage power supply boards already delivered. All gyros, batteries and a reconditioned FGS2 are ready to go, and shuttle support hardware necessary for the servicing mission is under development or testing. Modifications to the arrangements in the payload bay have been made to accommodate an IMAX camera which will record the astronauts' work.

Randy Kimble presented a report on the current status of WFC3 was presented. The instrument is fully integrated with the final flight detectors, has successfully completed the majority of required testing, and is currently undergoing the final vacuum testing and science calibrations at GSFC. There have been several hardware issues: (1) poor IR FPA temperature control; (2) problems with calibration lamps; (3) glint in UVIS detector package; (4) IR throughput degradation/variation in T/V-1; (5) banded bias offsets in IR detectors; and (6) lensing spots on UVIS-1'. Based on the T/V-3 results, the first four issues have either been resolved or deemed to have a minimal effect. The banded bias offsets of IR detector (low-level shift in bias in 1/400 reads) is due to fault on the Detector Electronic Box (DEB) board that is side-specific (Side 1). Engineers are not optimistic about finding/fixing issue, so will fly as is with recommendation to start flight ops on Side 2. In the worse case scenario, only Side 1 would be lost if problem gets worse since Side 2 is unaffected.

The spots on the UVIS detector (droplet residue from a condensation event on the outer surface of the vacuum window) also remain an issue. However, the calibration tests indicate that the scientific impact will be small. The intensity of all window features was greatly reduced in external flats, with the contrast reduced to 0.5% or less. The effect on photometry near the brightest-core spots (the worst case scenario) is only 1% (optical) and 2% (UV) within a radius of 3 pixels. Dithering should mitigate these effects further. The PSF is also only marginally affected in these regions, with near-field features at the only 0.2% level (consistent with the photometric results). While this problem was avoidable, is fixable, and could be repaired in time for launch, it would require a highly invasive unbuttoning of the instrument and a full re-qualification of the instrument afterwards. The Science Oversight Committee recommends that the instrument fly as is, and the STUC agrees.

HST Mission report – SM4 preparations

Ken Sembach provided the STUC with a comprehensive review of the impressive range of activities at the Institute in direct support of SM4. This effort ranges from playing key roles in ongoing simulations for the SM4 EVAs, to SMOV planning to ensure that the newly refurbished observatory operates well and to characterize the performance of the new instruments, to software support for both SM4 activities and SMOV. This work very clearly involves an extraordinary amount of coordination among various NASA entities to plan such activities efficiently. This work spans all the individual instruments to be installed at SM4, for which testing, documentation, observing strategy and planning, as well as SMOV operations. The institute is clearly playing a critical role in coordinating this work among all the instrument teams to ensure that all calibrations and early observations are carried out effectively during the fairly limited SMOV period after the SM4 mission. The special SMOV operations regarding tuning the detector parameters to optimize ACS performance represent a particularly interesting opportunity for the Institute to maximize the science output of this upgraded instrument. It was also encouraging to see that a new operations model for HST - with the large complement of extremely powerful instruments – has been developed and tested in detail. The STUC commends the Institute for their exemplary work in support of SM4 and to help ensure that HST returns to service after the mission as an even more powerful telescope than before.

A new way for implementation of pure-parallel is being developed for cycle 17. In order to simplify the new implementation, pure parallel will only be attached to COS observations in cycle 17. 6 pure parallel observing proposals have been submitted in cycle 17 totalling 1361 orbits. The implementation process of pure parallels is the following: After the GO proposals have filled their

phase 2, a list of pure parallel orbits opportunity will be defined by STScI. Then, 2 months after GO submits their phase-2, PP GO will fill their phase-2 according to orbits opportunity listed in APT. The pure parallel for cycle 17 should be considered as a minimal tool, that should expend in the following cycle, taking into account the other pure parallel opportunities with WFC3 and ACS as prime instrument. The new pure parallel implementation tool, should be ready for the next APT release planned on May 21, 2008.

Gerry Kriss outlined plans for post-SM4 instrument support. In order to accommodate the new activities that will result from a successful SM4 mission a number of hires have been made recently:

- Recruitment of three new data analysts for HST support
- Recruitment of seven 3yr-term scientists
- Recruitment of three FTE through JHU
- Recruitment of four ESA positions (one is still open)

The bulk of the instrument support teams are for WFC3, ACS and COS. COS and STIS support will be delivered by the same team. Final closeout of WFPC will also be part of the ACS team activities, expected to be completed by end of 2008. Thereafter the WFC2 staff will redistributed to WFC3, ACS and COS teams. There is expected to be a decrease of NICMOS activities after SM4, hence NICMOS people will most likely be redeployed to support WFC3. The balance of staffing will be adjusted as a function of success of the STIS and ACS repairs.

The overall level of personnel for the SM4 instrument support seems adequate.

The ERO program

Plans for Early Release Observations were outlined by Keith Noll. The selection of 6-8 targets intended for the ERO program is mostly completed. While the target list is confidential, the targets will include both galactic and extra-galactic objects with an emphasis on visually stunning objects covering a few different but coherent themes (e.g. star formation near and far, origin and distribution of elements, etc). The ERO will include demonstration of the capabilities of both the new instruments (WFC3 and COS) and the repaired instruments (ACS and STIS). The aim is to demonstrate that the suite of instruments on HST post-SM4 provides for the most powerful space telescope observatory to date. In addition, the observations will also meet the requirements for IMAX compatible mosaics. The team is committed to the earliest possible release of the ERO observations, but due to the necessary 6 week out-gassing process for WFC3 and COS the release will likely trail the launch by about 2 months.

COS operations update

Jim Green told the STUC meeting that the COS instrument is undergoing a final test before being shipped. It is expected that the NUV gratings will show a continued degradation due to aluminum oxide layer formation. But the projected decrease in efficiency is still acceptable. The STUC is pleased that other problems that were identified during tests have been resolved and COS is ready for launch.

WFC SOC update

Robert O'Connell of the WFC3 Science Oversight Committee reported on the latest WFC3 issues. He mentioned that the accidental venting of the IR detectors did not result in any performance degradation, hence the camera will meet all specifications. For the UVIS channel, attention has concentrated on the non-volatile residues scattered on the detector window which are predicted to remain unchanged indefinitely. Extensive simulations have been carried on in order to quantify the effect of the droplet residues on the accuracy of the photometry over the affected areas on the detectors. According to the simulations 3 pixel aperture photometry with accuracy at the ~1% level should be possible even over the affected areas, with an accuracy better than 0.5% for 10 pixel aperture photometry. As a consequence, the SOC has issued a resolution asking for no invasive

action to be taken at this stage attempting to remove the residues, concentrating instead efforts on possible mitigations of the problem, such as extensive description and documentation of the problem in the instrument handbook, and the release of accurate data quality maps associated to each UVIS image to be delivered to the users.

Cycle 17 proposal update

Neill Reid reported on the cycle 17 proposal process. This appears to have gone smoothly (with only one minor complaint about one of the ETCs). The proposal volume is within the envelope defined by prior cycles. The plans and schedules to complete the TAC process, as well as the anticipated levels of time allocation appear reasonable and well under control. The selection criterion to "pick the best science", free of programmatic modulation is also the most desirable of all possibilities. The STUC was asked to comment about whether to allow more flexibility in the proposal forms so that proposers need only meet a total page limit, rather than the specific sub-limits on some of the individual sections. The STUC considered this in some detail, and thought that having a specific limit on the science justification continues to be a good idea, and helps to ensure that proposals are on the same footing with one another. The recommendation is to keep things the way they are.

HST mission – standard operations

Rodger Doxsey gave an overview of Standard Operations of HST, excluding SM4. His report on Cycle 16 revealed that, particularly with the likely few-month slip in SM4 launch, suggests that there should be no problem in completing Cycle 16 programs, particularly those using WFPC2. If there are no further slips in SM4, the 'end game' for Cycle 16 includes filling in the remaining time for this cycle to complete all surveys, treasury program, snaps (which, ironically have had lower completion because of the increased overall efficiency of scheduling HST in 2-gyro mode), etc. Suitable Cycle 16 programs have been identified to ensure that HST is quite adequately scheduled up to SM4 and we greatly commend the Institute for their work to keep the observatory effectively utilized as Cycle 16's duration increases a bit beyond original plans. Any further SM4 launch delays will require further additions, and the Institute is considering how to handle this contingency as well. One aspect of this 'end game' is to keep WFPC2 working. The key problem of this instrument is the bias dropout problem in WF4. One recent operating temperature change for that instrument should minimize or largely eliminate dropouts through Sept 2008, enough to carry the instrument to SM4. The other HST instruments, ACS/SBC and NICMOS are functioning well, and the Institute is working to ensure that the data products are analyzed with the best calibrations available. For WFPC2, a final complete reprocessing of all of its data is planned when final observations are carried out with that instrument. Single-gyro mode has been tested on-orbit with no apparent degradation of PC images from WFPC2. This implies that this mode of operation can work and, compared to 2-gyro mode, can do so with little operation limitations that would make it difficult to complete Cycle 16 as currently planned. The STUC continues to marvel at the ingenuity and persistence shown by the Institute and the HST Project in ensuring the HST can operate in modes that were considered impossible not long ago, let alone to do so efficiently! Rodger also summarized recent work on multi-drizzle algorithm, primarily to allow images from multiple visits (with different possible orientations) to be combined. This work should make this already useful algorithm even more powerful and of broad astronomical utility. Finally, the STUC heard about usage and capabilities of the Hubble Legacy Archive. This tool, which may have been developed a bit too late to broadly help Cycle 17 proposers, has clearly shown its value for researchers using HST data. The STUC endorses continued work on this very useful analysis and proposal tool.

Multi-Cycle Treasury programs

Neill Reid presented the developing plans for the Multi-Cycle Treasury Program (MCT). He presented the schedule for the process which will have a likely phase I deadline of early February

and aims to be completed before the Cycle 18 call. The review process will consist of two major parts. The first is similar to the standard TAC review. The MCT TAC will consist of members of the Cycle 17 TAC, STUC members and other knowledgeable senior astronomers. Written external reviews may be requested. The TAC will rank the proposals and a set of the top proposals will move to the second stage. In the second round, the top proposals will be optimized with help from the STScI staff and the PIs will make presentations to a subset of the TAC which will decide which programs to be executed. There may be an attempt to "marry" proposals with parallel science goals. The results and targets will be known by the regular Cycle 18 deadline. The STUC finds that the process outlined is a good one for selecting and optimizing the multi-cycle programs. The STUC encourages the selection process to only approve multi-cycle programs with exceptional quality and impact. If no proposal reaches this high standard, then the best result would be no approved MCT programs.

ESA/ST-ECF update

Bob Fosbury gave an update on the ECF, which is continuing with its important contributions to the HST project through (1) the calibration of the slitless spectroscopy modes of NICMOS, ACS, and (post-SM4) WFC3, (2) production and maintenance of the Hubble Legacy Archive Spectroscopic Database and production of half the Hubble Heritage images, and (3) production of Tiny Tim PSF models for WFC3, (4) European public outreach (News and photo releases, Hubble casts, host for IAU and International Year 2009 activities), and (5) ESO-ESA coordination (topical working groups). All aspects of ECF's tasks are progressing smoothly and successfully. Especially the public outreach activities are highly successful with the community in Europe as well as in the USA with record download activity.

Antonella Nota reported on general ESA issues. She is the new head of the ESA delegation at STScI. ESA currently contributes 15 FTE people among the 75 FTE's at STScI, mostly in Instrument Teams (INS), supporting calibrations of instruments, user support, and SM4 preparations. ESA's 'Memorandum of Understanding' with NASA on the joint operations of HST will expire in 2010. It is expected that (a) the MOU will be renewed, especially if SM4 is successful and that (b) ESA will put HST on a 4 year funding scheme with financial reviews every 2 years. The first review will take place in the fall of 2008 in the context of existing ESA missions operations; ESA currently operates HST, XMM-Newton, and Integral). European STUC members are encouraged to engage the European community in discussion with their national representatives on the relative priorities accorded to those mission.