A RECOMMENDATION BY THE HUBBLE SECOND DECADE COMMITTEE:

# THE HUBBLE TREASURY PROGRAM

*A New Class of Hubble Observations*

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# I INTRODUCTION

The source of Hubble science is the competition of new ideas for observing time. As part of its charter to make recommendations for optimizing future Hubble science, the Second Decade Committee has examined the process of that competition in an effort to improve it. While the existing approach has produced a rich variety of discoveries in Hubble's first ten years, it has not provided a sure means of navigating observing-project selection toward strategic objectives. Most notably, it consistently failed to produce enough large observing projects, which have strong potential for special benefits. Furthermore, the planned end of Hubble operations in 2010 raises new strategic issues for the selection process, such as how best to handle observations in support of Hubble's longer-wavelength successor, the Next Generation Space Telescope (NGST), and how best to compensate for the potential hiatus in short-wavelength capabilities unique to Hubble.

*The Second Decade Committee recommends that the Hubble Treasury Program allocate 20% to 30% of Hubble orbits in the second half of the mission to large observing projects using a peer-review process that is separate and distinct from that of the GO/TAC process.*

In the mid 1980s, years before launch, the Hubble community debated and defined Key Projects "of such scientific importance that it would be a serious omission if they were not undertaken by HST." People were concerned that the Hubble mission might be short-lived. Today, we must think ahead to the year 2010 and ask the same sort of question, hoping never to regret classes of Hubble observations not made because the selection process was not attuned to them.

After reviewing earlier efforts to guide Hubble science strategically by means of the observing-time competition, the Second Decade Committee is convinced that a new process is needed to supplement the current approach. The name of this supplementary process is the Hubble Treasury Program. Its primary goal is to increase the number of large-sized observing projects in a proactive, flexible manner. Its primary motivation is to secure the full benefits of large projects. A secondary goal is to provide a means to address and decide strategic issues, such as Hubble-NGST co-operational synergism and the impending hiatus in UV capabilities.

## HISTORICAL REVIEW OF PROCESS

So far, in the first half of the Hubble mission, the main source of observing projects has been the General Observer (GO) program, where about a thousand proposals are reviewed by the Telescope Allocation Committee (TAC) each annual cycle. The template for the GO/TAC competition is the traditional principal-investigator (PI) proposal, which consists of a focussed scientific justification, a target list, and the desired instrument modes and exposure times. The TAC votes to select or reject whole proposals individually. Other than receiving technical support from ST ScI, proposal authors work independently from start to finish, from idea conception to proposal selection or rejection.

The Director of the Space Telescope Science Institute (ST ScI) conducts the science program of HST. Observing-project selection is the most critical aspect of this responsibility. To transact it, the Director governs the GO/TAC process, which he touches at just three points: issuing the Call for Proposals (CfP), instructing the TAC, and making the final selection of proposals based on TAC recommendations.

The Space Telescope Advisory Council (STAC) has been convened twice by the Director to provide advice on the GO/TAC process. Each time STAC has urged that a substantial percentage of observing time be awarded to large observing projects (100 orbits or more). In 1985, the STAC goal was 30%; in 1996, its expectation was 10-20%. Every CfP has attempted to achieve this goal by citing the STAC recommendations and explicitly inviting large-project proposals. The first CfP set the tone:

> It is likely that HST observing time will be heavily oversubscribed, and that the TAC will therefore be under considerable pressure to reduce the scope of many projects. This has led to a concern that large-scale observing projects, which have been of crucial importance to the advancement of astronomy in the past, might prove impossible to accomplish with HST. Following a careful discussion of this problem, the STAC has recommended that the TAC be encouraged to assign roughly equal total amounts of observing time to small, medium, and large projects.

Despite such encouragement, the GO/TAC process as constituted has never approached the desired percentage of large projects in any of its eight years. Out of 2173 approved GO observing projects awarded 22,328 orbits in Cycles 1-8, only 18 projects were awarded more than 50 orbits, and only 5 more than 100 orbits. As shown in Table 1, TAC awards have been far from equal in the three size categories, with large programs receiving only 4.4% of all orbits thus far.

| | **Projects** | **Orbits** | **% Orbits** |
|---|---|---|---|
| Small projects, 0 to 29 orbits | 2063 | 17,047 | 76.3% |
| Medium projects, 30 to 99 orbits | 105 | 4,291 | 19.2% |
| Large projects, over 100 orbits | 5 | 990 | 4.4% |

*Table 1. The size breakdown of TAC awards in Cycles 1-8. Projects continuing over multiple cycles and totaling more than 100 orbits are counted as large projects only once. (The multiple-cycle H0 and QAL Key Projects are two of the large projects. There is only one single-cycle, non-Key, large project.)*

Fair-minded people can disagree about the reasons why the GO/TAC process produces so few large observing projects. Some may feel that the daunting effort of organizing and writing a proposal for more than 100 orbits discourages their submission. Others may hold that the process is biased in favor of giving many people small amounts of time, or, more generously perhaps, that it is intellectually or emotionally difficult for a single group to allocate resources in both small and large denominations. Still others may think that meritorious ideas for large observing projects are lacking, but that, if and when they arise, they will be attracted to and approved by the existing GO/TAC process. The Second Decade Committee itself holds a range of opinions on this point. Nevertheless, the Committee is unanimous that a major, proactive step must be taken to assure that Hubble in its last years does not miss great opportunities in comprehensive science projects—or in other strategic opportunities—by default, lack of effort, or want of process. The step to be taken is establishing the Hubble Treasury Program.

## THE KEY PROJECTS & HUBBLE DEEP FIELDS

Despite their small number, large observing projects have made outstanding contributions to the sum of Hubble science as well as to the manner of Hubble science. The Second Decade Committee drew particular lessons from the experiences of the Key Projects and the Hubble Deep Fields (HDFs) in formulating the Hubble Treasury Program.

The Key Projects were commissioned by the same pre-launch STAC that set the goal of 30% for the percentage of large observing projects. STAC required the initial Key Projects to meet strict criteria. They had to be

> (1) of such scientific importance that it would be a serious omission if they were not undertaken by HST, (2) of such a nature as to require a coordinated effort involving large amounts of observing time, and (3) technically feasible during the initial GO scheduling cycle.

STAC defined two such Key Projects for the first observing cycle to use primary (not parallel) observing time. These were (1) determining the Hubble Constant (H0) using Cepheid variable stars and (2) probing the universe using absorption lines in quasar spectra (QAL). (The Medium Deep Survey is not included in this analysis because it used parallel observing time.)

To implement the recommendation of STAC, the first CfP invited proposals not only for the approved Key Projects but for any other large, multi-year projects as well. Both kinds would be subject to TAC peer-review. Both kinds, it was hoped, would be sources of widely-useful data:

> Where possible, the observations should be obtained in a manner that will make them suitable for purposes beyond those relevant to the large project, even if the proposing team does not itself plan to carry out such analyses.

Both kinds were expected to experiment technically and push the state of the art:

> Typically, the first year's program might call for a set of exploratory observations designed to test the feasibility of conducting the entire large project using one or more avenues of attack. If the suitability of the chosen approach were demonstrated by these observations, the bulk of the observational data would then be obtained.

In fact, pre-proposal vetting was the only feature that distinguished Key Projects from other large, multi-year projects.

Successful proposals for the H0 and QAL Key Projects ultimately received 330 and 158 orbits, respectively. The former project has improved the accuracy of the distance- and time-scales of the universe to the desired level of 10%, while the latter project has revealed strong evolution in the intergalactic medium. Both Key Projects have provided data sets of immeasurable value to other research projects.

The HDFs were different from both typical GO observing projects and Key Projects. Here, the ST ScI Director defined the goal, which was to push Hubble to its limits for deep imaging. The Director provided the 314 orbits of observing time from the Director's Discretionary (DD) reserved time. (DD time can be up to 10% of the available observing time in each cycle.)

The HDFs pushed the envelope of what can be done with Hubble. They required many long camera exposures, which were executed and processed using advanced techniques. For example, in planning and scheduling the observations, new approaches were taken to minimize wavelength-dependent scattered light by tailoring exposures according to the proximity of the line of sight to the bright earth limb. The HDF project mainstreamed the techniques of sub-pixel dithering and combining exposures by drizzling to eliminate cosmic rays and improve angular resolution. Also, the customer orientation towards the archival researcher prompted improved dark and flat-field reference files. All these methods are the operational heritage from the HDFs to the astronomical community, which now observes with a more capable Hubble observatory.

The proprietary period for the HDF data was minimal. Furthermore, when they were released to the community, the HDF data were prepared in such a form and accompanied by such explanations as made them immediately useful to a broad segment of the community. HDF researchers could apply for funding from the Archival Research (AR) program. Facilitated by the open, community-oriented philosophy of the enterprise, the HDFs also spawned supportive observations with other telescopes, such as use of the Keck and other ground-based observatories to measure the redshifts of the newly discovered galaxies.

The HDFs are the most penetrating view yet of the early universe at optical and near-infrared wavelengths and have been an incomparable scientific bonanza. They have enabled us to look back to a time when galaxies were recognizably different from their present-day descendants, thereby putting the study of galactic evolution firmly in the realm of direct observation. The HDFs have thus provided much of the inspiration and many of the facts on which NGST is being built.

## THE BENEFITS OF LARGE OBSERVING PROJECTS

As exemplified by the Key Projects and HDFs, large observing projects have at least four distinctive and desirable characteristics. First, they can address widely recognized scientific issues that could not reasonably be handled by any likely combination of smaller GO observing projects. Second, they can produce homogeneous, carefully calibrated data sets relevant to wide areas of archival research. Third, they can achieve efficiencies of scale in both pre-observation planning and scheduling and in the post-observation calibration and data-reduction. Such savings are relevant to the goal of significantly reducing future Hubble operational costs. Fourth, based on both qualitative and quantitative assessment, large observing projects can have disproportionately high scientific impact.

Our investigation of citations finds that publications from large observing projects are cited in the scientific literature more frequently per orbit—by at least a factor three—than typical small and medium observing projects. Further, the most-cited papers from smaller observing projects commonly incorporate the data or results from the larger observing projects. The informed opinion of the astronomical community confirms this result: the most important Hubble results are often based on large observing projects like the H0, QAL, or HDF projects.

## THE HUBBLE TREASURY PROGRAM

The Key Projects and HDFs open what could be called new 'proposal space' for the Hubble observatory. One dimension of this space—pioneered by the HDFs—is characterized by increasing technical capability, minimizing the proprietary period, and providing data products of immediate usefulness and durable value to broad segments of the astronomical community. The other dimension, exemplified by the Key Projects, involves the community defining priorities and setting standards for research conducted in a PI mode. In the opinion of the Second Decade Committee, it is now imperative to explore and exploit the proposal space spanned by these two modes of observing-project selection. The Hubble Treasury Program will be set up to undertake that experimentation in a proactive, flexible, and adaptive manner, without negating the inherent strengths of the two approaches. For example, "HDF-like" projects may be more valuable if proprietary periods for data are minimized, while those that are "Key Project-like" may benefit from longer proprietary periods, to assure careful, thorough data analysis and scientific interpretation.

To further define the Hubble Treasury Program's domain of opportunity, Table 2 compares and contrasts the characteristics of the new program with its progenitors.

| | Typical GO | Key Project | HDF-like | Hubble Treasury Program |
|---|---|---|---|---|
| Size | Sm/med/(lg) | Large | Large | Large |
| PI-led | Yes | Yes | No | Optional |
| Peer review | TAC | TAC | None | New |
| Archive focus | No | Optional | Yes | Yes |
| Science focus | Specific | Specific | Broad | Either |
| State of the art | Use | Use | Extend | Either |
| Encouragement of ideas | Passive | Proactive | Proactive | Proactive |
| Topical definition | PI | Community | Director | Optional |
| Planning locus | Community | Community | ST ScI | Best mix |
| Initial data reduction | Community | Community | ST ScI | Best mix |
| Data proprietary period | 1 year | 1 year | Minimal | Appropriate |
| Research funding | GO | GO | AR | AR; GO |

*Table 2. Characteristics of the new Hubble Treasury Program compared with those of its progenitors.*

The Second Decade Committee recommends that the Hubble Treasury Program allocate 20% to 30% of Hubble orbits in the second half of the mission to large observing projects using a peer-review process that is separate and distinct from that of the GO/TAC process. This 20-30% allocation, however, would not preclude the ST ScI Director from using his/her DD time to undertake separate "HDF-like" projects or from augmenting peer-reviewed projects of the Hubble Treasury Program to maximize their scientific utility or efficiency.

The Hubble Treasury Program has several features in common with the Legacy Science Program of the Space Infrared Astronomy Facility (SIRTF) as described at:

`http://sirtf.caltech.edu/SciUser/A_GenInfo/SSC_A1_legacy.html.`

There are also some important differences. One is the Hubble Treasury Program's option for proprietary time when the investigations are more in the Key Project mold. Another is the possible role for ST ScI in investigations that are more like the HDFs.

## THE HUBBLE TREASURY PROGRAM COMMITTEE

To help guide the Hubble Treasury Program, the Second Decade Committee recommends the formation of a community-based committee, advisory to the ST ScI Director, to be called the Hubble Treasury Program Committee (HTPC).

In addition to providing oversight and advice, the main functions of the HTPC are to stimulate community awareness of and involvement in the program, and, when appropriate, to help coordinate the efforts of different PI-led observing teams and the ST ScI. It is not envisioned that the HTPC would select or direct observing projects; the former is the responsibility of the ST ScI Director (following peer review), while the latter is that of the PI of each observing project. However, the HTPC should be actively involved throughout via oversight and advice. Given these roles, the HTPC should be a standing committee with revolving membership.

The Second Decade Committee believes the Director and HTPC should have significant latitude in establishing their manner of doing business. Nevertheless, the Committee does wish to share its thinking on certain issues and concerns, and put forward some options for setting up the Hubble Treasury Program.

Possible roles for the HTPC include the following:

1. Solicit ideas for and about the Hubble Treasury Program from the astronomical community. This could be achieved by email and web questionnaires or by workshops on broad scientific topics (e.g., formation of stellar and planetary systems; study of galaxies with resolved stellar populations; early Universe and cosmology).

2. Advise the ST ScI Director on proposal solicitation, peer review, and selection criteria for Hubble Treasury Program observing projects. The unique qualities of these projects—including their diversity—may require significant flexibility in the selection process.

3. Monitor and report on the progress of ongoing Hubble Treasury Program research. The membership of the HTPC should have enough continuity to monitor and coordinate observing projects that may extend over several cycles. It should be composed of both external and ST ScI scientists.

## WAYS OF DOING BUSINESS

The Second Decade Committee recognizes that this recommendation creates the need for working relationships between the new HTPC, the ST ScI staff responsible for conducting science program selection, and the new peer review panel of the Hubble Treasury Program. Because each of these groups either advises or reports to the Director, he should define their interfaces. The Committee limits itself to making some suggestions on implementation.

The ongoing GO/TAC program and the new Hubble Treasury Program should be mutually supportive. Hubble Treasury Program orbits not allocated in a given cycle should revert to the GO/TAC pool. Also, the GO/TAC process should still consider any large, Treasury-independent, PI proposals that are submitted through normal channels. The GO/TAC and HTPC activities should be coordinated to optimize science. This could be accomplished, for example, by the chair of each committee serving as a member of the other committee. Among other benefits, this would prevent duplication of observing plans between GO/TAC and Hubble Treasury Program projects.

The separate peer review process for the Hubble Treasury Program should be based primarily on scientific excellence and technical feasibility, and should reflect the aspirations of the astronomical community. However, because of the scope and multiple uses of large observing projects, the HTPC may recommend additional selection criteria as appropriate, such as

- Technical innovation; pushing the envelope; advancing the state of the art.
- Plans to provide high-level, calibrated, science data products to the archive.
- Provision of value-added data-analysis software.
- Coordination with other observations.
- When appropriate, minimum proprietary period needed to produce a uniform, easily accessible and calibrated data set.
- An education/outreach component.
- Cost effectiveness; possible outside resources.
- Overall management plan.

The Hubble Treasury Program selection process should not be binary, which is to say, not limited to approval or rejection. It should allow considerable latitude in suggesting changes or identifying synergism with other proposals, and encourage the re-submission of improved proposals where appropriate. The resulting approval process might be multi-staged, which the Second Decade Committee regards as advantageous. The first stage could be mainly for scientific merit and technical feasibility. The second and subsequent stages, after feedback to the proposers, could be mainly for the additional factors listed above. The HTPC should be proactive, before and after peer review; flexibility is the watchword.

Early strategic planning could achieve significant gains in observing efficiency. By opening the possibility of examining several projects together, to identify common observations, the Hubble Treasury program could achieve more science per orbit. (For example, deep images of fields at high galactic latitudes, if carefully planned, could be used for studies of galaxy evolution, galaxy clustering, weak lensing, supernovae, cosmological parameters, and so forth.) When such “marriages” occur, the PIs of the separate observing projects could meet as a working group under the auspices of the HTPC to develop a detailed plan for their combined or coordinated observing. Pilot studies for some of these larger, combined programs could be undertaken with DD Time.

The goal of cost effectiveness may call for close coordination between the Hubble Treasury Program project teams and the ST ScI staff. This would bring to bear the operational experience gained from previous observations, their analysis, and archiving. The application of such experience would benefit the entire Hubble science program. However, deep involvement of ST ScI staff should not be considered mandatory except in cases in which the desired efficiencies could not otherwise be achieved.

The funding profiles for Treasury observing projects may differ from those of typical GO projects. For example, more early funding may be required for the larger tasks of planning, coordinating, and preparing uniform data sets and catalog products for the archive. Economies of scale should be possible, and the funding per orbit should not exceed that of typical GO teams. Indeed, it might be substantially smaller. (It is vital to assure adequate funding in the AR program for Hubble Treasury Program data analysis.)

The Second Decade Committee recommends the Hubble Treasury Program as Hubble's new way of doing business on the large scale. We are unanimously optimistic that outstanding results—and no harm—will come from this new departure in observing-project selection. After it progresses from an experiment to a working reality, Committee members would not be surprised if the Hubble Treasury Program itself were regarded as a lasting intellectual contribution of the Hubble science program.

# COMMITTEE MEMBERS

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