# APC white paper: State of the profession

## Research scientists in support of facilities and missions: Facility support and research as an interlocked pair

**Lead author:**

David R. Soderblom, Astronomer
Space Telescope Science Institute
3700 San Martin Drive, Baltimore MD 21218
1-410-338-4543; drs@stsci.edu

**Additional authors:**

Belinda Wilkes, Director, Chandra Science Center
Abhijit Saha, NOAO
Jeff Hall, Director, Lowell Observatory
André-Nicolas Chené, Gemini Observatory
Alexei Pevtsov, NSO
Bradley M. Peterson, Ohio State University and STScI

# Research scientists in support of facilities and missions:

## Facility support and research as a necessary pair

David R. Soderblom, et al.

### Abstract

Modern observatories – on the ground or in space – are mostly run as remote, largely hands-off facilities in which an observer relies critically on the expertise of staff scientists to craft the commands that will acquire the desired data; monitor, calibrate, and maintain instruments; develop data reduction pipelines; and to extract fully calibrated data that is then archived. Scientists who themselves depend on the facilities that they support in order to address their own science goals have a much deeper knowledge of the facilities, leading to a higher level of user support and to new modes, more efficient telescope use, and overall more and better scientific output. This white paper urges a policy statement that supports the value of research scientists at facilities and missions, irrespective of the funding source. This will be especially important for missions and facilities now being planned and constructed.

## Key issue and overview of effects

Astronomy is distinguished by concentrated facilities with distributed users. The underlying model is that an astronomer anywhere is eligible to use a publicly-funded facility, primarily limited by the quality of the science proposed. These facilities and the services they provide have evolved enormously. In the early years of the NSF-funded ground-based observatories (Kitt Peak National Observatory, Cerro Tololo Interamerican Observatory, and the National Radio Astronomy Observatory, for example), telescopes and basic instruments were made available, but the material acquired was usually retained by the observer, and any processes for reduction and analysis were often those of the observer and/or his or her home institution. At the same time, these facilities included active research astronomers from the start, knowing that individuals who themselves depend on tools for their own work will be motivated to create and maintain the best tools possible.

For facilities and missions to be good for astronomy, the institutions that support them need to be good places to be an astronomer. That philosophy was codified in the Hornig Committee Report of 1976[1] that established the astronomical community's intents for how the Space Telescope (i.e., Hubble) would be operated. They foresaw an institute outside of a NASA center with scientific independence, and they advocated for an Institute with

> *"a director and staff of the highest professional stature…which, through its own involvement in research with the ST, will ensure the optimum use of the telescope by monitoring and improving the technical performance of the ST and by assisting visiting scientists in making observations and in processing data."*

The study also noted that

> *“Unless [STScI] is thus involved in advancing the state of the art, it will be difficult for the Institute to recruit and keep a professional staff of the requisite quality."*
>
> *"There must be a full-time staff of astronomers who make use of ST in their own research. … A permanent central staff has been found to be essential to the scientific productivity of complex facilities in all areas of science."*

This concept for the Space Telescope Science Institute from the 1970s continues to work today across all of astronomy and has been fundamental to the enormous growth and success of astronomy and astrophysics in the last several decades. In addition, the roles of observatories have expanded beyond just data acquisition, to include reduction and analysis software and archiving: if the data were acquired with public funds they should be preserved and made freely available, and similarly there is a strong move toward open-source software.

This statement of better scientific results through an actively involved research staff is more than just a philosophy. The effectiveness of a science staff in carrying out this larger mission hinges on the staff's credibility and reputation as scientists. Credibility with peers depends on a vigorous research program, publications, effective outreach, and service in scientific organizations and peer review; in other words, joining in and initiating broader community activities. Credibility outside the science community hinges on the ability to effectively communicate the knowledge, importance, and excitement of scientific research to a broader public. A strong institution has scientists with a broad range of expertise relevant to the mission, ranging from observers who know how to make the most precise observations with the minimum observing time, to instrumentalists who understand the physics of detectors or the complex behavior of optical systems.

A strong science support institution needs a degree of independence, so scientists within that institution need to develop strong independent research programs. This comes with a recognition of the value of freedom of expression in a scholarly enterprise. In this case, this freedom is to allow astronomers to take positions of advocacy that may at times diverge from those of their funding agency, or even from the views of the leadership of the institution. The latter is a formal and direct recognition of complementary roles of staff astronomers to serve as advocates and spokespersons for the mission and as well as productive members of the community using the observatory to conduct science. Without a strong research component, a science center can lose touch with its community, and may very well miss opportunities to bring about, participate in, or support future cutting-edge facilities.

## Roles of research scientists in mission and facility support

In addition to conducting independent research, scientists play key roles in the success of missions and facilities:

***Catalyst***: In institutions with complex and demanding technical tasks, the research scientist helps to ensure that scientific interactions are a regular part of daily work life. This includes actively fostering formal and informal interactions, possibly creating new venues for talks and discussions, and advising on how to allocate the resources that are devoted to internal research activity (colloquia, conference travel, publishing, etc.). Knowing of the research interests and accomplishments of the rest of the staff, such a person helps to pollinate ideas between research groups.

***Strategist****:* Immediate needs can cause staff and management to take their eyes and minds off the long-term future of an institution, yet it cannot afford to lose sight of the future while mastering the present. The research staff participates in staying abreast of national and international developments, monitoring and guiding long-term trends in astronomy, and in attracting and retaining talent in fields of greatest relevance.

***Advocate****:* The independence of research staff members enables them to act as advocates within the groups and communities they serve.

## Advantages of research scientists in mission and facility support

Among the concrete advantages of staff research to a facility or mission are:

***Staff recruitment and motivation:*** Having research time as part of the position helps to attract and retain a high-quality science staff. A good and supportive research environment provides general motivation for the science staff that will generate better research and support.

***Better user support:*** Having staff that are facility users who have to take data through to publication allows them to understand the full user perspective and anticipate needs. When combined with detailed technical knowledge of the instruments, procedures, and systems, this produces superior user support. Also, in the case of queue observations, it is the research staff that can see details that may not be noticed by those outside, leading to direct improvements.

***Production of new modes and capabilities:*** Staff research interests drive and aid the development of new observing modes and capabilities. There are many examples that can be cited, and a few include:

- Gemini Altair SFO open-loop focus technique for observing sources with faint guide stars, plus LGS+P1 mode for studying targets without Altair guide stars.
- Gemini Using narrow filters and micro-slits for highly multiplexed kinematic studies of globular clusters.
- Gemini: GMOS nod & shuffle technique for studying faint, high-redshift galaxies.
- Gemini: Target of Opportunity observing mode.
- Gemini: Fast-IR time series observations

- HST: WFC3 spatial scanning mode, invaluable for achieving parallax precision close to that of Gaia, and for exoplanet transits.
- HST: WFC3 IR channel DASH technique to enable eight times larger surveys.
- HST: STIS BAR5 occulter usage for high-contrast imaging.
- Chandra: Developing joint proposals to enable multi-wavelength science over shorter time-scales (joined by Spitzer and HST).
- Chandra: Developing a combined catalog and data products for all detected Chandra sources, used by all the community.
- Chandra: Developing metrics to track publications connected to individual datasets to measure mission impact and archive use.
- NSO: New synoptic data products for space weather research and forecasting.

***Improved data reduction techniques and products:*** Producing publication-quality data produces a deep and thorough understanding of data and instrument systematics. This usually involves improving data reduction, analysis procedures, etc.

## Broader benefits to the astronomical community

As examples of how research scientists have used their independent research time in service to the community, we note:

- Creating a means to recover from the flawed HST mirror.
- Seeding an infrared channel on HST/WFC3. This IR camera has been extremely productive in itself and has proved vital in preparing STScI for JWST.
- Starting the effort that led to JWST as a NASA flagship mission.
- New initiatives for other space- and ground-based observatories, including DKIST for solar research.
- Initiating active encouragement of the role of women in astronomy through the Baltimore Charter.
- Double-blind proposal reviews, to minimize biases.

## NASA science operations centers

In 2007, NASA requested that the National Research Council of the National Academies of Sciences carry out a study of NASA astronomy science centers. The study was chartered to conduct a comparative review of current science centers; identify best practices and lessons learned; and assess whether there are optimum sizes or approaches for science centers. The study focused on six science centers: the Chandra X-ray Center, the Michelson Science Center, the Rossi X-ray Timing Explorer mission guest observer facility, the Space Telescope Science Institute, the Spitzer Science Center, and the X-ray Multimirror Mission-Newton guest observer facility. The results of the study were published as the NRC report “Portals to the Universe: The NASA Astronomy Science Centers”.

A 2012 workshop was commissioned by the SMD Astrophysics Division to assess progress in addressing recommendations made in 2007 “Portals to the Universe” report. In particular, the meeting gave a forum for current missions to highlight areas or tasks that are well supported at their respective science centers, enabling the compilation of a consensus set of best practices for current and future NASA missions. In addition, the meeting provided an opportunity for centers to provide direct feedback to Headquarters on policy issues.

The workshop addressed a number of issues specific to mission operations and support, but the first two "Best Practices" cited were these:

> **The primary goal of a NASA Science Operations Center is maximizing the scientific return of a mission for the user community**. Maintaining the health and safety of the facility is a crucial part of this goal.
>
> **An active research staff is an essential component of an astronomy center in all phases of a mission.** Research staff members play a vital role during the development phase, ensuring that instruments and operations are designed to optimize the scientific performance. In the operational phase, the research staff interacts with and represents the user community, and has a vested interest in maximizing the scientific capabilities and overall productivity of the mission. An active research staff is crucial to maintaining scientific vitality as a mission evolves. During closeout, research staff members optimize the data products for archival science. Finally, research time provides an incentive to attract and retain high quality staff to support and maximize the science return from NASA missions.

## Strategic plan

The "strategy" we adopt is simple: we urge the Astro2020 survey to include a strong and positive statement on the value of active, independent research astronomers in supporting facilities and missions of all kinds. NASA has accepted the statement above, and we feel it should be broadened to all facilities and missions, current and anticipated. Our suggested modified statement is this:

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***An active research staff is an essential component of an astronomy center in all of its phases.*** *Research staff members play a vital role during the development phase, ensuring that instruments and operations are designed to optimize the scientific performance. In the operational phase, the research staff interacts with and supports the user community, and is motivated to maximize the scientific capabilities and overall productivity of the facility or mission. An active research staff is crucial to maintaining scientific vitality as an institution evolves. Research staff members optimize the data products for archival science and the access to those data, an increasingly critical part of operations. Finally, research time provides an incentive to attract and retain high quality staff to support and maximize the science return from all facilities and missions.*

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## Organization, partnerships, and current status

As a statement of principle, the adoption of the essential nature of active research staff in successful facilities and missions is up to individual funders and institutions.

## Schedule

The statement should appear in the Astro2020 final report.

## Cost estimates

There are no direct costs associated with our proposition; what is needed is an explicit policy statement. There may be perceived indirect costs for institutions in order to maintain a research staff and provide research-related services to them, but that is offset by the tangible gains in quality and quantity noted above. In addition, research staff often bring in research funding to support their programs through open competition. For example, at STScI about 7% of total annual funds come in from grants, in a staff with roughly 20% researchers.

[1] "Institutional arrangements for the Space Telescope," National Academy of Sciences, 1976