The Ground-Based O/IR National Observatory: A Roadmap to 2020

A White Paper from the AURA Future of NOAO Committee

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Preamble

A National Observatory for ground-based optical-infrared (O/IR) astronomy remains as necessary and relevant today as it was when NOAO was founded 50 years ago. Enormous challenges and opportunities face the US astronomical community in the decades ahead. Now is the time to reaffirm the basic mission of the National Observatory and to define a core set of activities to meet those challenges. In order to fulfill the community aspirations for a strong National Observatory, NOAO can and must continue to evolve to complete the missions of both today and tomorrow.

The Essential Roles of the Ground-based US O/IR National Observatory

I – Access for All to the Entire Range of Science Capabilities

Science advances most efficiently when researchers with the best ideas have access to the capabilities they need, regardless of who they are or where they work. In the ideal, everyone would have access to the entire range of science capabilities across all telescope aperture sizes. Although often expressed in terms of under-represented groups or people without access to their own facilities, even researchers with access to non-federal facilities benefit from open access to capabilities outside of their immediate institutions.

A strong National Observatory must provide every US astronomer with merit-based access to world-class capabilities that span the entire range of telescope aperture, from 1-m to 10-m (and beyond, as new extremely large telescopes emerge) and ensure access to large public survey datasets and the tools to exploit them.

II – Leader of the US O/IR System

The continued development of the US ground-based O/IR System is critical to the future success of the "open access mission" (as defined above). This public-private alliance, first outlined in the 2000 Decadal Survey, enables the broadest participation, at the highest level of excellence, in scientific research, education, and public outreach. The concept has gained support from participating institutions, and has also proven successful in attracting US federal resources from beyond the National Science Foundation.

A strong National Observatory must be the backbone of this public-private alliance, to provide the leadership and perspective necessary to develop the US O/IR System for the benefit of all American astronomy, and to facilitate open access via peer review to all System facilities.

III – Focal Point for National and International Ambitions of the US Community-at-Large

The astronomical research enterprise has become more diverse, complex, and international. It is difficult for many universities, even in partnership with each other, to develop new, world-class research capabilities in this environment without the enabling leadership of a strong center with on-going scientific and technical expertise. Furthermore, individual universities or university-based consortia, by their nature, articulate their own needs and ambitions, not necessarily those of the US astronomical community-at-large.

A strong National Observatory must distill and represent the needs and goals of the entire US astronomical community in discussions with present and future national and international partners. In particular, a strong National Observatory is the natural focal point for national and international collaborations funded by national-level funding agencies. A strong, on-going National Observatory contains the scientific and technical expertise needed to enable world-class projects involving university-based consortia and international partners.

IV – Excellence in Education and Public Outreach: Development of the STEM Workforce

The United States faces a growing challenge to maintain and improve its general level of science literacy and to attract young people into the STEM (science, technology, engineering, mathematics) fields, especially from groups historically under-represented in science. Astronomy remains a powerful inspiration for drawing young people, from grade school to undergraduate level, into the STEM enterprise.

A strong National Observatory must assist STEM education stakeholders and strategic partners to collectively improve science literacy and promote STEM workforce development. The National Observatory can play a critical and catalytic role in the educational and workforce development efforts of professional organizations like the Astronomical Society of the Pacific,

the Optical Society of America, the National Science Teachers Association, the Association of Science-Technology Centers, and the American Astronomical Society. The National Observatory can create the high quality programs to support primary education teacher and student astronomical research, and thus help colleges and universities attract and train a diverse group of students for STEM careers. The National Observatory can provide under-represented groups from across the country with training opportunities in astronomy and astrophysics, as well the engineering disciplines needed to build modern telescopes, instrumentation, and data systems.

V – Excellence in Research, Technology, and Program Management

National and international leadership requires organizational excellence in scientific research, technology, and program management. Maintaining such organizational excellence requires on-going research and development activities executed by a world-class staff.

The National Observatory must operate facilities across a range of telescope apertures, be capable of developing instrumentation and data management systems, and play both leadership and supporting roles in technological endeavors in cooperation with other national centers and university-based partners. Within the framework of a US O/IR System, the National Observatory will be one of several national centers of excellence in these areas.

NOAO is the US National Observatory for Ground-Based O/IR Astronomy

The National Optical Astronomy Observatory (NOAO) is the US National Observatory for ground-based optical-infrared astronomy. The Association of Universities for Research in Astronomy, Inc (AURA) manages NOAO under cooperative agreement with NSF. The rest of this document describes how NOAO should proceed in the next 5 – 10 years to fulfill the vision of a strong National Observatory.

NOAO: A Roadmap for the Next Decade

I – NOAO Must Continue to Lead Development of the US O/IR System

In response to the 2006 report of the Senior Review of NSF astronomy facilities, *From The Ground Up: Balancing The NSF Astronomy Program,* NOAO organized two external committees to review current and future capabilities across the US O/IR System. Both committees independently surveyed the astronomical community and distilled extensive input. The *Renewing Small Telescopes for Astronomical Research (ReSTAR)* committee report described the excellent scientific research enabled by 2- to 5-m telescopes and made prioritized recommendations about upgrading infrastructure at facilities, improving science capabilities, and increasing access to telescopes in this aperture range. The *Access To Large Telescopes for Astronomical Instruction and Research (ALTAIR)* committee focused on similar issues for telescopes in the 6- to 10-m aperture range.

The ReSTAR committee gave highest funding priority to ensuring safe, reliable, and efficient operations at existing telescopes, followed by the development of competitive instrumentation and associated data processing software. They recommended the incorporation of three or four new, or existing, 2- to 4-m class telescopes into the US O/IR System, and that specialized time domain facilities should also receive priority.[1]

The ALTAIR committee concluded that the Telescope System Instrumentation Program (TSIP) has been successful and well received by the community, providing powerful new instruments for large telescopes in return for increased access to independent observatories for the broader US community. The ALTAIR committee recommended the annual TSIP budget be increased to 10 M$. The ALTAIR committee also identified an increase in US participation in Gemini as the most straightforward way to increase the number of open-access nights in this aperture range. This recommendation was contingent on a realignment of Gemini instrumentation to better meet US scientific interests, among other concerns.[2]

This panel strongly endorses the recommendations of the ReSTAR and ALTAIR committees and urges their implementation over the course of the next five years.

The roles of NOAO in this arena include: coordinating the development of an efficient and capable O/IR System through organization and strategic planning, providing broad access to

[1] The ReSTAR final report is available on-line from http://www.noao.edu/system/restar.

[2] The ALTAIR final report is available on-line from http://www.noao.edu/system/altair.

excellent facilities, managing the TSIP program, enhancing instrumentation, and coordinating development at federal and non-federal facilities to increase the overall efficiency of the O/IR System. In the next decade, NOAO should explore broadening the System concept to include international partnerships on a variety of telescope apertures.

II – NOAO Must Be Unified with a Restructured Gemini Observatory

NOAO and Gemini should be united into a truly flagship National Observatory that provides scientific direction and state-of-the-art observational capabilities across the full range of telescope apertures and enfranchises the broadest community of observers.

As emphasized in the findings of the ALTAIR committee, the US community is not satisfied with Gemini in its current configuration. Satisfaction with scientific productivity and cost effectiveness can be regained, and a strong community of users can be re-engaged, if Gemini better meets the scientific aspirations of its communities, both US and international. This vital component of the US O/IR System must be re-cast before the community will endorse increasing its share in Gemini. New instruments that enable a broader range of science than the present suite of Gemini instrumentation must be designed, built, and commissioned, on the shortest feasible timescale.

This panel recommends that the NSF, in consultation with its international partners, consider unifying the three current nodes of the ground-based O/IR System in Hawaii, Chile, and Tucson under one management structure within an integrated Observatory that combines the current NOAO and Gemini facilities and activities. We recommend that Gemini be reformed with a streamlined management and organizational structure that can improve the quality and quantity of scientific output. This will simultaneously increase the efficiency and effectiveness of the Observatory, with the potential for cost savings. This newly invigorated Observatory will meld the historically strong connection of NOAO to its user community with cutting-edge science enabled by the Gemini telescopes. Potential improvements in the performance of Gemini will benefit all of the partners, not just the US. Moreover, a structural reorganization could offer the Gemini international partners access to other components of the O/IR System of telescopes to which NOAO currently provides access.

III – NOAO Must Continue to Participate in the LSST Project

The Large Synoptic Survey Telescope (LSST) will be a powerful and unique tool for astronomical research. LSST will survey the entire visible sky every few nights with short repeated exposures. Over a ten-year period, LSST will assemble a survey of unprecedented depth and temporal coverage across the entire southern sky in multiple wavelength bands, producing an image and object database of unprecedented size. The LSST Project is fully committed to producing a

community dataset for professional astronomers and the public alike. LSST data will be available to everyone in the US community without any proprietary period.

NOAO has played a central role in the LSST project since its inception, including being one of the four founding members of the LSST Corporation. NOAO must continue its active roles and current activities in the development of the LSST project (especially in the area of telescope design/development and cross-project system engineering) and serve as the focal point for scientific participation by the astronomical community-at-large via the LSST science collaborations. These collaborations are helping to shape the science goals and plans for LSST, and it is vital that the community-at-large be able to engage now.

The anticipated operational role of NOAO in the LSST Observatory should be further encouraged and given appropriate financial support. LSST will be located on Cerro Pachón in Chile, near existing facilities that NOAO already operates. Furthermore, one of the key LSST data centers is planned to be co-located with existing AURA/NOAO facilities in La Serena, Chile. It seems natural and appropriate that NOAO become the operating organization for LSST in Chile on behalf of the entire LSST collaboration.

IV – NOAO Must Engage with Next-Generation Extremely Large Telescopes

NOAO must be charged with ensuring open access for the US community to the next generation of extremely large telescopes (ELT: aperture > 20m), which are currently being developed by three international partnerships. NOAO should help integrate these projects into the O/IR System and should be provided with the resources necessary to carry out these tasks. The amount of time available to the community through NOAO should represent a significant share of the time on one or more such telescopes. Open access is essential to ensure that these expensive facilities produce the best science, independent of institutional affiliations of individual investigators. Ideally, access will be distributed, to provide the US community with the broadest possible range of capabilities available internationally; development of these capabilities should be coordinated to minimize redundancy.

The NOAO roles will evolve, commensurate with federal funding, as the projects proceed from design through construction, and from commissioning to operation. NOAO and the broader astronomical community it represents require mechanisms that enable proactive participation in current and future decision making in the ELT era. The role of NOAO during design and construction should focus on augmenting the initial instrument suite, design of operations in support of the full US community, and education of the community regarding ELT capabilities. NOAO should exercise oversight of the expenditure of federal funds for ELTs, on behalf of NSF. NOAO should participate in the construction of new instruments, and should ensure that

capable groups throughout the US have similar opportunities to compete for instrument development funds. NOAO should also provide assistance during commissioning of the telescope(s) and instruments.

During the operations phase, NOAO should act as the gateway for community access and represent the US astronomical community in observatory governance. It could provide on-site support for operations, or off-site support in such areas as data management, instrumentation development and maintenance, and other areas where an NOAO contribution is efficient and cost-effective. NOAO staff would maintain familiarity with ELT capabilities through direct support of operations and through scientific use of the facilities.

V – NOAO Must Support Survey Science and Associated Technologies

NOAO must recognize and respond to the increasing importance of survey science in astronomy and astrophysics. The execution of wide-area survey projects, the creation and management of massive datasets, and the development of collaborations that involve tens to hundreds of widely distributed scientists is changing the way many astronomers conduct their scientific investigations. The Sloan Digital Sky Survey (SDSS) may be the most well-known and high-impact survey in recent memory, but it is not alone. Future surveys – large and small, photometric and spectroscopic – will equal or exceed SDSS in impact.

NOAO must continue to facilitate medium- and large-scale observing programs spanning multiple facilities throughout the US O/IR System, and ensure the delivery of rich, well-calibrated data sets suitable for multiple investigations by the community-at-large.

NOAO must adopt and promulgate cost-efficient, best-practice data description and data management standards throughout the US O/IR System to maximize potential data reuse. NOAO must encourage elements of the System to develop raw data archives that serve public science data and any associated calibration data. Technical leadership by NOAO would allow elements of the System to implement these raw data archives for substantially less cost than a distributed effort. NOAO should also support high-level archives that serve calibrated data, in cases where such archives are cost-effective. Finally, as appropriate, NOAO should explore and evaluate new observing approaches, beyond classical and queue observing, to maximize survey planning and execution. LSST provides a natural focus for NOAO activities in this area. In turn, NOAO should endeavor to distribute processes, tools, and lessons learned from LSST for the benefit of other NOAO and non-NOAO projects.