

GSMT: The Case for Community Access to an Extremely Large Telescope

Astro2010 White Paper submitted to the State of the Profession Demographics (DEM); Facilities, Funding and Programs (FFP); and International and Private Partnership (IPP) Infrastructure Study Groups

March 13, 2009

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1. Introduction

The essential characteristics of an optimal “OIR system” were summarized by a recent AURA committee report on the Future of NOAO¹:

The greatest scientific progress comes from providing opportunity for all scientists to participate, 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.

[This process] must ensure that any person’s good scientific idea can go through peer review and gain access to scientific capabilities competitive with those offered anywhere in the world. Merit-based access must be available to the entire range of telescope aperture from 2-m to 10-m (and beyond as new extremely large telescopes emerge) to enable the broadest and best possible participation in the astronomical science enterprise.

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.

This paper discusses the needs for open access to future extremely large telescopes, and possible routes to achieving this access.

¹ This report, *The Future of NOAO: Essential Roles, Roadmap to 2020*, has also been submitted to the *Future of the Profession* panels.

2. Background

Serious consideration of the feasibility of an extremely large telescope² began in the late 1990s, prior to the start of the 2000 Decadal Survey. These investigations included technical studies of specific aspects of such a facility, as well as exploration of the science case. From the outset, the national OIR observatories (NOAO and Gemini) provided scientific and technical leadership in developing the science case for an ELT and in exploring technical issues. These efforts included two AURA-sponsored “Maximum Aperture Telescope” workshops (Madison WI, August 1998 and Woods Hole MA, September 1999) as well as similar international workshops in which there was significant US participation (e.g., Backaskog, Sweden, June 1999). The ability of the national observatories to act in a leadership role and join with other efforts within the broader US community was critical to providing an early start to the current US-based ELT projects.

These collective efforts laid the groundwork for the recommendation in “Astrophysics in the New Millennium” for construction of an extremely large telescope (the “Giant Segmented Mirror Telescope”, GSMT) with significant Federal participation. Since then, two US-based consortia – the Giant Magellan Telescope (GMT) and the Thirty Meter Telescope (TMT) – have undertaken the design and development of such a facility. In addition, the European Southern Observatory (ESO) is engaged in an even more ambitious development effort (E-ELT). NOAO has acted as a vehicle for Federal investment in the US-led design and development efforts, primarily through supplementary funds from NSF awarded to AURA, which were then awarded to the two projects, but also through a modest investment of NOAO resources. Use of NOAO resources was terminated at the end of 2006 at the request of NSF, and the future of the NSF supplementary funding is very uncertain at this time.

NOAO also established a community-wide science working group (GSMT SWG) in response to the 2000 decadal survey. This working group, again supported by NOAO scientific staff, produced white papers on scientific opportunities with an ELT and participated in the studies for the “GSMT” conceptual design led by NOAO. The AURA GSMT project subsequently merged with TMT, while the SWG continued as an independent body charged with providing advice to NOAO and NSF. In recent months, the SWG has been in hiatus pending a better understanding of NSF and NOAO involvement in one or more ELT projects.

Both GMT and TMT are presenting information to the current decadal survey, Astro2010. The purpose of this paper is to outline why open access by the US community to one or both facilities is an important goal over the next decade. The focus of this paper is therefore *not* on the science enabled by GMT or TMT, since the projects should provide a comprehensive presentation, but rather on the ways in which broader access to

² We consider an extremely large telescope (ELT) to be a telescope with an effective aperture greater than 20 m.

such facilities will enhance the science that is done. There is also a brief discussion of ways in which such access might be enabled

Given uncertainties in Federal investment, it is possible that one or more projects will reach fruition without Federal support and thus the US community-at-large will have no direct path to access an ELT. On the other hand, it is possible that both US-led projects will be unable to obtain the funding they need, meaning *no* US astronomer has direct access to an ELT. This worst case is plausible but not inevitable. A minimal outcome for the US, which we argue below is not healthy for the state of ground based O/IR astronomy, is that only people at a few US institutions will have access. If ESO then does obtain funding for the E-ELT, leadership in this scientific area may shift away from the US permanently.

Science advances best when more investigators have access to tools at the leading edge of exploration. The purpose of this paper is to make the case that a significant amount of open access to an ELT justifies the resources required to obtain it.

3. Community Science

Both TMT and GMT have expressed a strong commitment to participation by U.S. scientists from non-member institutions in the building and use of their facilities. NSF, AURA, and NOAO support the goal of U.S. public participation in at least one, and possibly both, of these ambitious projects. The designs of these two telescopes are well advanced. However, the opportunity for public involvement in planning and executing science programs, specifying and constructing instrumentation, modes of operation, time allocation, integration into and coordination with the full system of US astronomical facilities, and the processing, archiving, and public distribution of data products are all topics that require strong involvement from the full US astronomical community.

Accordingly, NOAO, the GSMT SWG, GMT and TMT sponsored a community workshop, held in Chicago June 15-18, 2008. Close to 100 participants attended, representing astronomers from a broad range of institutions and with an equally broad range of scientific interests. Most – intentionally – were not from institutions already associated with GMT or TMT. Presentations at the workshop fell into three areas:

- An initial set of presentations covered current status of the two projects, as well as the corresponding European effort. A presentation from the NSF was also made.
- Four panel discussions were organized, covering many of the key aspects of operations mentioned above. Time was allotted for audience participation.
- Interspersed with the panel discussions, speakers provided overviews of possible science programs to be carried out on an ELT; the speakers were expected to follow up with a written description of their science program or programs.

The presentations from the workshop were originally expected to provide a starting point for the development of a “Design Reference Mission”, whose purpose is to outline the science case for an ELT facility in which there would be public participation, the scientific performance of such a facility, and a description of the manner in which it would be equipped and operated to meet community needs.

Presentation materials from the workshop are [posted](#) on the World Wide Web. The posted material includes summaries of the panel discussions (including questions and comments from participants in the audience) and any written science cases provided by workshop speakers.

The presentations and discussions demonstrated both projects’ interest in engaging the general community and providing public access in exchange for Federal support, as well as the existence of a significant portion of the US astronomical community with an interest in such access. The GSMT Design Reference Mission would provide a more comprehensive description of this access.

Several other conclusions can be drawn as well:

Limited access to current large telescopes. It is clear that many of the people who envisage using an ELT for their science suffer from limited access to existing large facilities. That is, the community outside the GMT and TMT partnerships is, to a large extent, also outside current US-based 6-10-m telescope partnerships (Keck, Magellan, LBT, HET and MMT). Thus their current large telescope access is primarily through Gemini and the limited public access provided through the Telescope System Instrumentation Program (TSIP). We conclude that, in order to be competitive in getting ELT time a decade hence, the general community needs access to a broader range of capabilities as well as more time on telescopes in the 6-10-m aperture range.

Also, in the short term, the community needs better exposure to the capabilities that are available or potentially available, in particular rapidly-developing technologies. For example, it became clear at the workshop that many people’s perceptions of laser guide star adaptive optics as “experimental” lag reality considerably. NOAO is sponsoring a specialized session at the summer 2009 AAS meeting on LGS AO to help inform the community.

Possibilities and value of enhanced operations. Both projects envisage very simple operational modes for their baseline operations. In particular, neither contemplates queue observing nor support for a true data archive as part of initial operations. Both do expect to provide on-site scientific support, as well as some means of storing raw data on at least a temporary basis. Queue observing and data archive development and operations compete for funding with instrument (and adaptive optics) development and support. This competition for resources will be severe even with Federal participation on a project of this scale. A variety of views were expressed on the relative priorities, with no final consensus achieved.

Some compromise possibilities were mentioned. The value of a data archive is greatest for large, uniform data sets, such as those produced by surveys and other large programs. The scientists involved in such projects must produce such data sets in order to achieve their goals. So the issue is then primarily one of public access. As an example, time is allocated through the NOAO survey program only on condition that the data are made public, and the survey proposal must demonstrate that the data can be properly reduced and made available. Thus the burden on the observatory of supporting such large datasets could be manageable without great expense.

The requirements for obtaining quality data were discussed. It was generally agreed that proper calibration is critical, and that calibration and data-taking procedures must be properly documented. The value of “pipelines” or quasi-automatic data reduction procedures was more controversial (as opposed to a minimal set of reduction and analysis tools and recipes). It was emphasized that a true pipeline represents a substantial development effort as well as a rigorous calibration and data quality control program – even if it is able to draw on prior development work – and far from an afterthought.

The value of queue observing relative to its cost was also debated. Queue observing can serve at least two distinct purposes. One is the ability to obtain data requiring relatively rare conditions (including targets of opportunity). The other is the ability to prioritize higher-ranked programs among those scheduled on the telescope. The panel discussions included mention of ways in which some of these goals could be accomplished through semi-classical modes such as “delegated” or “service” observing in long blocks of time. The discussions were fairly vague because neither GMT nor TMT has both a final site and a well-defined initial instrument complement.

The costs of adding advanced operational modes increases as the date of implementation moves later; the planning by both TMT and GMT allows “upgrades” early on but these interfaces may be harder to maintain as the projects mature³.

Issues of community participation. There is currently no mechanism for substantial community participation in either project, though both have added scientists to their scientific advisory committees who are not directly affiliated with the partner institutions. In addition, NOAO has observer status with both projects. Until there is a commitment of substantial Federal funding, it is not reasonable to expect much more – but by the time such a commitment materializes (if it does), both projects will be well down their development paths, if not into very early construction.

How can the community be assured that a facility in which they join at a late stage is in fact something that they need and want? It is reassuring that the science cases developed by both GMT and TMT (and by the GSMT SWG and the ESO E-ELT) are very similar. This suggests that the underlying scientific needs of the general community will be met even if they are not well-represented throughout the development phase. Fortunately, too, there are areas where the baseline can be modified at a later date. In particular, neither project will be able to build the full instrument suite it desires right away; public input

³ The E-ELT baseline does include many of these advanced operation modes.

can therefore affect choices for the second (and later) generation instruments. Second, some of the expanded operating modes (archive or queue, for example) can be implemented at a later date provided the projects build in the capability to “upgrade”. Both projects have indicated their intention to do so.

4. Gemini and TSIP as a Test Case

If an extremely large telescope is built, the potential user community will surely be composed of most of the same people who are currently using the largest available telescopes. Thus it is not surprising that the US institutions in the GMT and TMT consortia are already associated with the HET, Keck, LBT, Magellan, and MMT telescopes. As noted in the preceding discussion of the Chicago workshop, the primary access to facilities of this class for the rest of the US community is through the two Gemini 8-m telescopes, with some additional time available through the NOAO-administered TSIP program on other telescopes and through NASA Keck time.

What do the users of this time look like? In particular, are they mainly people from institutions that already have access to similar facilities, or do they represent a broader community? A great deal of statistical data has been assembled by the ALTAIR committee (committee mission and report [here](#)); the most relevant information is summarized and discussed below.

The ALTAIR committee carried out a detailed on-line survey of the community, which obtained a large number of responses (570). The [ALTAIR report](#) also summarizes extensive statistical information on Gemini and TSIP observing time proposals⁴. We believe that the community represented by the survey responses is also representative of the demographics of potential ELT users. The following data are particularly relevant:

- Among the respondents, 56% had some sort of institutional access to a large (>6-m) telescope, while 44% did not. Examination of the responses suggests that the fraction of this group who would have access to TMT or GMT if both are built is probably close to 50%, perhaps slightly less. If only one is built this fraction will drop significantly.
- The fraction of the respondents who had applied for Gemini time was 62% - that is, a significant fraction of the people with institutional access to other telescopes nonetheless found it useful to propose for Gemini time in order to carry out their science.
- Based on telescope time allocation statistics, the fraction of successful Gemini+TSIP proposers (PIs) without institutional access is quoted as “about 2/3”, which indicates that the success rates for people with and without institutional access are similar.
- Over-subscription rates for the open-access time are somewhat facility-dependent, but generally average near or above 3 for the Gemini and TSIP time; exact

⁴ Data from the most recent Gemini proposal cycle (2009A) are consistent with the ALTAIR data.

statistics for the NASA Keck time were not provided but the over-subscription is quoted as being between 2.5 and 3.

- The distribution of successful Gemini and TSIP proposers is not restricted to universities with large astronomy programs, though these comprise roughly half of the US-based PIs and Co-Is. Large universities with small astronomy programs comprise the next largest fraction, followed by other categories such as government labs, colleges, and private observatories.

The data demonstrate that there is an active, diverse and scientifically competitive community of large-telescope observers that will not automatically obtain access if a US-based ELT is built. In the absence of Federal support, the group of institutions with extremely large-telescope-access is likely to be significantly smaller than the current group of institutions with direct large-telescope access.

The number of nights of non-Federal access to ELT time will be far less than for current 6-10-m telescopes. The ALTAIR report tabulates 9 facilities comprising 12 telescopes to which there is some degree of US institutional or open access. The combined access amounts to the rough equivalent of 9 telescopes. (For reference, the equivalent access for all non-US astronomers is almost exactly the same.) The US open access amounts to somewhat less than 20% of the total US access.⁵

The most positive scenario results in the construction of 3 ELTs world-wide in the next decade. In this case, the US access will be to less than the equivalent of 2 telescopes, since both TMT and GMT have non-US partners. In this optimistic scenario, the open-access time would be equivalent to about 0.5 ELT (following the recommendation of the 2000 Decadal Survey, and consistent with the aspirations of the GMT and TMT partnerships). In this case, the bulk of the community that now is productively using the equivalent of more than 7 telescopes through institutional access would be trying to make do with the equivalent of perhaps 1 - 1.5; this would almost certainly increase the demand from this same community for open-access time. At the same time, the amount of open-access time available would be less (in nights) by a factor of 3.

What would the situation be in such a case? The outcome would probably not be a consistent over-subscription rate of 10. One possibility would be a trend toward large collaborations and smaller proposals (both trends seen for Gemini proposals and described at the Chicago workshop referenced above). Some fraction of the US community could become disengaged in ELT science. Even now, a modest fraction of the ALTAIR respondents (around 10%) indicated that they did not propose for Gemini because of over-subscription; one would expect additional drop-outs from the pool of potential ELT proposers. Plausibly, these drop-outs would come from institutions with smaller astronomy programs, but some might come from larger institutions with a new emphasis on space-based observing or large-survey science.

⁵ For the purposes of this discussion we assume that all telescopes in this size class are the same. Obviously, they are not – there is a factor of 3 range in collecting area as well as significant differences in site characteristics, telescope image quality, field of view, and emissivity. But attempts to deal with these difference merely confuse the discussion without changing the conclusions.

These trends would be aggravated if the amount of US time available is only provided through a single telescope, or Federal support leads to a significantly smaller fractional participation.

5. Enabling Access

Several mechanisms for enabling community access to an ELT using Federal support are potentially available. There are effectively three possible mechanisms, which overlap in part:

Participation by the Federal government in one (or both) projects as a partner. The advantage of this approach is that the community's interests are well-represented since NSF (or its agent) is an equal partner. The disadvantage is that the time scale for such a commitment is difficult to reconcile with budgetary realities and project schedules.

Subsequent participation by the Federal government as a partner. In this case, the project or projects proceed with no Federal commitment, but subsequently the Federal government does become a partner. It would presumably contribute enhanced capabilities, such as additional operations capabilities and additional instruments. (In principle, one could even contemplate contribution to construction of a duplicate telescope, analogous to Keck II.) The advantage of this approach is that it is not tied to a specific time frame, though of course the later the Federal government joins, the less the impact. The disadvantage is that the projects must be able to proceed through construction into regular operations with no certainty of additional funding; if they succeed in this they may have limited incentives to include the Federal government as a partner. Also, because the Federal funding would most likely be drawn from annual operations budgets, the impact on other Federal astronomy priorities may be disproportionate to the benefit received; this is the "ALMA" problem. The only way to avoid this consequence is to grow the entire Federal budget outlay to NSF AST operations.

Participation by the Federal government, but not as a partner and without a long-term commitment. This would be directly analogous to the current TSIP program, where NSF funds are used to support instrumentation on "private" telescopes in exchange for open access to nights on these facilities; the NSF is not a partner in these facilities and the TSIP commitments span at most a few years. This approach has the advantage that it is simply an expansion of an existing, successful program; it has the disadvantage that the amount of access enabled is modest and can fluctuate significantly over relatively short periods. The fluctuations adversely impact the facilities, which cannot make long term development plans, and community astronomers, who are not guaranteed they will have stable enough access to complete their science programs.

6. Conclusions

When the next generation of extremely large telescopes is built, the US will have an extensive community capable of doing forefront science with these facilities. Expected

demand for access will far exceed the amount of time, even under the most optimistic estimate of the number of facilities that might be built. Over-subscription will be far greater than for the current largest telescopes. In more pessimistic scenarios, open access would be minimal and leadership in those scientific areas that require observations with large apertures would be restricted to (at best) a few institutions, and (in the worst case) would quickly move out of the US.

We recognize that the financial support needed to ensure such access is significant; it must be recognized that difficult decisions and (most likely) innovative approaches to partnership will be required. But these decisions cannot be put off another decade; the consequences of neglect are serious and potentially permanent.