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A Plan for Gemini Observatory Operations Through 2015

Submitted to the Gemini Board
by the
Gemini Observatory

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Executive Summary

This plan provides for the operation of Gemini Observatory as a leading facility following the withdrawal of the United Kingdom from the Gemini Partnership and a corresponding budget cut. The transition will be implemented through 2014, with sustainable operations in place from 2015. We propose to take advantage of investments in the near-term to reap savings and improved operations over the long term. We do so within a framework of maintaining the core goals the Gemini Board established.

We will deliver and operate high-quality instruments that represent the priorities of our community. The first component of this work is to complete the instrumentation projects that are already underway. Into the future, a regular budget will allow continuing development and rapid updates in light of scientific and technical advancements.

Queue operations are scientifically valuable, delivering useful telescope time to the highest ranked programs. They also allow all the partners to benefit from their allocated time. We will continue to provide the requested fraction of queue observations with appropriate data quality control, data products, and completion rates, while also supporting classical observing for those who desire it.

We will develop remote telescope operations. During the transition period, we will move to nighttime operations from the base facilities, which brings a number of advantages, including cost savings. These procedures may serve as a segue to more remote observing, such as from the partner countries.

Gemini will better interface with the partner communities. We will promote more direct interaction with Observatory scientists, engineers, and management. Instrumentation is crucial to the partners, and they will continue to contribute to future planning of Gemini capabilities.

We anticipate reducing the staff size by ~32 FTEs in order to achieve the needed savings. Science Operations will be the most significantly altered. We will realize significant savings through non-research observers who will execute the queue, leaving only a small core of scientific leaders and greatly diminishing the total research effort within Gemini. We intend to realize further savings through developments in technology and software, but even without these improvements in place, the human effort of running the queue will be trimmed. Administrative and Engineering staff will also be reduced. These changes will be apparent to users with a limited number of instruments that can be supported and the risk of increased telescope down-time. However, with this significant reorganization, the core mission of the Observatory will be maintained and will be sustainable within the future reduced budget.

1. Introduction

We describe here a plan for the operation of Gemini Observatory within a reduced budget effective January 1, 2013. These budget realities, which are common to many facilities in the current global economic environment, have led us to reconsider our approach to operating Gemini as we seek to provide the maximum research capability to our community, within the resources available. While this change obviously results in a loss of capability and service provided to the scientific community of the international partnership, we aim to retain some fundamental functions. The core requirements that determine the path forward, as the Gemini Board established, are:

- To deliver and operate high-quality instruments that represent the priorities of our community;
- To provide a high fraction of queue operations with appropriate data quality control, data products, and completion fraction;
- To have the ability to remotely operate the telescopes; and
- To better interface with the partner community.

We seek to fulfill these goals, while taking advantage of and developing our existing strengths. One of these strengths is the international partnership. The partners bring different benefits and perspectives to the Observatory and enhance its scientific results. As operations and instrumentation become more complex, and the research questions become more profound, international collaboration often provides effective solutions. Any new model for Gemini must retain the benefits of the international partnership. A second strength is the innovative instrumentation and operations capabilities of the Observatory. Merely supporting technical capabilities and operations as they currently exist with no further development would result in a facility that falls behind its present-day competitors.

Within this framework, we present a plan that enables Gemini Observatory to remain a forefront international facility, operating telescopes in both the northern and southern hemispheres. The transition to new operations requires short-term investments, which will provide for long-term sustainability under a reduced recurring budget in the future. A key step during the transition is to complete ongoing development projects. These include near-term tasks such as returning GNIRS to regular use and upgrading GMOS-North with red sensitive CCDs, and longer-term programs to make FLAMINGOS-2 and the Gemini Multiconjugate Adaptive Optics System (GeMS) operational facility instruments.

While the above core requirements and competitive advantages can be retained, doing so within a reduced budget demands major revision of Observatory operations. Gemini's Science Operations will undergo the most significant change in the new plan. Part of the transition program entails evaluating the queue operation, to identify its truly essential components. The net human effort of running and evaluating queue observations must be reduced, which we will accomplish by automating, simplifying, and eliminating procedures. A small core of senior scientific staff will be retained to provide essential leadership and interact with the professional astronomy community of the partnership, but the total research effort of the staff will be reduced. Toward this end, a major change is to introduce staff with no research responsibility to conduct ~75% of the queue observations. We will also greatly reduce the training of postdoctoral scientists.

Moving toward remote telescope operations, during the timescale of this transition plan we propose to establish base facility observing. The advantages of this approach, including long-term cost savings, are significant. The period of the transition presents a unique opportunity for the foreseeable future to

introduce this modern and improved approach. We expect the base facility observing to be a useful segue to more remote observing, such as from the partner home countries, although implementing fully remote operations is not part of the current plan.

The changes to improve interactions with the partner communities are more subtle, but they represent a crucial shift of attention throughout Gemini. While the National Gemini Offices will remain as the operations interface with their local communities, the Observatory must directly engage with the scientific and technical members of the partnership and respond to their needs, considering both strategic goals and shorter term interests. Greater visibility and communication between the Observatory's managing leadership and the partner communities is an important element of this plan, which continuing scientific and technical interaction further support.

The total administrative and engineering effort of Gemini will be reduced correspondingly. While the former more readily scales with the number of personnel and the scope of the operation, we expect the latter may result in increased telescope or instrument down-time. One final significant consequence for the partnership is that the total number of instruments that can be supported is limited (4 instruments plus AO at each site). The decision about which instruments and modes to retain will be made in consultation with the partner scientific communities.

2. Instrumentation – Current Baseline and Noteworthy Trends

Astronomy is among the most technology driven fields in all of science. Accordingly, the long term success of Gemini is intricately linked to the arrival of a steady stream of new instruments and upgrades to existing instruments that exploit new technologies. The blend of instruments Gemini Observatory provides its community is determined by a complex range of factors including the research needs of the Gemini community, the unique design features of the Gemini telescopes (as a high spatial resolution infrared optimized platform), resource considerations (budget, support staff, unique expertise required, etc.) and technology trends. In summary, Gemini seeks to offer a combination of "work horse" imagers and spectrometers that can be applied to a broad range of research topics, and a handful of more specialized instruments, which target unique opportunities for discovery.

The current set of instruments Gemini provides to its community is listed in Table 1. Historically, GMOS-N/S have been the most popular instruments offered, reflecting the many modes of these instruments and the large optical component of Gemini's community. In contrast, Gemini's mid-IR instruments collectively represent the most sensitive mid-IR ground based capabilities in the world yet they support a much smaller community. The laser AO fed NIFS merits particular attention in the years ahead, as demand for this capability has been steadily growing due in part to its world-leading sensitivity among all ground based NIR integral field spectrometers. The more specialized instruments built or under development now include NICI (though it has a number of applications as a dual channel AO imager) and GPI, which has a rather focused mission of exo-planet search and characterization. Together Gemini's instruments are sensitive across a factor of ~50 in wavelength, offer imaging and single-slit, multiple-slit, or integral field spectroscopy. An additional dimension to consider in Gemini's development program is the range of instruments that are compatible with adaptive optics. Table 2 lists AO systems as well as instruments which can either be fed with an AO beam or feature a built-in AO system. In many respects, these instruments are the technology pathfinders in Gemini's entire instrument program.

Gemini North			Gemini South		
Name	**Description**	**Band**	**Name**	**Description**	**Band**
GMOS North	Multi-object imager and spectrograph; R~4000; ~50 objects at a time; IFU	Optical	GMOS South	Multi-object imager and spectrograph; R~4000; ~50 objects at a time; IFU	Optical
NIRI	Imager with AO mode; Low-resolution spectrographic mode	Near IR	FLAMINGOS-2	Imager and multi-object spectrograph; R~3000; AO mode	Near IR
GNIRS	Long-slit cross-dispersed spectrograph; 5000≤R≤18,000; AO mode	Near IR	NICI	Dual-channel coronagraphic imager; Internal 85-element adaptive optics	Near IR
NIFS	Integral-field spectrograph; R~5000 coronagraphic mode; AO-fed mode	Near IR	GPI	Planet imaging AO coronagraph; Internal high-order adaptive optics	Near IR
MICHELLE	Imaging spectrometer, long-slit; R~5000	Mid IR	GSAOI	AO imager, works with MCAO; Rapid tip-tilt on up to four stars	Near IR
ALTAIR + LGS	Facility adaptive optics system; Single natural or laser guide star	Near IR	T-ReCS	Imager and spectrograph; Broad and narrow filters; 100≤R≤1000	Mid IR
			MCAO	Facility multi-conjugate adaptive optics system; five laser guide-star	Near IR

Table 1 – The current baseline instruments and AO systems at Gemini, either available now or under development, are listed. Note that mid-IR instruments are diffraction limited in natural seeing. Near-IR instruments are near diffraction limited with AO.

Instrumentation - The Revolution at Gemini-S

Taken piecemeal it is easy to underestimate the magnitude of change already underway in the instrumentation suite bound for Gemini-S. New capabilities planned for Gemini-S will be as sweeping as the recent refurbishment of instruments on HST. This new instrumentation puts Gemini-S in an extremely competitive state for much of the next decade, particularly in the area of laser AO, with no other observatory currently planning a multi-conjugate system comparable to GeMS.

These new AO based capabilities represent a major investment that easily exceeds $50M in value and demonstrate the technology leadership of the entire Gemini Partnership. The technologies developed for these systems include high power solid state lasers, advanced new deformable mirrors, AO control systems and reconstructors, laser beam launch systems, aircraft safety systems, and even an exquisitely sensitive interferometer capable of working in any orientation. The Observatory takes pride in not only leading the development of these systems, through the Partner labs and agencies, but in providing this technology base for other observatories to benefit from.

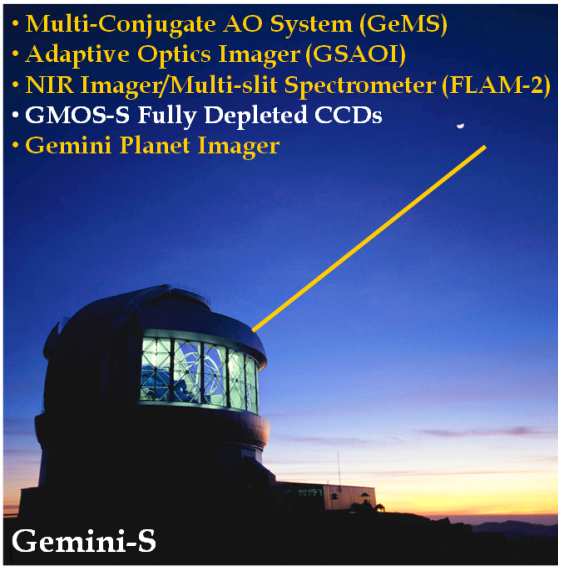

Figure 1 – Stepping back and looking at the entire suite of new instruments under development for Gemini-S, many of which are AO based (orange text), it is clear that Gemini-S will be an extremely competitive AO platform well into the next decade.

Gemini North	Gemini South
NIRI	FLAMINGOS-2
GNIRS	NICI
NIFS	GSAOI
ALTAIR (NGS or LGS)	GPI
	GeMS

Table 2 - NIR AO-enabled instruments and AO systems are listed, demonstrating the importance of this capability in Gemini's future plans.

Instrumentation – Major Upgrades at Gemini-N

The centerpiece of new instrumentation at Gemini-N is GNIRS which is now being commissioned. With the advent of this instrument on Mauna Kea, Gemini will once again provide the large community needing near-infrared spectroscopy to conduct their research with a powerful tool. The new GNIRS configuration will feature an infrared guider and will be compatible with ALTAIR's beam feed, making it possible to use exceptionally narrow slits in complex fields for target isolation and spectral contrast enhancement.

The other main thrust of near term development activity at Gemini-N is in the form of a program to upgrade the GMOS-N CCDs with fully depleted red sensitive CCDs. Combined with the already existing nod-&-shuffle mode, this will allow Gemini's community to have outstanding sensitivity using modern detectors that are well matched to the already

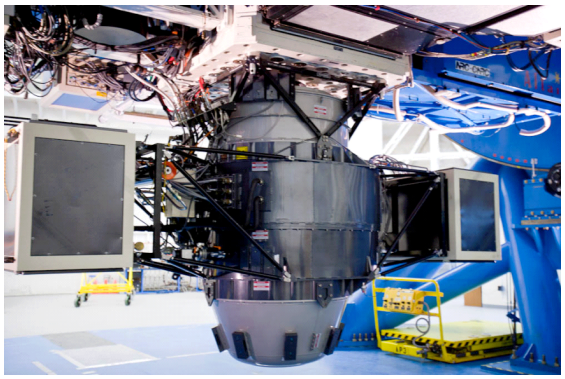

Figure 2 – GNIRS, as it appeared recently on the up-looking port of Gemini-N. With repairs near completion, this instrument will provide exceptional NIR spectroscopy capabilities for Gemini's community, once again.

high throughput of GMOS optics and reflectivity of Gemini's primary, secondary, and tertiary 4-layer silver mirror coatings.

New Principles Guiding New Instruments

A number of changes are sought in Gemini's instrument program, compared to recent years, to help ensure the success of not only the Observatory but the entire Gemini Partnership. These changes should ideally lead to a development program that –

- Is predicated upon a steady funding stream for new instruments, enabling commitments to complete instruments, once they are started
- Rationally balances between work horse and specialized instruments, as well as the need to replace aging instruments with brand new capabilities driven by contemporary research trends
- Continues to build upon inter-observatory time swaps to help consolidate capabilities and provide access to capabilities that likely could not be provided any other way (e.g., wide field optical imaging)
- Is updated regularly, at a cadence (e.g., every 1-2 years) that tracks the pulse of research trends and allows for the timely development of new instruments in response to these changing trends
- Is grounded in a long range plan (5-10 year forward look) that factors in development at competing facilities, technology trends, the finite support resources at Gemini, and strikes a sustainable balance between commissioning new instruments and decommissioning older facilities
- Cultivates a symbiotic inter-dependence between the community and Observatory to support advanced research with advanced tools

Consistent with this path forward, the first instrument under serious consideration for development is a new high resolution optical spectrometer. Community interest in such an instrument was most recently expressed through a series of polls conducted in 2009 and discussed in the April 2010 GSC meeting. That such an instrument is of interest to the Gemini community is not a surprise, as this basic capability was identified as extremely desirable through the original Phase 1 and Abingdon programs but, for various programmatic and technical reasons, was never delivered. Further definition of this instrument's science case and derived top-level performance requirements will be assessed through a Gemini led solicitation of white papers from the community in mid 2010. These white papers will be reviewed by an expert committee, serving as a working group of the GSC, who will assess options and, together with the Observatory, make a final recommendation to the Board in November 2010. This phase of the program will allow for the immediate release of an RfP to build such an instrument in late 2010.

New vs. Old – Striking the Right Balance

While the basic definition of the next instrument Gemini should provide its community is fairly clear, the path beyond this instrument is less clear. The GSC (as representatives of the community) and Observatory need to continue to assess options before bringing a proposal to the Gemini Board. Among the interesting new possibilities include a new near-infrared high resolution NIR spectrometer, or perhaps an instrument akin to ESO's X-shooter, recognizing Gemini's unique ToO capabilities and likely increasing demand in this area with the advent of various synoptic survey capabilities. With each new instrument though, careful consideration must also be given to decommissioning less popular or obsolete instruments that are proving unreliable or are no longer maintainable due to component

obsolescence. The future budget constraints drive a "4+1" model (4 instruments plus laser AO) at each site. Ostensibly, an observatory that features twin 8 m telescopes that can target any region of the sky, each equipped with modern laser AO systems and a combined 8 instruments between them should cover an enormous range of research needs of its community. With clever planning and development, even a 4+1 model should maintain Gemini as a forefront observatory as long as new instruments are developed to meet new research needs.

Near term, a possibility under consideration that reflects these boundary conditions of user demand, resource availability, and obsolescence is the consolidation of MIR capabilities into a single site, perhaps including the Japanese MIR community, which is also modest in size. The advantages of this model include –

- Preserves core technology and expertise at Gemini designed into the Observatory, from its inception, and provides the most sensitive ground based MIR instrumentation available anywhere
- Might expand the Gemini/Subaru time exchange program, thereby catalyzing access to wide field optical capabilities for Gemini's community
- Consolidates demand from two previously distinct MIR communities around a single 8 m telescope, hopefully making the demand large enough to justify further support demands

Beyond consolidation to reflect demand and budget realities, Gemini's development program must also replace an aging fleet of workhorse instruments. A good candidate for replacement is NIRI, which would be ~20 years old before a replacement could be made if a decision were made this year to build it. In practice, given the incredible technology advancements on these timescales, replacing NIRI does not necessarily mean just replicating its capabilities with a more reliable instrument. Options to consider include the use of a more sensitive larger format NIR detector, for example a HAWAII-4RG. New optics which provide a wide field (e.g., ~7 arcmin vs. the 3 arcmin currently offered) could yield ~5 times the areal coverage of NIRI using the same integration time. Such an instrument could likely also be configured with an AO plate scale to critically sample an AO corrected field. In this sense, replacing old instruments doesn't mean "more of the same" but in fact new workhorse instruments that provide an exciting superset of what has been accepted for decades as Gemini's baseline capability.

These changes in the approach to instrument development at Gemini occur within the context of a reduced total instrumentation budget, due to the loss of a major partner. However, given the importance to both the user community and the Observatory of maintaining a vital development program, the remaining instrument budget is reserved exclusively for that purpose. None of it is applied to make up for losses on the operations side.

Taking under consideration the myriad of factors that are behind Gemini's instrument program, the Observatory's approach toward and emphasis on near and long term instrument development is fully in line with the Gemini Board's highest priority – to "*deliver and operate high-quality instruments that represent the priorities of our community*".

3. Science Operations

Gemini considered a wide range of models for science operations in response to future budget challenges. Key criteria for evaluating the different options are 1) total science productivity of the observatory; 2) needs and desires of its international astronomical partnership; and 3) feasibility within the sustainable budget envelope. As a result, we propose to maintain significant queue observing while offering classical observing for users who desire it. Sources of significant cost savings are reducing the human effort of planning, executing, and checking the results of queue observing, reducing the total scientific research effort of the observatory staff, and introducing non-research observers.

Queue and Classical Observing Modes

User choice determines the current balance of observing modes, with 90% of time in queue and 10% classical. The current plan sustains this fraction. It can also accommodate a somewhat greater fraction of classical observing, although planning for and requiring a different ratio would not result in significant cost savings. We estimate a net cost savings of ~$200k per year in Gemini's expenses by migrating to a fully classical model, compared to the revised queue model proposed here.

Classical observations are scientifically useful for some types of programs, such as those exploring unknown objects, where a principal investigator must make decisions in real time as data are acquired. Even if classical observing is not essential, the interaction of the astronomical user community and the observatory can be valuable. The visiting astronomers better understand Gemini, its processes, and its people, and the observatory benefits from the visitors' expertise and intellectual contributions. In some cases, returning classical observers may receive enough experience to establish partner astronomers as expert queue observers for the future.

While classical observing is familiar, Gemini's current queue operations are efficient and effective. As mentioned above, completely eliminating queue operations would reduce expenses somewhat (the science staff would be reduced by 2-3 FTE's if a 100% classical model is adopted), but the marginal cost addition of maintaining this capability to reap the corresponding benefits is worthwhile. With planning, the highest ranked science programs obtain their required time on sky; weather is not the factor that determines successful execution of the programs. The highest ranked programs indeed produce the highest impact publications (Figure 3).

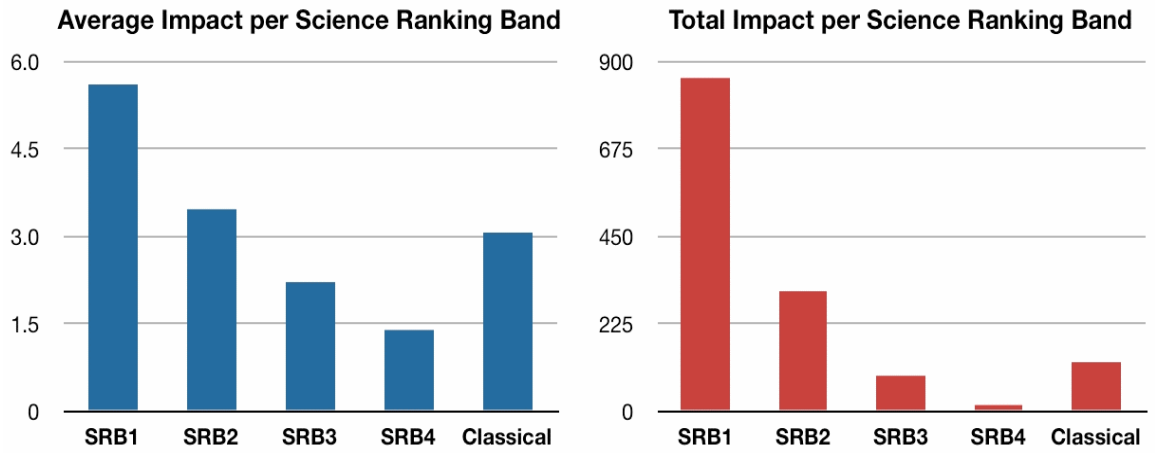

Figure 3 – Scientific impact of Gemini publications as a function of science ranking band (or classical status).

Maintaining queue operations is also a way to leverage Gemini's strengths. Currently around 25% of Band 1 programs are targets of opportunity (ToO's), where the observations cannot be planned well in advance. Running a multi-instrument queue means that the full range of observations is generally possible when required. The use of Gemini's ToO capability is expected to grow with new operating facilities (PanSTaRRS and the Palomar Transient Factory), and LSST would likely further increase the demand. A second great strength is the adaptive optics capabilities, available on both Gemini telescopes. AO observations are only productive in good seeing, and laser AO operation is only possible under clear skies. AO science is therefore demanding, but an operational queue can preferentially deliver the data.

Small Core Scientific Leadership Team

Reductions in staff throughout the Observatory are essential to fulfill the budget requirements. While we propose to reduce the size of scientific staff, we must retain a core scientific leadership team. The expertise of these active research astronomers is critical to guide the Observatory overall, to mentor the junior staff, and to interact with our international community. A key group of world-class researchers who use Gemini themselves pushes the capabilities, and their experience helps them identify even subtle problems and subsequently find solutions. They are able to understand the goals and needs of the partner astronomers, and then apply their familiarity with the facilities so the community scientists can be successful.

In addition to the senior leadership team, we will continue to employ Science Fellows, although in significantly diminished numbers. These entry-level positions offer recent PhDs the opportunity to interact with a broad international community and understand (and contribute to) the operations of a modern observatory. The Gemini Fellows also provide a crucial vitality to the Observatory, bringing fresh perspectives to the permanent staff.

Non-Research Observers

A significant change in Gemini's approach to science operations is to move about 75% of the execution of the queue observing to non-research staff. This change brings significant savings because these staff members do not require funded research time; 100% of their effort is functional work of the Observatory. We anticipate accomplishing this by merging our current groups of System Support Associates (SSAs) and Data Analysis Specialists (DAS) into one group and expand the group slightly. The members of this new group, the System Supports Group (SSG), are expected to ether have technical backgrounds and specific interest in astronomy as the current SSAs and DASs or be PhD astronomers who choose not to pursue research career. Research astronomers will serve as observers for the remainder of queue operations, primarily to ensure that this staff group retains the familiarity with the instruments and nighttime operations necessary for instrument and users support.

These non-research observers will be introduced early in the transition. We will begin training one SSA or Data Analysis Specialist (DAS) per site as a queue observer in 2010B and more in 2011. They will provide useful feedback on the training procedure and its documentation before we expand this pool with additional hires in subsequent years.

Making a Successful Transition to New Operations

The long-term budget is sufficient to maintaining Gemini's core strengths, but the total scientific staff and non-essential (albeit valuable) functions must be reduced. One important consequence we propose is the significant reduction of the total research effort within the Observatory. The introduction of professional observers and employing fewer Gemini Fellows achieve this result.

A second significant area where human effort must be reduced compared with current operations is in the execution of the queue. Our preferred approach is to make an investment in software to reduce recurring work. In particular, we desire better tools for queue planning, and better systems to do time accounting without significant manual effort. The plan for developing software begins with the tasks where the saving of effort would be greatest, so some of the benefits could be realized during the transition. (See Section 4 for more detail on software planning.)

Before developing any new software, however, we are currently engaged in defining its essential requirements. The goal is not to replicate the existing queue fully but to offer functionality that achieves most of our desired benefits. We are now beginning with the examination of other queue facilities. Moreover, recognizing that software delivery is always a risk, we are also planning for modified queue operations in the absence of complete software tools. In this scenario, we accept some inefficiencies and lack of optimization in the queue, although we retain its basic functions with less manual effort. Some specific options include reducing data quality checks on poor-weather observations and eliminating formal planning and completion goals for poor conditions. We will also eliminate backup queue planning during classical observing runs, encouraging astronomers to develop backup programs if their primary observations are not possible.

The Observatory and the National Gemini Offices (NGOs) together support the scientists of the international partnership. With such a major reorganization of the Observatory, we also propose revising the relationship with the NGOs. The existing memorandum of understanding serves as the starting point for developing a new agreement. The NGOs already help their respective communities prepare observing plans, and we propose they take more complete responsibility for this work. We do not suggest introducing completely new tasks and look forward to finding the optimal blend of responsibilities and expertise needed at Gemini and the NGOs to support our joint mission. The NGOs and Gemini can work collaboratively to eliminate duplicated effort (in checking Phase II programs, for example) while still providing expertise of contact scientists where necessary. Work to make this change successful is part of Gemini's transition plan. The NGOs require better access to information about preferred observing sequences, and more complete example libraries would be helpful. Post-observing support of our users should also be factored in, e.g., perhaps through NGO searches of the Gemini helpdesk which tend to focus on post-observation issues more than initial program setup.

In addition to the major changes described above, the diminished science staff will be able to support four instruments per site plus laser AO capabilities, consistent with the Engineering staffing. Additional instruments would require duties of an instrument scientist, effort of contact scientists, and software support to maintain more instruments through upgrades of the common Observing Tool. Finally, while current data processing efforts include major software development (e.g., to bring IRAF into a PYRAF environment) such development projects must be completed by the end of the transition. This will be accomplished near-term through an expansion of Gemini's software development team (e.g., through fixed-term hires) and likely through additional contracted effort. All of this points toward a greater need

for instrument developers to deliver robust and well-documented software interfaces and data reduction recipes.

Nominal Science Operations Labor Staffing Model

Tenured and tenure-track astronomers and Gemini Fellows comprise the research science staff. Scientists, who maintain smaller research efforts, will also serve important roles, often as instrument scientists. Current SSAs and DASs will be merged into a new Science Support Group (SSG), who will operate the telescopes and observe at night, while providing some routine daytime support and data quality control. The Data Process Development (DPD) group will remain fully staffed during the transition, helping to develop the tools that will enable more efficient operations, scaling down by the end of 2013. This reduced DPD group will be able to support new instruments arriving at a rate of 1 every 2 years as well as system maintenance.

Despite the range of changes prescribed here in our science operations model, the net result remains a system capable of preserving the many attributes of the queue system the Gemini partnership has invested in over the past decade. These changes still leave in place a system that can match observing programs to changing conditions, optimally use laser AO, provide the community with exceptional ToO capabilities, and systematically complete the highest ranked proposals. Combined we believe this fully supports the Board's priority to "…*provide a high fraction of queue operations with appropriate data quality control, data products, and completion fraction*."

4. Engineering – Transition Overview & Timeline

In parallel with transition activity in science operations, Gemini's engineering team will be focused on various elements of the transition plan enabling base facility operations in 2014 at both sites. Near-term, Gemini engineering and development will continue to devote considerable resources to completing high priority instrument projects, namely GeMS, F-2, GPI, and GMOS-S CCDs at Cerro Pachon and GNIRS and GMOS-N CCDs at Mauna Kea. The bulk of the activity in Gemini's transition plan has been pushed out as far as possible to minimize near-term resource conflicts with these high priority instrumentation activities, culminating in exciting new capabilities that are described earlier.

Figure 4 illustrates key milestones through 2014 in Gemini's engineering and science operations. The planning phase has effectively already begun, with the bulk of that planning activity coordinated through Gemini's well established annual planning process which will yield a series of Band 1 (2011), Band 2 (2012) and Band 3 (2013-15) projects. Special emphasis will go into Band 2 and Band 3 Transition projects to ensure that all Transition projects have been adequately defined and resourced. The detailed design phase of all engineering Transition projects (e.g. remote monitoring systems, telescope modifications, etc.) will nominally be completed by the end of 2012. A much better understanding of what will not be done within engineering as a result of a new emphasis on the timely completion of our transition plans will emerge after our annual planning process in late 2010. In parallel, significant effort will be invested in new science operations software designed to augment our queue planning systems and streamline the definition and execution of queued observations. During 2013 most of the new hardware required for base facility operations will be built and integrated on the telescopes, allowing 1 year trial periods at both sites during which time science operations will be conducted from the base facilities while technical support remains on the summits. These trial periods will help ensure that we are truly ready to remove all staff from the summit at night to remotely operate the facilities. In any event, as a fall-back strategy, we will explore options of sharing tech-support with our neighbor observatories on Mauna Kea and Cerro Pachon, many of which are well on the path to remote observing and may have a common interest in sharing a nighttime technical support pool as a cost effective means of retaining sufficient presence on the summits. It is also important to note that the Gemini-N laser has been operating regularly from the HBF during routine nighttime operations for about a year, giving us confidence in our ability to operate lasers at both sites remotely, if required. Finally, an essential element of this timeline includes the cross-training of our SSA and DAS pool to take on increased responsibilities as we use non-research staff to conduct ~75% of queue observations in the future.

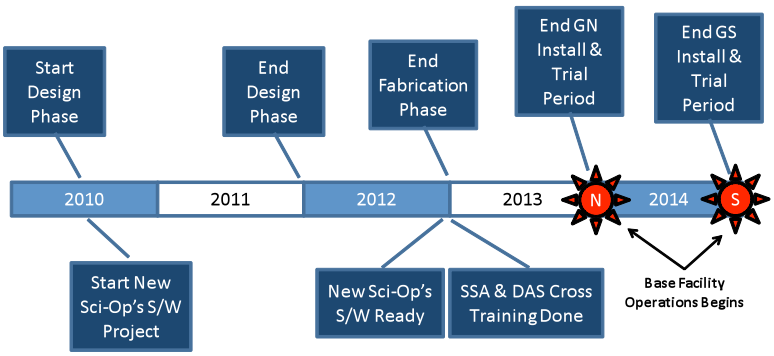

Figure 4 – The basic timeline including key milestones in the transition plan are shown in this timeline. Base facility operations are anticipated in 2014 in this plan, initially at Gemini-N where the benefits of base facility operations are expected to be higher given the harsher conditions on Mauna Kea compared to Cerro Pachon. Detailed design work over the next year may lead to slightly different milestone dates, but this represents the overall plan as currently envisioned.

Development of New Science Operations Software

Table 3 lists new software that will be developed as part of this proposal. Most of this targets improved queue planning, as required by a smaller research staff that will be available to prepare the queue on a regular basis. While the current queue planning methods are robust in terms of supporting an efficient multi-instrument queue across both Gemini sites, they are also fairly labor intensive and we have a high degree of confidence that many aspects of this planning system can be handled through improved

Name	Goal	Deadline
ITAC software	Fill the queue more effectively with significantly reduced effort associated with ITAC activity	January 2011
TA timeline	Significantly reduce the time spent on observing time accounting	October 2011
LGS clearances	Reduce Laser Clearing House overhead for more efficient planning and execution of laser guide star science	October 2011
Queue visualization	Improved and more efficient long-term queue planning	December 2011
OT sequence model	More efficient Phase II checking in Observing Tool	December 2011
QA pipeline	Automated data quality assessment pipeline to improve efficiency of night-time operations	June 2013
Adaptive queue planning	Semi-automated creation of queue plan with oversight of queue-coordinator. Real-time queue adjustment at night to respond to changing conditions	June 2013

Table 3 – Essential software tools with goals and estimated delivery dates. Actual delivery estimates will be developed during 2010 once requirements are finalized and engineering resources required have been identified.

software tools. Completion dates listed in Table 3 are nominal at this early stage and will be refined in 2010 as these projects are better defined. It is already clear that new effort will be required to develop this new software, which will likely be provided through a combination of in-house and contracted effort. The prioritization of these software packages has already been conducted and, as aforementioned, part of the risk mitigation strategy associated with delays in completing this new software includes reducing the scope/efficiency of the queue planning and execution.

Base Facility Nighttime Operations – Advantages and Implementation Details

The proposed transition to base facility operations is predicated on a number of desirable outcomes for such a change at Gemini. These include –

- The possibility of extending this model initially through eavesdropping to truly remote operations, with astronomers world-wide participating in queue and classical observing at some point.
- Modest but still significant cost reductions, leading to a “return on investment” of a few years and, long term, significant savings (millions of dollars) compared to continuing with Gemini’s current operations model
- Improved working conditions for the night staff through a safer, warmer, and more oxygenated environment.
- More comfortable and effective classical observer support, via extensive base facility accommodations
- More seamless day/night staff transitions at the beginning of each shift change, with the possibility of shift changes in the middle of the night for staff

Logically, given the timescale for reduced funding and related staff reductions, this transition needs to happen while the observatory still has resources available. In practice this means butting transition projects against near-term strategically important work (instrument activity) and careful management of the entire effort, consistent with Gemini's well established planning system, will be required. Off-ramps in the transition plan will be defined as part of the necessary contingency planning. Some of these off-ramps may include reduced queue efficiency, hiring short term contract labor in key areas, and greater NGO support.

New Acquisition and Guiding (A&G) Project

A core component of our strategy to migrate to base facility operations is to increase overall telescope reliability. While new systems will be in place to remotely monitor and control various observatory subsystems, the most effective means of addressing technical problems that might emerge over the course of a night is to prevent the problem from happening in the first place. This implies a number of things, including aggressive preventative maintenance, redundancy in key systems, and elimination of reliability obstacles across various systems. Today, one of these is in the form of the A&G units that are in use now at each Gemini site. Gemini's A&G units function as the central nervous system for the entire telescope, which is fully active and requires a steady stream of wave front sensing data to preserve guiding, M1 mirror figure, and overall collimation, not to mention guard against wind shake and counter atmospheric tip/tilt aberrations. While the basic design concept used in Gemini's A&G's is sound (e.g., redundant peripheral guide probes, a highly articulated tertiary mirror, and an acquisition camera with associated high-resolution wavefront sensor), in practice these units have been unreliable in several areas. This problem was known at the beginning of the 2006-2010 NSF funding proposal, hence the request for funds to build 2 new units, perhaps with GLAO functionality and infrared wavefront sensors. In the subsequent annual Observatory plans though, priority has always been given to other major projects (e.g., MCAO) that require the same engineering effort, hence little to no progress has been made with developing new A&G units. In recent years, instead of developing new A&G units, engineering effort has gone into aggressive preventative maintenance which has reduced the down time associated with the A&G's but at the cost of telescope shutdowns and reduced science time. To avoid further delays in replacing the A&G units, Gemini will no longer treat these as substantially in-house development projects but instead will contract them out, along the lines used for instrumentation (e.g., competitive bid across the Partnership). Near-term this will still require significant in-house effort to generate all of the technical requirements documents and ICDs, but overall this approach will accelerate the completion of this important project and keep the load on Gemini's engineering team to a minimum. Since the GLAO concept and attempts to spawn the development of high speed NIR wavefront sensing arrays have not gone forward, as a consequence the new A&G's will be more modest in design than previously proposed, preserving baseline functionality with a premium on system reliability. This procurement is starting in 2010.

Nominal Engineering Labor Staffing Model

Engineering staffing levels will remain roughly fixed through 2012 due to the large number of high priority projects that remain to be completed, particularly new instrumentation. Beyond then, a sustainable staffing model that is consistent with projected budget constraints leads to an estimated 14% reduction in the number of positions in Gemini's engineering team. The decline will occur gradually over a 2-3 year period toward the end of this transition plan.

The anticipated cuts are strategic, preserving essential skills and taking advantage of long-term improvements to optimize sustained operations. However, succeeding in this ambitious challenge to simultaneously close out multiple major development projects and to transform Observatory operations demands major investments in personnel and non-labor expenses in the short term and meticulous oversight to ensure success with so many variables on our horizon, some of which are unpredictable.

Likely Impact on Engineering at Gemini

The dominant long term effect of the future staffing plan for Gemini engineering is to reduce the Observatory's margin and capacity to deal with unexpected events in the future. That capacity has been tapped repeatedly over the brief history of the Observatory, ranging from responding to a major earthquake in Hawaii to catastrophic instrument damage to GNIRS. Several years ago the MCAO optical bench was delivered incomplete by a commercial company that essentially went out of business, forcing major rework at Gemini that was never planned. Likewise, FLAMINGOS-2 was recently delivered needing significant rework to its science detector, key mechanisms, and vacuum systems. Prior to these instruments, with the shutdown of RGO, Gemini's coating chambers were delivered incomplete and unreliable A&G units were delivered during the construction phase of the observatory, the fallout from which we are still addressing today. An obvious knock-on effect of the reduced capacity of Gemini's engineering team is their ability to rectify instrumentation or facilities delivered in a poor or incomplete state. This applies to both hardware and software deficiencies. In the future such projects will likely be terminated without additional resources provided by the Partners to bring them to a successful closure. The Observatory will take tangible steps to bolster the management component of its development program, including greater on-site involvement during the design/development phase of instrumentation projects and clear interfaces to our data reduction system to prevent such mishaps. The use of Gemini engineering resources to more proactively engage instrument builders will likely be a net savings of effort over the long term.

Other risk areas which stem from a reduced engineering team include increased telescope down-time, increased time to complete various repairs, and delays of in-house initiatives designed to yield a more robust engineering environment including training, standardization of hardware, software, and procedures.

Summary

Taken together, through the plan summarized in the previous pages Gemini engineering is aligning resources and skills over the next ~5 years in a manner consistent with the Board's priorities. Completing strategically important instrument projects will remain the highest priority within the Observatory's development program. From there we will transfer resources, as required, to support "…*a high fraction of queue operations*…" under the new (professional observer) model proposed, with the key element of new queue planning software provided by a combination of in-house software expertise and out-sourcing. Finally, starting in 2013, Gemini engineering will outfit both telescopes with new systems to enable base facility operations in 2014, yielding a lower cost yet still competitive approach to operations that naturally lends to increased community engagement, which is consistent with the Board's priority to "*have the ability to remotely operate the telescopes*".

5. Engaging the Gemini Communities

An important cultural shift with Gemini's reorganization is an explicit emphasis on serving the needs of the Partnership. Gemini Observatory must more directly interact with the scientific communities, and both high-level management and scientists will participate in this significant activity.

Direct Interactions between Gemini and the Partner Communities

The national astronomy and facility meetings offer opportunities for engagement. We plan to participate in national functions regularly, ideally including each partner at least once every other year. In 2010, for example, the US NGO coordinated a Gemini Town Hall at the January American Astronomical Society meeting. The Observatory participated in a Brazilian workshop on the future of its major facilities (Gemini, SOAR, and OPD). This was a valuable experience, allowing Brazilian astronomers to learn more about Gemini and its future plans, and giving the Observatory better insight into the needs of this community and the role of Gemini in fulfilling them. The Argentine NGO organized a workshop on Gemini, which included national representation at all levels, including the relevant funding agency. Observatory scientists presented talks covering both detailed use of existing Gemini facilities and more general talks on capabilities such as AO. We look forward to continuing similar interactions between Gemini and the partner communities in the future.

Instrumentation is crucial to the scientific success of Gemini and the satisfaction of the partners. The most fundamental needs of the communities are the facility instruments they can use. Planning for new instrumentation offers another means to interact with and respond to the scientific and technical communities of the partnership. Scientific goals fundamentally determine the instrument requirements, and the expertise of the instrument builders is critical to define what is feasible. The instrument builders can also reveal what is both novel and possible.

Direct interaction with astronomers visiting the observatory remains important. The science operations modes continue to make this feasible, supporting both classical observing and queue visitors. Although the program for long-term visiting scientists will have less financial support in the future, we will continue to be able to host visitors and encourage their contributions to the institutional scientific culture.

Interface through the NGOs

We propose to maintain the distributed support model that includes NGOs working collaboratively with the Observatory to support our broad community. Thus, these offices remain a vital component in our long-term plans and this reorganization offers a genuine opportunity to evaluate the roles and responsibilities of the NGOs and Observatory, with the aim of better serving the partner needs. Fundamentally, the NGOs remain the local face of Gemini within their respective communities, so Gemini's success depends on the effective functioning of these offices.

The proposed operations modifications–to make the NGOs immediately responsible for their work in preparing observations–can enhance the role of the NGOs. Indeed, their staff must be fully engaged in observing with Gemini to be successful, lacking the fallback option of duplicated Observatory effort to catch errors. While recognizing the initial challenge of changing the process of preparing programs, we expect the clarity of responsibility that includes a direct and significant role for the NGOs to make a

more effective support model. Fundamentally the NGOs remain the local face of Gemini within their respective communities, so Gemini's success depends on the effective functioning of these offices, which in turn rely on strong engagement between them and the Observatory.

These proposed changes require improvements in the products and information Gemini delivers to the national offices. We have already identified a number of specific ways the Observatory can help the NGOs with their existing tasks. For example, they require more complete example programs and better access to procedures and instrument performance data than they now have. The NGO staff will also have more input into the requirements of the systems they rely on, such as the Observing Tool, that are integrated with Observatory operations. These improvements are part of the transition plan.

We are currently engaged in several collaborative projects with individual partner offices, and we propose to continue these efforts. In 2010, the US NGO and the Observatory together organized a Gemini data workshop that was open to the entire partnership. NGO and Observatory staff, including a number of instrument scientists, gave key presentations to help users better understand and work with data from Gemini. The workshop also offered the benefits of interaction between the Observatory and NGO staff, and with some of the expert user community who contributed as presenters. (The primary audience of the workshop was students and postdocs.) We anticipate using this project as a model, replicating it in other partner countries in the future. A further positive residual outcome will be the development of basic data reduction cookbooks, including examples, for most of the current instruments and modes.

Leveraging Community Expertise

Gemini experts are dispersed throughout the international community. They are skilled observers, sometimes having particular knowledge of the instruments, and they know how to reduce Gemini data to obtain scientifically meaningful results. The Observatory can leverage this expertise, serving as a center for sharing knowledge about Gemini observing, data, and data reduction. We have relationships with some experts, such as those on the Data Reduction Working Group, and we can more actively seek the key contributions of others.

Two possible starting points are to make questions and answers from Helpdesk exchanges public, and to host electronic forums for software contributions. One limitation of the current Helpdesk is that it is not globally visible, yet repeat questions are common. We expect shared software contributions to be valuable, as well, even if they are not fully reliable as the official software packages must be. We know that many members of the community use proprietary packages (like IDL), and their solutions may help others. Moreover, many people may benefit by having some examples of issues and possible approaches, even if the sample code is not applicable in all situations.

Unifying Gemini Interests within Partner Countries

Under the current Gemini governance and organizational structures, partner desires for Gemini are conveyed through numerous channels. Community representation on the Board, Gemini Science Committee, AOC-G, Operations Working Group, etc., all yield input to the Observatory. We encourage each partner to develop and deliver a clear and consistent message so Gemini can respond successfully. The scientific communities can be more engaged and have more influence if their paths of communication with Gemini are clear locally. While the different advisory and organizational bodies

concentrate on distinct aspects of the Observatory, collectively they describe each partner community's interest in Gemini. The Observatory can best serve the communities if their needs are clear.

Taken collectively these various community related initiatives are intended to deepen the working relationship between the Observatory, NGOs and ultimately the entire Gemini research community, recognizing the success of each party in this relationship is essential to the scientific legacy we collectively build. Consistent with the Board's priority to "*better interface with the partner community*", we look forward to working with all of Gemini's stakeholders to build that legacy.

6. Conclusions

The plan for future Gemini operations builds on the past investments in the Observatory. Beyond the telescopes and instrument suite, we aim to take advantage of and cultivate the developments in operations and technical expertise, despite the limited budget. The core aims of the Observatory can be maintained, although doing so requires continuing investment. Delivering productive instruments for the Gemini community, for example, demands current staff effort beyond basic operations in the short term, and long-term contributions for new capabilities. An effective queue operation can build on experience, but as this plan illustrates, its successful execution in the future must proceed differently, with reduced human effort. The development of remote operations capabilities offers a challenge as Gemini changes, but it is an opportunity for true transformation. Finally, the effort to distill the Observatory's mission focuses attention on the need to interact with and be more responsive to the partnership. This proposal is restricted to operational aspects of the Observatory, although broader consideration of governance and the structure of Gemini in the context of the partnership may also promote meeting the needs of the partners and their scientific communities.

A number of fallback positions are under consideration as we flesh-out the various projects required by this proposal. Central among them is the possibility of near-term reduced queue efficiency or capability in the event new software is not completed on schedule. Near-term telescope down time may rise, temporarily, as engineering effort is invested in supporting the transition to base facility operations. If resource conflicts arise, a higher priority will likely be given to software development and migrating to the use of non-research staff observers than base facility operations, as the former will yield significantly higher cost savings. It is also feasible to use a hybrid approach to nighttime technical support, working with our neighboring observatories to pool resources and leave a small team in place each night to address technical issues that might arise at several facilities. These and other scenarios will be considered as the transition to a new operating model is actively managed.

While preserving the essential attributes of the Observatory, the losses will have impact. Overall the staff will be reduced by about ~20% from the current level over several years, mostly through attrition. The margin available to respond to the unexpected and unplanned problems will be reduced, with increased risk for loss of time on sky. However, the fundamental end-state of Gemini under this plan provides a long-term balance between funding resources and operational needs, and it is ultimately sustainable.

Appendix A: Summary of Risks

We identify three categories of significant risk in the near-term Observatory transition and long-term operation described in this proposal.

- Personnel
  - The transition itself and uncertainty during this time threaten the loss of key staff amid declining morale.
  - We risk losing critical staff who find the transformed (and more limited) Gemini a less desirable place to work, even if they have the opportunity to remain. Research scientists may decide that the environment is not sufficiently intellectually stimulating. Similarly, Engineering and Administrative staff may find fewer opportunities to participate in or lead innovative projects.
  - Non-research staff may suffer high turnover rates.
- Timescale and Transformation
  - The transformation we propose here is large and must be completed on an aggressive schedule. While the technical challenges are surmountable, implementing them while simultaneously continuing regular operations and completing major instrumentation initiatives presents a significant risk.
  - The software that is important for supporting the new operations model is at risk for timely completion, largely because of its complexity.
  - The transition to base-facility operations is similarly complex and its requirements are not yet fully defined.
- Astronomical Capability
  - A robust instrument development program is needed to keep Gemini as a forefront astronomical facility.
  - Rigorous training procedures must successfully replace the expertise of active PhD astronomers for non-research staff observers to execute the queue successfully.
  - Responsibility of the National Gemini Offices must increase to produce fully defined observing programs.
  - Delivered instruments must be high quality without relying on staff efforts to integrate them into regular operations.
  - In the long-term, engineering operations and maintenance are at risk, especially for staffing and budget. For example, the primary mirror coating scheduled for 2010 with a full staff at Gemini South is low-risk, whereas the next Gemini North M1 recoating could become a high-risk activity.

Risk mitigation strategies are being developed in parallel with the various projects required by this transition plan to minimize overall risk. The nominal sequencing and cross-links of these projects is depicted in Appendix B. Gemini's well established planning system is being used in the remainder of 2010 to flesh-out and resource these projects, from which a fairly detailed staffing plan will be

developed to ensure the right amount and type of expertise is available throughout the transition to our new operations model.