The Gemini Observatory Science Operations Plan

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ABSTRACT

We review the Gemini Observatory science operations plan including the proposal submission, allocation and observation planning processes; the telescope operations model; and the scientific staffing plans and user support. Use of the telescope is shown by via a scenario involving a sub-stellar companion search program to illustrate the planning tools and level of integration required between the observatory control, telescope control and data handling software systems.

Keywords: Gemini telescopes, operations planning, telescope applications, staffing

1. INTRODUCTION

The emphasis of the Gemini telescopes' design on delivering superb images and a low system emissivity makes realizable striking gains in sensitivity compared with their 4m-class predecessors, particularly during exquisite site conditions. One of the challenges of Gemini science operations is to ensure that the telescopes can exploit such conditions when they occur whilst recognizing that the telescopes must be used effectively and efficiently a much larger fraction of the time.

In the following sections we describe elements of the operations plan, including the proposal application and planning process (section 2), with the latter illustrated by an example science scenario (section 3), daily activities during routine operation (section 4) and the scientific staffing (section 5). This plan will continue to evolve as more is learned about the Gemini capabilities as well as from the experience of other large telescopes operating in these innovative ways.

2. TELESCOPE PROPOSALS

Two schematic representations of the Gemini proposal process are shown in Fig. 1 from (a) the viewpoint of the process as a whole as well as (b) from an applicant's perspective. The main feature of this process that distinguishes it from conventional ground-based telescopes is that it comprises two stages. The intent is not to subject unsuccessful applicants to the, necessarily time-consuming, detailed observation planning stage.

2.1 Phase I preparation

Phase I applications will be made to the responsible body (National Time Allocation Committee, NTAC, or National Gemini Office, NGO) within each of the Gemini partners. These applications will be evaluated to establish their scientific merit as well as their technical feasibility. To serve this purpose, Phase I proposals must therefore contain a scientific justification, technical description of the instrument resources and time justification, proposer information, target details, scheduling constraints and availability of guide stars.

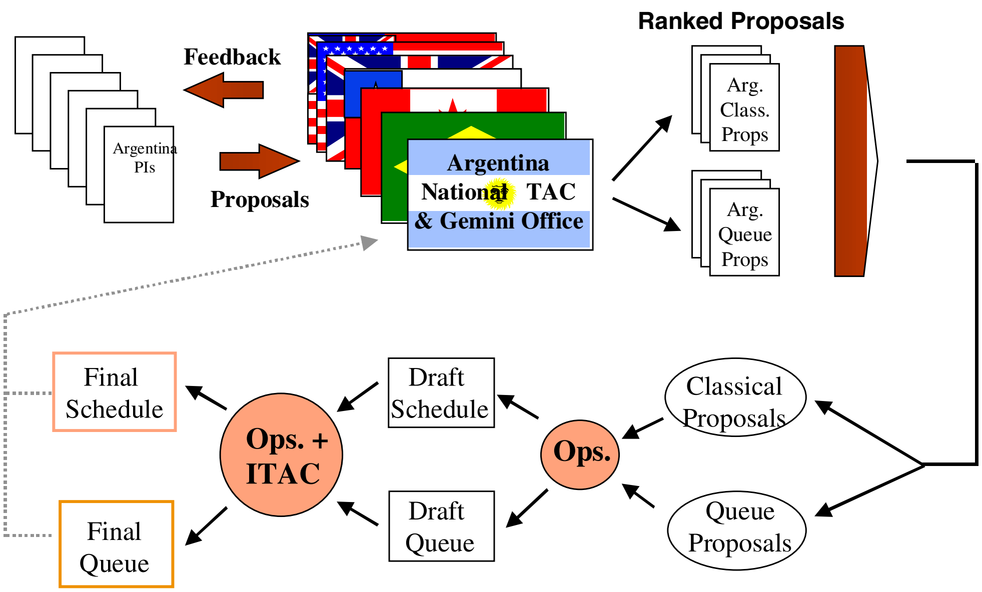


Figure 1a: The Gemini Phase 1 proposal process

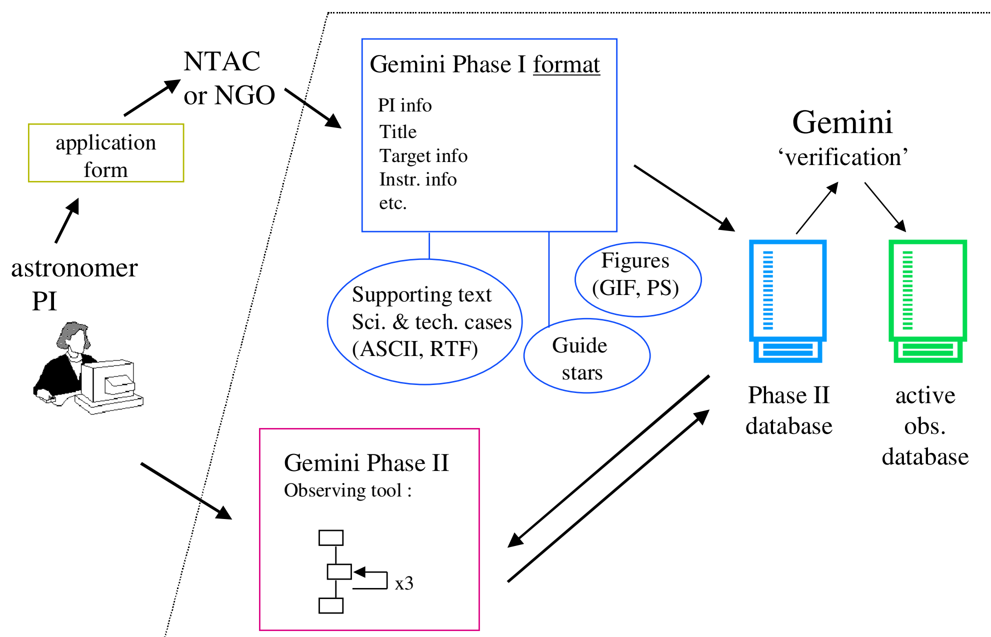
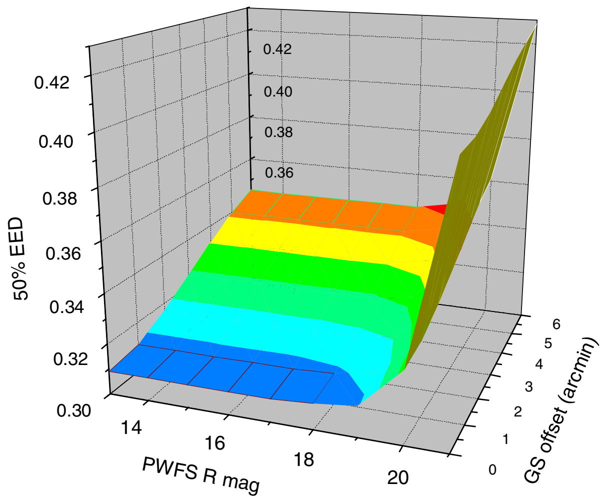


Figure 1b: The two phases of Gemini proposal and observation planning

For queue programs the scheduling constraints define the poorest site conditions (e.g. image quality, cloud cover, IR or optical sky brightness) under which each observation can be carried out as well as any time constraints. In general the constraint details are still to be defined but will likely be based on the frequency of occurrence. Thus the image quality might be specified in one of four bins (best 20%-ile, 50%-ile, 90%-ile and unconstrained; the latter accounting for the extended tail in seeing distributions) with the actual encircled energy or Strehl ratio corresponding to these percentiles defined separately for several principal wavelengths. An example developed from preliminary modelling of the tip-tilt performance of the telescope, taking into account the performance of the optical and near-IR wavefront sensors, is shown in Figure 2.



Frequency of occurrence	V 50% EED	K 50% EED	10mm 50% EED
20%-ile	0.30	0.22	0.33
50%-ile	0.50	0.35	0.36
80%-ile	0.70	0.50	0.40

Figure 2: A model (left panel) of the delivered image quality (50% encircled energy in arcsec) at 10mm as a function of peripheral wavefront sensor guide star brightness and off-axis angle, and (right panel) estimates of the frequency of occurrence of image quality in the visible, near and thermal infrared

Demonstration of the availability of guide stars, though not necessarily identification of the specific stars to be used, is an important aspect of the Phase 1 information and technical justification because of the key role of peripheral and on-instrument wavefront sensors (WFSs) in delivering the image quality and guiding performance. The principal object catalogue for guide star selection will be the "second generation" Guide Star Catalogue (GSCII) presently under construction at STScI with the 2-MASS point-source catalogue also of value, particularly in dark clouds. Note that the astrometric accuracy of the guide stars only becomes an issue if precise blind offsetting from them is required; the catalogue accuracy is expected to be more than adequate for acquisition of the guide stars by the WFSs.

2.2 Phase I submission and the National TACs

Proposals will be solicited by each NGO or NTAC from its own user community twice a year and will be coordinated to occur simultaneously in all countries. Each NGO or NTAC will be responsible for collecting proposals from its own user community, for ensuring that all proposals are complete and valid, for scientific assessment and for the first level of technical review. In addition, at their discretion and subject to the available Gemini support, each NGO or NTAC may solicit proposals more frequently for placement in pre-reserved classical or queue slots. The intent of the latter mechanism is to permit a quicker response than provided by the regular submission process which, together with the ability to specify "trigger" events (e.g. a g-ray burst detected by the BeppoSAX satellite), will provide considerable flexibility in the types of programs which can be carried out.

To support the collection of the required Phase 1 information Gemini will distribute common submission software to any partner that desires it. The Phase 1 tool is described in more detail at this meeting [1] but briefly this platform-independent (JAVA) software will contain a knowledge of the Gemini instrumentation complement, baseline observatory scheduling and capabilities for the upcoming semester, and incorporates the ability to access and search a number of on-line digital catalogue servers to manually or automatically select guide stars.

As indicated in Fig. 1 each community may run its NTAC and submissions mechanism in any way it deems appropriate, including alternative Phase 1 proposal mechanisms, however each NTAC is expected to electronically transmit the following to Gemini:

- Two ranked lists of the proposals it would like to see scheduled in order of scientific priority, one for classical programs and one for queue programs. If desired, these lists should included designated programs from the previous semester's queue or classical schedule for inclusion in the new semester's queue or schedule e.g. those unlikely to be executed or those allocated "long-term" status.
- A recommended amount of observing time for each program, together with an estimate of the minimum required to produce any meaningful scientific result. These times are based on the scientific judgment of the TAC combined with the data input from the technical review and the arguments put forward by the proposer.
- Electronic versions of the recommended programs in a defined standard format i.e. the same as that generated by the Gemini Phase 1 tool.

This e-submission procedure allows the relevant information to be readily extracted from the proposals and will be used to populate the initial Phase 2 database (see section 2.5).

It is expected that the combination of the list and recommended times will substantially exceed the expected allocation, to allow some degree of flexibility in merging the national lists. From simulations of the queue execution process[2] it is anticipated that this overloading will be in the range 25-40%, although this value is subject to variations in site conditions about which we have presently only sparse information. In general, programs which require any environmental parameter to be better than its median value should be queue-scheduled unless there is a scientific reason against this. One exception to this guideline will be programs using visitor instrumentation. It is expected that these too may wish to exploit some aspect of Gemini's superb performance.

2.3 Preliminary Merging

Following receipt by Gemini of the NTACs Phase 1 output, the various lists will be merged into a draft classical schedule and draft queue with a number of constraints involving the fractional allocation to the different partner countries, the host institutions and an allowance for Director's discretionary and engineering time. Simulations of this merging process have been carried out with representative queue and classical programs[3] and demonstrate the importance both of the queue containing a reasonable distribution of programs requiring different conditions and of starting with an initial approximation to equitable partner usage. Taken together these conclusions imply that the individual partner's lists should contain a balanced distribution across the range of site conditions.

A simulation of the forthcoming semester's queue execution using a statistical model of the expected site conditions to analyze the usage distribution will follow the list merging (see [2] for details).

2.4 The International TAC and final schedule

The International Time Allocation Committee (ITAC) consists of representatives from Gemini and the NTACs, and is advisory to the Gemini director. It meets to consider modifications to the draft schedule and draft queue required by conflicts identified in the merging process and subsequent execution simulation. If necessary, programs may be moved from one observing mode to the other, or additional programs may be substituted from the NTAC lists, based on the best scientific judgment of the ITAC. The final recommended schedule and queue are forwarded to the Gemini director for approval.

Upon publication of the final schedule and queue, feedback on the proposal status, including scientific, technical and ITAC comments if appropriate, will be collated by each NGO or NTAC and returned to the applicants.

2.5 Phase 2 Proposals and the Observing Tool

Each successful proposal will be assigned a contact scientist (CS) who is the Gemini representative for that program. For queue programs the CS is responsible for ensuring that all information required to execute the program is available to the observer. This information is submitted in Phase 2 of the application process and includes:

- Program object list with appropriate positional information. Usually this will be a refinement of the positions specified in Phase 1. In the case of a queue program involving, for example, multi-slit spectroscopy, where images of the field must first be obtained to produce a slit mask, the program may be put on hold while awaiting this information to be provided by the proposer through the CS.
- Target acquisition details. Given the plethora of acquisition options available, including imaging with the acquisition camera, use of the imaging mode of an instrument or accurate offsetting using the wavefront sensors, this information will generally be in the form of a text-based description of the intent but may include finding charts.
- Identification of guide stars or adaptive optics reference stars. These are selected with the assistance of image quality estimation software.
- Specific instrument configuration, including the sequencing between instrument configuration(s), telescope motions and observations.
- Quality assurance recommendation. This may incorporate S/N requests or identification of specific spectral or morphological features and includes configuration of the on-line data processing system. The goal is for the observer to use this real-time quality assessment to determine whether an observation can be terminated early because the desired result has been obtained.

Phase 2 proposals are developed using the Observing Tool (OT) JAVA software distributed to all proposers. This software is described in more detail at this meeting in [4] and in [5]. It allows the user to work directly with the Phase 2 database at the Gemini sites, or off-line, via a graphical user interface to define completely their observations, select and sequence instrument, telescope and data processing configurations, refine Phase 1 positions, describe acquisition requirements and constrain observation scheduling by grouping, chaining or specifying temporal controls. Examples of use of the OT are presented in section 3.

Once all of the required information has been entered, the proposer notifies their contact scientist, the program is verified by Gemini staff and transferred from the Phase 2 database into the active database where it is available for execution by the Observatory Control System.

As in the queue-scheduled case, each classical program is assigned a contact scientist. In this case, the CS is responsible for assisting the proposer to prepare for the observing run. Such preparation is expected to include assembling all the information that is required to be supplied for queue-schedule programs, for example using the OT to pre-plan the observations. In addition, the CS is responsible for ensuring that appropriate personnel are available to assist the proposer when she arrives for the scheduled telescope time, will typically provide direct support for the first night of the observing run and can advise on-site, post-observation data processing.

3. A SCIENCE SCENARIO

It will be evident from the previous description that the Observing Tool plays a key role in observation planning for queue-mode users of the telescope. The OT is no less important for classical observers, as well as the Gemini queue observing staff, as it provides the instrument user interface and the means for constructing simple or complex sequences of observations at the telescope. In this section we describe use of the OT via a science scenario that also serves to illustrate the deep level of interaction between the observatory and telescope control systems and the data handling system.

Let us suppose we wish to observe the nearby M-type star GL229B to search for sub-stellar companions. The observations will make use of the near-infrared imager[7] and employ a differential technique observing alternately in two narrow-band filters in and out of the deep methane absorption near 1.6mm expected in the low-mass companion's spectrum. GL229A will be placed behind a cold coronagraphic occulting mask to reduce scattered light from the primary. Minimizing systematic effects is important in such observations and thus we have elected to intimately associate the calibration observations (detector dark current and flat field) with the science observation. Within the OT one such grouping method is to "chain" the observations (note the chain links in Fig. 3a) which enforces their consecutive execution. The GL229B observation description from the OT is shown in an expanded hierarchy in Fig. 3b.

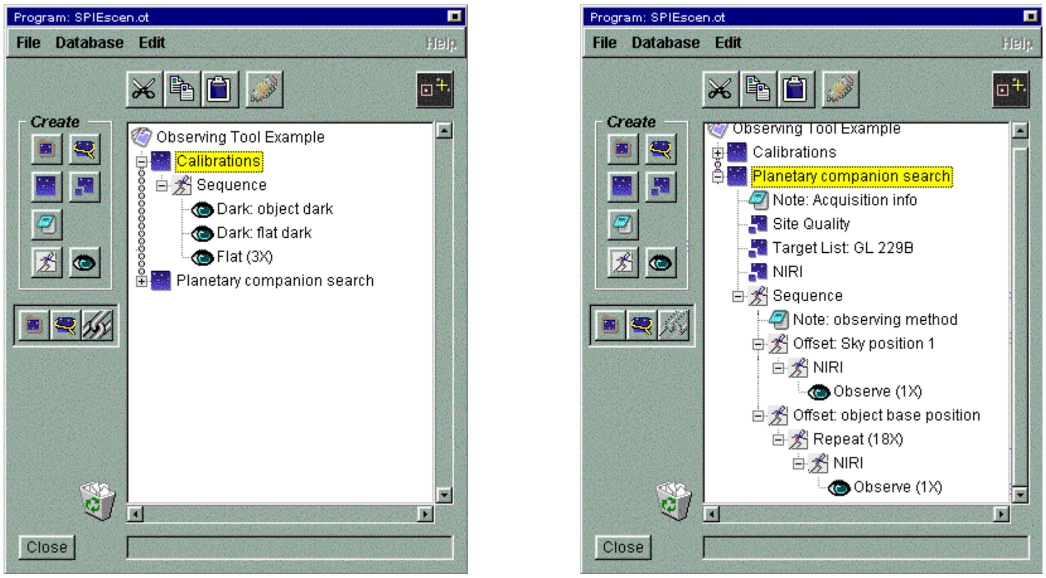


Figure 3: The program development screen from the Observing Tool showing (a) the calibration observation and (b) an expanded view of the science observation.

Each major aspect of the observation is defined by its own component. For example, the "target list" component (Fig. 4a) specifies the base pointing position as well as the pre-selected guide stars to be used by the peripheral and

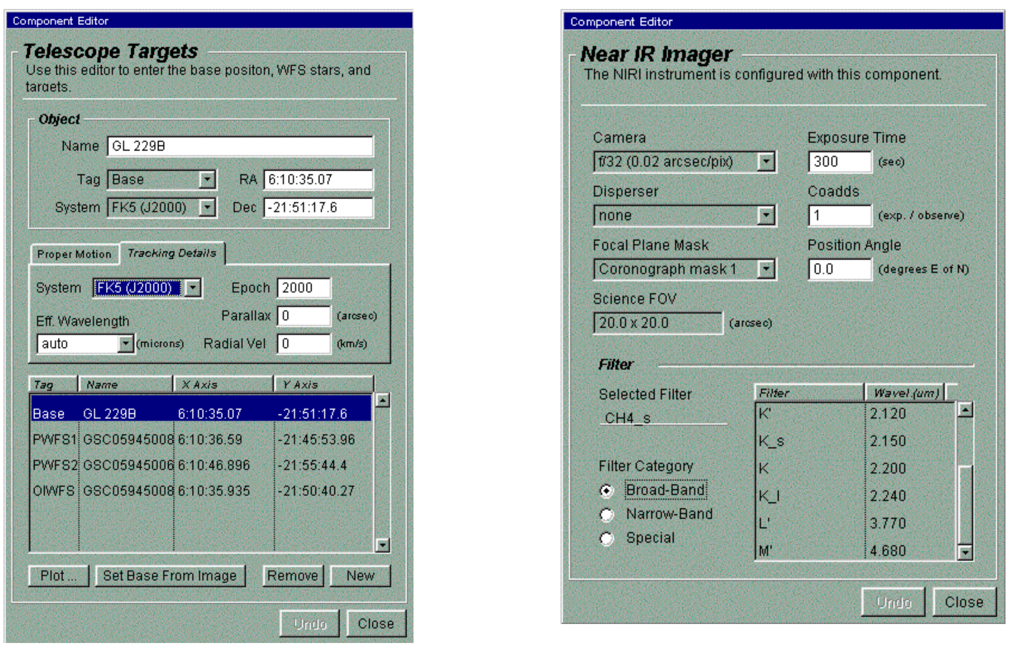


Figure 4: The Observing Tool components used to define (a) the telescope and wavefront sensor positions and (b) the near-infrared imager configuration.

on-instrument wavefront sensors, and the “NIRI” component (Fig. 4b) defines the initial instrument configuration. The target list may be viewed graphically (Fig. 5) using a representation of the telescope field with overlays of the wavefront sensor positions and sensor constraints, possible (catalogued) guide stars, telescope sequence positions and science field. The image of the field may be drawn from sky survey images, images from other telescopes, or images from the Gemini acquisition camera or science instruments.

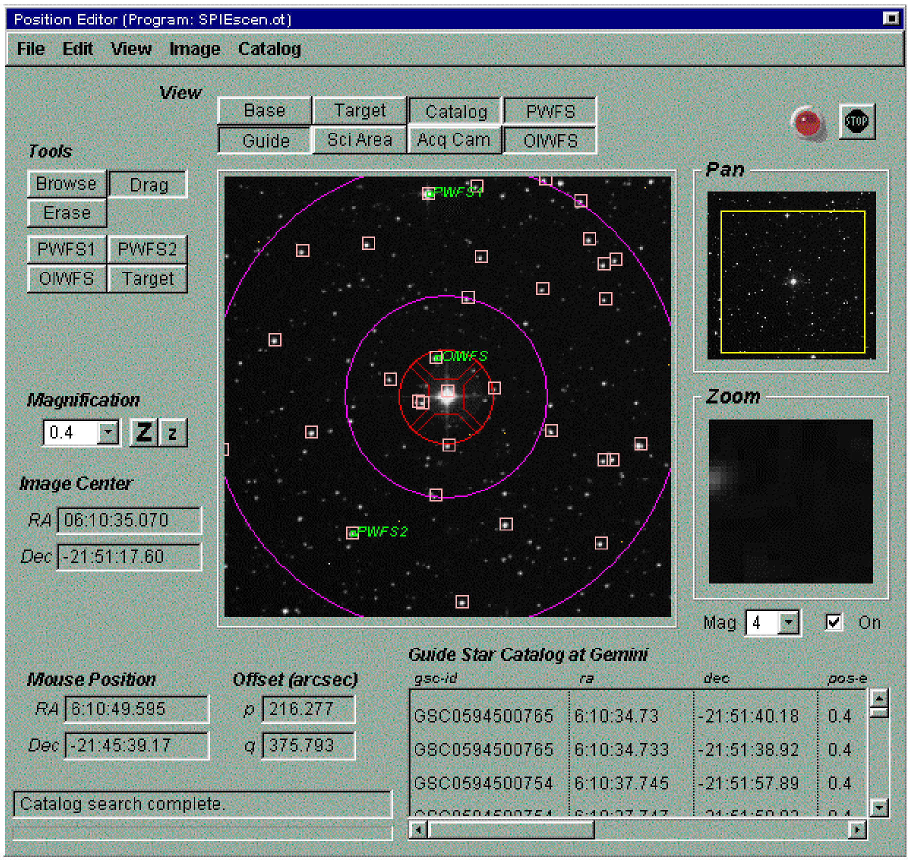


Figure 5: Visual representation of elements of the pre-planned science program showing catalogued guide stars (square boxes) and those selected for the wavefront sensors (labelled), and patrol fields for the WFSs: outer circles for the peripherals and inner circle and vignetting pattern for the on-instrument.

Selection of this observation for execution causes several parallel actions. The telescope slews to the target, the peripheral and on-instrument wavefront sensors position themselves in the expected locations to receive light from the guide stars and the instrument camera and filter mechanisms adopt the desired configuration. Often, and particularly in this instance, the observing team would have configured the control system to pause before the observing sequence itself is started to allow fine adjustment of the telescope position. A typical acquisition process might be (i) close the control loops around the wavefront sensor error signals to provide a tip-tilt stabilized image, (ii) take a short-exposure image of the star without the coronagraphic mask, (iii) perform synchronous data processing on this image, using a recipe specified in the acquisition configuration, (iv) display the processed image and overlay with a fiducial corresponding to the previously-calibrated precise location of the mask center, (v) either interactively select the desired target position or apply a profile-fitting algorithm to determine the image center and (vi) apply the offset vector to the telescope. At this point the instrument science configuration can be applied and the observation sequence shown in Fig. 3b initiated.

In this case the observing sequence is rather simple involving numerous repetitions of successive exposures through the two filters. However the OT also allows complex sequences to be built up by iteration over any of the instrument mechanisms and co-ordination with telescope motion. Likewise the on-line data processing system can be pre-configured by the OT to reflect the data-taking sequence. This will most likely involve ‘attachment’ of recipes driving IRAF (or IDL) scripts at any of the nodes in the observation hierarchy, for example to do dark current subtraction and flat-fielding after each exposure (“Observe” node in Fig. 3b), differencing of the two filter images (“NIRI iterator” node) and combination of accumulated data (“Repeat” node). Each of the intermediate or final data processing products may be displayed in a variety of formats on a quick-look display. The intent of this system is to provide real-time quality assessment to the observers so that they may adjust details of the observation.

A “library” of commonly executed observation and data processing configurations and sequences is provided as part of the OT and which may be cut-and-pasted to accelerate program definition.

4. SCIENTIFIC SUPPORT

4.1 Distribution of support responsibilities

Scientific support for users of the Gemini telescopes will be provided by a combination of Gemini staff and the National Gemini Offices (NGOs). Broadly, Gemini will be responsible for observation execution, on-site support, for providing expert response to user queries and as the control authority for the release of general information and data. The NGOs will be responsible for pre- and post-observation support and will be the first point of contact for user queries. It is not expected that each NGO will maintain a full complement of staff capable of responding to queries in all areas, instead a distributed support network, involving collaborative support by two or more partners, is envisaged.

4.2 Types of scientific staff

The Gemini scientific team comprises four types of staff member:

- Gemini Fellows - these fellowships are intended to create the new generation of astronomers who might cycle back into the user community after their ‘apprenticeship’ with Gemini. They would typically be fixed term 3-5 year appointments and contain a major research element (~40%) in addition to the other Gemini support duties. Alternatively, more ‘senior’ members of the community looking for interesting sabbaticals might fill some of these positions.
- Staff Astronomers – provide the continuity of experience vital in keeping world-class telescopes working and scientific productive. They would typically be continuing appointments (tenured, tenure track or long-term contracts) and with a substantial research component (~30%).
- System Support Associates – are responsible for the nighttime control of the facility, in concert with Gemini and visiting astronomers, as well as a variety of daytime activities including data verification and distribution, instrument and systems support and control of the facility from the sea-level operations rooms.
- Associate Directors – each key scientific function of the observatory will be led and directed by an Associate Director. They will be responsible for overseeing the scientific productivity of the facility as a whole, including ensuring that Gemini scientific staff are able to devote the required amount of time to their own scientific research. Devolution of many of the traditional management duties associated with such positions to an overarching management team will enable the Associate Directors to be scientifically productive in their own right. These positions would typically be tenured or long-term appointments.

It is anticipated that the Gemini scientific staff will be further augmented by extended visits from astronomers in the Gemini community who can contribute their wide experience and expertise to the operation of the facility and help foster a lively scientific culture.

4.3 Estimated and planned staffing levels

To determine the required level of staffing, estimates were generated both from top-down and bottom-up analyses. For the former, it was assumed that scientific staff work 4 (Mauna Kea, plus one for acclimatization) or 5 (Cerro Pachon) nights per month on the mountain supporting all queue, engineering and discretionary nights as well as those in which they are directly involved as principal or co-investigator. In addition, it was assumed that visiting observers in a typical classical observing session of 2-3 nights would require support for the first night only. The results were benchmarked against existing 4-m telescope to verify their validity.

For the bottom-up analysis, a detailed breakdown of the required duties was produced. Since this model was also used to generate the profile for staffing ramp-up it included the facility integration, test and commissioning phases as well as post-handover routine operations. Only in the final year of the plan does the staffing model approach steady state. The top-level list of tasks includes (i) establishment of the science support team; (ii) definition, establishment and management of the TAC process; (iii) definition, establishment and management of queue and classical activities; (iv) scientific direction and management via Science Working Groups, international Project Scientist groups and external, ultimately user, committees; (v) direction and support for development, integration and testing of the Gemini principal software systems (control, telescope, data handling and instrument); (vi) support for internal and external environment monitoring, including definition and establishment of site characterization and monitoring, and the impact of ambient conditions on delivered image quality; (vii) support for the facility integration, test and commissioning activities, including tracking and pointing performance; static, smear and dynamic image quality; mirror coating, cleaning and emissivity; (viii) instrument support, incorporating overall oversight of the instrumentation development program as well as specific instrument tasks; (ix) definition and establishment of the telescope and sea level facility scientific infrastructure; (x) science research activities; (xi) support for construction of the object and pixel catalogues at STScI (see section 2.1); and (xii) operations support directly related to nighttime observing (see section 5).

Directorate				
	Associate Director for Development	0.6		
	Director's Fellow	1		
Mauna Kea			**Mauna Kea**	
	Associate Director	0.6	Facility tasks	12.4
	Staff Astronomers	4	Staff Research	4.1
	Science Fellows	6		
	System Support Associates	6		
Cerro Pachon			**Cerro Pachon**	
	Associate Director	0.6	Facility tasks	11.6
	Staff Astronomers	3	Staff Research	3.3
	Science Fellows	5		
	System Support Associates	6		
	Gemini-funded science staff effort	**32.8**	**Facility & research tasks**	**31.4**

+ Operations support from National Gemini Offices
+ Visiting scientists from NGOs and community

+ "Citizenship" tasks

Figure 6: One model of the scientific staff resources (left column) and duties (right column) during steady-state operations. Note that significant support is provided by the National Gemini Offices (see section 4.1).

Each of these major tasks was further broken down into its constituent parts. For example, the generic instrument task list, of which there is one per instrument, includes: acceptance testing, instrument and science commissioning, standard performance checks, continuing development of observing modes, development of integration time calculators, maintenance of manuals, staff training and leadership of future instrument development.

The results of the two approaches to developing the staffing model were found to be in excellent agreement. A summary of the anticipated steady-state resources and integrated duties is shown in Fig. 6.

5. ROUTINE OPERATION

In this section we describe various aspects of the routine science operation of the Gemini observatory.

5.1 3-shift operation

During routine operations the Gemini observatory will be staffed continuously. The daily cycle consists of three shifts and is illustrated in Fig. 7.

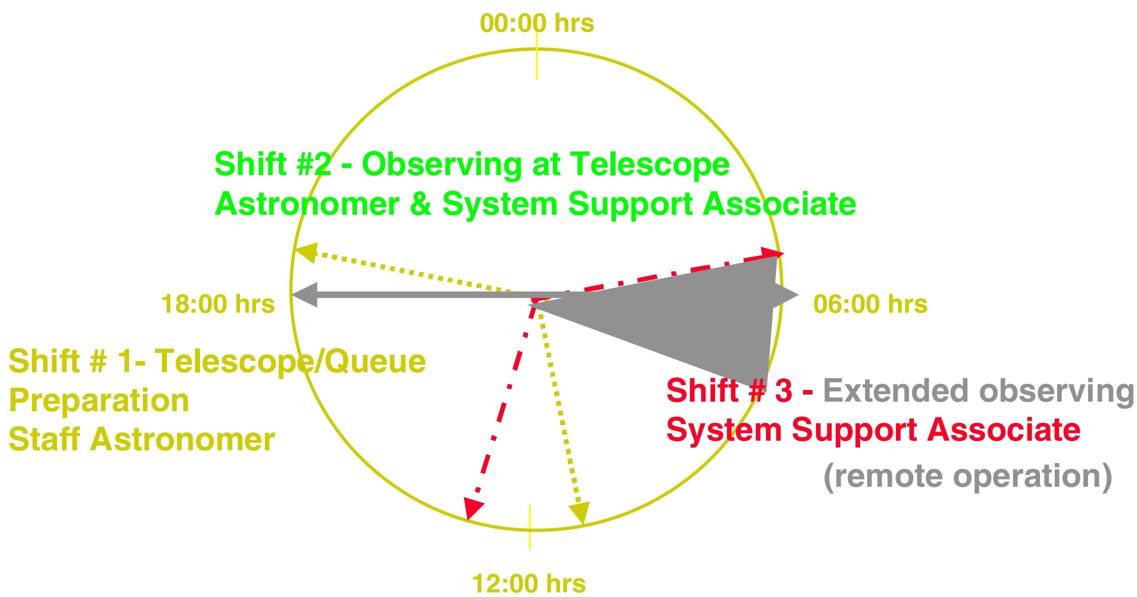


Figure 7: The daily cycle of telescope operations and scientific staffing requirements.

Shift #1 runs from 11am until 7pm and is executed by a Gemini staff scientist from the sea-level operations room. In this shift scheduling tools and weather predictions are used to draw up plans for the nighttime observations, calibrations and instrument checks are performed using the facility calibration unit [6], when permitted by engineering and maintenance activities, and the telescope and enclosure are conditioned. The latter involves establishing equilibrium between the dome air, telescope structure and mirror temperatures with the expected air temperature, as well as setting the mirrors' rate of change (dT/dt), for the start of nighttime observing. To meet the stringent image quality requirements the mirror surface must be maintained within 1 C of the ambient temperature. Depending on the accuracy of the weather forecast, the shift operator may use the scheduler with a number of different sets of conditions and "policies" (describing the combination of parameters affecting queue execution) to construct several nighttime plans using the Observing Tool to link together pre-defined observations from a number of different programs.

Handover to shift #2 occurs at 6pm, commencing with the arrival of the nighttime observing team, Systems Support Associate and staff or visiting observers, at the summit. This provides an overlap of one hour for shift #1 to update the second team on the system status, calibrations and to discuss the observing plan. However, the queue observer has the minute-by-minute responsibility for the decision of what observation to execute and, after evaluation of the current environmental conditions or if an instrument is malfunctioning for example, may choose to switch programs in a way not reflected by the possible plans. The queue observer is also responsible for understanding the programs in sufficient depth to know how to make the observations and how to evaluate the success of the observations. Medium range schedules, typically drawn up 7-14 days in advance from models of the queue execution, will enable the contact scientists to discuss likely upcoming programs with the queue observers.

Shift #3 runs from 5am until 1pm and is carried out by a SSA at the sea-level facility. The one-hour overlap before the nighttime shift relinquishes control of the telescope at 6am allows for an update of that night's observations and communication of any faults or problems that might have occurred. It is anticipated that development of a near-infrared peripheral wavefront sensor will enable science observations in the thermal infrared to continue for several hours after morning twilight, to be controlled from sea-level and with safe telescope shut down verified by the daytime summit engineering team. The shift #3 operator will also be responsible for archiving the data and for arranging its distribution and quality assessment by the contact scientist.

5.2 Quality assessment, PI monitoring and feedback

After each exposure, the observer is responsible for a low level of quality assessment. Was the sky brightness level as expected? Have environmental conditions changed? Is the object producing approximately the expected number of counts?

As the execution of the observation proceeds, and especially with regard to the start of a new program, a higher level of evaluation is required. A pipeline data processor, configurable by the proposer via the Observing Tool as part of their pre-planned observation, or by the observer, will take each science frame and reduce it using default or standard parameters. Given the criteria submitted by the proposer, and discussed between the contact scientist and the observer, does the proposed exposure time achieve the required S/N ratio? If there is a small discrepancy, the program parameters may be adjusted. If there is a large discrepancy, the problem will be flagged for discussion between the contact scientist and the proposer the following day. In this case, the observer would proceed to another program.

Many queue proposers may elect to have the programs put on hold after the first observation in a program is obtained so that they may assess is quality and adjust the program if necessary. The Observing Tool will provide this facility. Proposers can be made aware that their observation could be executed once it appears in the medium range schedule and may adjust their personal schedules accordingly. This notification would be repeated each day following until the program is executed or until the program is no longer viable. If the program is executed, or started, the proposer would be notified how to inspect the data.

5.3 Operation of the queue

A detailed description of possible operation of the queue is given in [2]. The status of queue observations (e.g. awaiting Phase 2 definition, active, completed, on hold) will be made constantly available.

5.4 Time accounting

Classically scheduled programs will be counted as nights allocated. Queue scheduled programs will be counted as hours used. The clock for a queue exposure begins at the start of the slew for that observation. Thus the time to slew to the object, acquire it, configure the instrument and the telescope, read out the detector and confirm that the data are satisfactory are all charged. Some of these activities (e.g. slewing and reconfiguration) may occur in parallel. A nominal set of calibrations, defined in each instrument handbook, will be provided; any calibration taken between the hours of astronomical twilight will have its charge divided among all the programs that use it. Any additional calibrations required for a specific queue-scheduled program will be explicitly charged to that program. The intent is to achieve overall parity in time accounting between classical and queue programs.

It is not necessary that the agreed fractional allocations of time to the Gemini partners are exactly satisfied every scheduling period, only that they approach these values over the longer term (say, 2 or 3 semesters). However, there is a given amount of observing time, and if one partner exceeds its allotment, another one will fall behind its allotment. Therefore, the queue will be capable of adjustment periodically throughout the semester to ensure that no partner seriously deviates from its allotment. A possible model for feedback of the time accounting information into the queue execution process is described in [2]. To incorporate possible preferences amongst the partners for different site conditions, the queue-scheduled time will be accounted separately for the best conditions (of image quality and IR background), median or better conditions (in any category) as well as the total usage.

5.5 Data archiving and proprietary period

The proprietary period for Gemini data will be 18 months from the collection of each science observation within a program. Applicants will be permitted, via their NTACs, to petition the Director for an extension to this period, or to shorten it. Normally this would occur at the time of submission. Certain information (e.g. Gemini calibrations, the title, investigators and abstract) will be treated as non-proprietary and available in the publicly accessible queue or classical schedule. The full science case is considered to be the intellectual property of the applicants and will not be released by Gemini without consent.

The Gemini archive serves two purposes: (a) as a backup and record of the data taken with the Gemini telescopes, and (b) as a database for future scientific studies. In its first role, all raw data will be written to the archive. All instrument settings will be encoded and written into the headers of data frames. All engineering and environmental variables will be recorded as well, in a manner that permits their association with the scientific data, most readily via their time-stamp.

In order to be useful for future scientific studies, processed data as well as raw data will be saved. It is acknowledged that the ultimate level of data reduction may involved precise adjustment of the parameters and algorithms, but a very large fraction of the data can be effectively reduced using a standard pipeline procedure and ‘default’ parameters.

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