GEMINI 8-M Telescopes Project

NEWSLETTER

October 1994 Number 9

Gemini Project Overview

The Gemini project has passed a number of major milestones since June.

- Gemini System Review No. 1 took place July 25-28, 1994, immediately followed by the first meeting of the new AURA Oversight Committee - Gemini;
- The Operating and Site Development Agreement (OSDA) between the NSF and the University of Hawaii, which is required to proceed with construction of the Gemini northern telescope on Mauna Kea, was executed on August 8, 1994;
- Initial excavation of the Gemini southern telescope site on Cerro Pachon, Chile, was completed;
- Brazil signed the Gemini Agreement to formally become a party.

The project is moving increasingly from design into fabrication and construction, as I indicated in the last newsletter. Progress towards award of fixed price contracts for Gemini fabrication and construction is on schedule. Highlights of the project's recent accomplishments are:

Systems Engineering. The Gemini System Reviews are one indication of the increased emphasis placed on systems engineering. These semiannual reviews provide an open forum for review of all technical aspects of the project and critical examination of system-level issues. The first such review, which is described in the Systems Engineer's Report of this issue, was very useful to the project. Considerable progress has also been made in the areas of interface control and document and drawing control.

Telescope. Proposals have been received in the international competitions for fabrication of the structures and azimuth tracks for both telescopes. Proposal evaluations are complete and the winning contractors should be selected in the near future.

Enclosure and Site Facilities. The interfaces between the rotating enclosure and the base structure are completely defined allowing completion of the support facility construction drawings. An 80% design review of Coast Steel's enclosure design was held October 11, 1994.

As indicated above, the OSDA for the Mauna Kea site has been signed and all permits received to proceed with construction. Contracts for relocation of the access road

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THE GEMINI 8-METER TELESCOPES PROJECT is managed by the Association of Universities for Research in Astronomy for the National Science Foundation under an international partnership agreement.

and utilities are in the final approval cycle, and work on Mauna Kea will start in October. The request for proposals to construct the Mauna Kea support facility was released at the end of September. At Cerro Pachon excavation of the site to the 2715-meter level is complete, and work is underway on the main access road and power lines.

In the area of mirror coating development, the test program to deposit aluminum coatings by sputtering in the 4.2-meter coating chamber of the UK's William Herschel Telescope is nearly complete. Both subcontractors working on development of protected silver coatings have achieved emissivities of 0.8% in small scale sputtered depositions.

Optics. Following successful completion of the 8.3-meter Subaru mirror blank, Corning successfully fused the first Gemini primary mirror blank. The blank will be slumped next spring. Work on the second mirror blank is ahead of schedule. REOSC Optique has started preparations for polishing of the Gemini mirrors, and the project has selected a configuration for the metrology mount matching the mirror support system to be used in the telescopes. Proposals for the design and fabrication of the Gemini secondary mirror fast articulation mechanism were received in August and preliminary evaluation has been completed.

Controls. Along with heavy involvement in Gemini System Review No. 1, the Controls Group finalized the Gemini Software Design Description in preparation for critical design review on September 22-23. With completion of the comprehensive top-level software design, work on the various elements of the software system will accelerate.

Instrumentation. The Cassegrain cluster (rotator, cable wrap, and instrument support structure) preliminary design review was successfully completed on June 15, 1994. Preliminary design work in the UK on acquisition & guiding and wavefront sensors has continued in preparation for a PDR in November 1994. Functional requirements for the Gemini adaptive optics system were reviewed in June and conceptual design is underway. The request for US proposals to design and build the Gemini 1-5 micron IR spectrograph was released in July. Proposals are due October 21,1994.

-Richard Kurz
Project Manager

Project Scientist's OUTLOOK

Observing with Gemini - some new approaches

Within the next 5 years we will begin to have access to 8 meter telescopes whose performance will be limited only by the physics of the atmosphere -- principally atmospheric turbulence and emissivity. An increased understanding of the effects of dome and mirror seeing combined with the use of sophisticated control techniques to maintain telescope alignment and reduce the effects of wind buffeting mean that in conditions of good seeing the Gemini telescopes will deliver images of 0.1 - 0.2 arcseconds. In conditions of median seeing, the delivered images will be ~ 0.4 - 0.6 arcseconds. Telescope emissivities of 2 - 4% will reduce the background for thermal infrared observations by factors of up to 4 compared to conventional telescopes at those times when the atmospheric emissivities drop below 1 - 2%. So, in good atmospheric conditions we will be able observe with 16 - 200 times the sensitivity of our current 4m telescopes. However, if observing time is allocated randomly throughout a given semester, the probability of a particular experiment being able to exploit the best tenth percentile conditions for 3 consecutive nights is ~ 0.1^3 (or 0.001), assuming conditions fluctuate on a nightly basis and the entire semester is clear. The probability that an observer will get 3 consecutive nights where conditions are median or worse is 0.5^3 (or 0.125). Of course, the most probable outcome is that there will be a mixture of conditions during each run, which means that, for example, the integration times for seeing limited spectroscopy may vary by factors of 10 throughout the run -- even if there are no clouds.

The planning needed to exploit the tremendous gains offered by Gemini will be intimately linked to understanding the behavior of the atmosphere. Unless we find ways of quickly adapting observations to exploit atmospheric conditions, realizing the scientific potential of these telescopes will rely heavily on luck and the scientific benefits to the Gemini partnership as a whole, I believe, will be diminished.

In the following sections, I look at a couple of examples -- the variations in atmospheric emissivity and the changes in seeing conditions -- and try to quantify the effects these will have on observations with Gemini.

Atmospheric Emissivity

The variations of the atmospheric emissivity at thermal IR wavelengths are predominantly due to water vapor variations in the atmosphere.

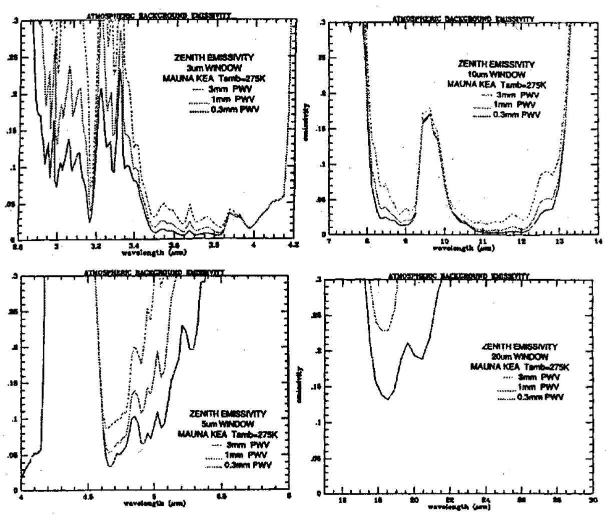


Figure 1. The variations in atmospheric emissivity as a function of water vapor column density (in mm H_2O) for 4 thermal IR windows.

The physics are fairly straightforward. The atmospheric emissivity can be approximated by $\varepsilon \sim 1 - e^{-\tau \sec(z)}$ where τ is the molecular optical depth and z is the zenith angle. Away from saturated H_2O lines, this can be approximated by $\varepsilon \sim 1 - e^{-(\sigma+X)\sec(z)}$, where σ is the water optical depth and X is the contributor to the atmospheric optical depth from other molecular species and is considered a constant for a given infrared window. Using an atmospheric model to calculate X, the variations of emissivities with water column are shown in Figure 2 for the 3.8μm and 11μm windows. As is apparent, the emissivities can be sensitive functions of water vapor, especially at low column densities. The fact that the water column can vary with time is shown quite graphically in the time sequence of satellite images of the water vapor column shown in Figure 3. Variations in the water column actually measured on Mauna Kea by the CSO "tau meter" (measuring the water optical depth at 225Ghz) are shown in Figure 4.

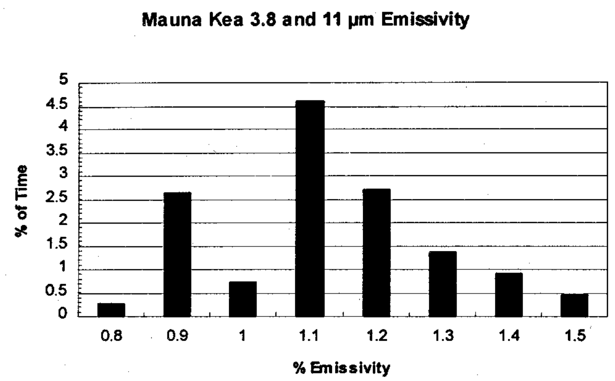


Figure 2. Histograms of $\varepsilon_{3.8}$ and ε_{11} for Mauna Kea are plotted, based upon CSO measurements and formulae described here. The emissivity at 3.8 and 11 µm is essentially the same, hence only one histogram is shown.

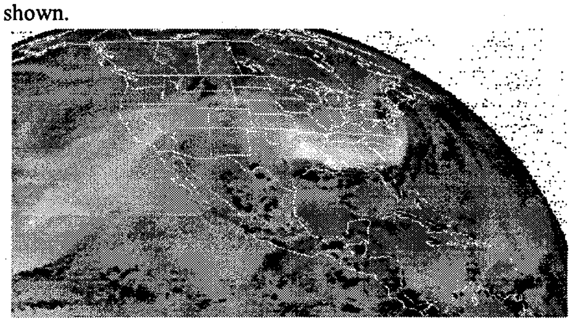


Figure 3a. Water vapor satellite imagery of the earth on August 22, 1994 is shown. Dark areas correspond to increasing water vapor absorption. Note the swath of relatively dry air across the southern U.S. behind a cold front. Also dry air is streaming from the Pacific over California and the Rockies.

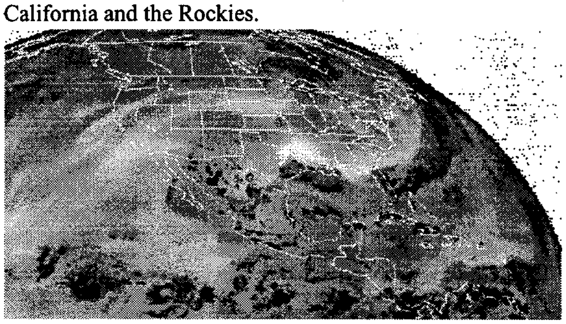


Figure 3b. Same as Figure 3a but 24 hours later. This time series illustrates the rate at which typical dry patches of the atmosphere move, i.e., generally time scales of days, not hours, are required to change τ significantly for a fixed site on the earth.

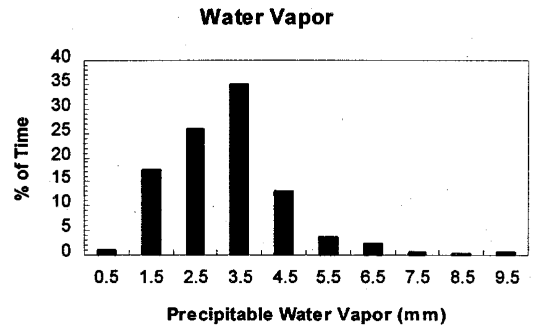


Figure 4. A histogram of water vapor measurements made with the CSO τ meter is shown for 100 nights. The conversion between 225 GHz opacity and precipitable water vapor was provided by Colin Masson (1992, Proceedings of IAU Colloquium No. 140, "Astronomy with Millimeter and Submillimeter Wave Interferometry").

So what are the effects of these variations in emissivity on actual observations at these wavelengths?

At thermal infrared wavelengths the predominant noise source is the combined shot noise from background emission from the telescope, any contribution from the instrument, and atmosphere. Consequently the S/N ratio achieved for observing a fixed brightness source is ~ $1/(\varepsilon_{tel} + \varepsilon_{inst} + \varepsilon_{atm})^{1/2}$. Alternatively the integration time to required to achieve a particular S/N on any given object is ~ $\varepsilon_{tel} + \varepsilon_{inst} + \varepsilon_{atm}$.

In Figure 5, I have calculated the relative integration times required to do a specific observation in the 3.8 and 11µm windows as a function of water vapor column. The integration times are normalized to 1mm H_2O. The two curves represent the variations expected for a telescope + instrument emissivity of 10% (ε_{const} = 0.1), comparable to values currently measured on Mauna Kea Telescopes, and 3% (ε_{const} = 0.03), the value expected for Gemini.

As can be seen, for a constant emissivity of 10% the observations are relatively unaffected by the variations in the atmosphere. Integration times vary ± 5%. However, if the telescope and instrument emissivity is reduced to 3% (ε_{const} = 0.03), the variations in the same observation could be as great as ± 20% depending on the water column density that night.

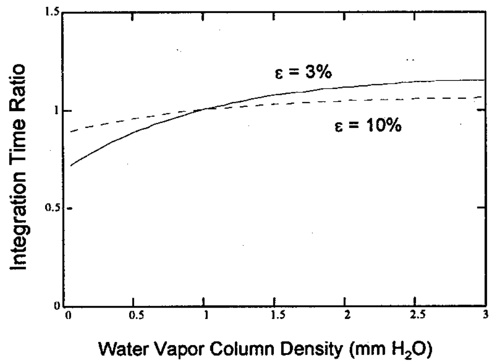


Figure 5. Relative integration times for observations in the 3.8 and 11 μm windows for telescope emissivities of 3 and 10% are shown. Integration time ratios are normalized to the value at 1 mm H_2O.

This effect is even greater where the atmospheric emissivities are even larger. Figure 6 shows the equivalent to Figure 5 for the 5.0μm and 19μm windows. As is apparent, the actual integration time required is less dependent on the value of ε_{const}, and is in fact swamped by the variations in the atmospheric emissivity. For example, at 19μm, the integration times can be halved if the water vapor column density changes from 1mm H_2O to 0.3 mm H_2O.

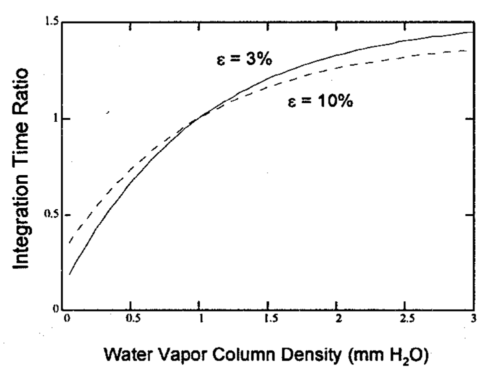


Figure 6. Same as Figure 5 except the 19 μm case is shown. Note how large the variations in integration times are to reach a desired S/N ratio.

The key to developing a successful operating strategy designed to exploit the infrared atmospheric emissivities is therefore to understand the time scales of water vapor variations. Figure 7 shows several consecutive nights of CSO measurements and confirms that the basic time scales of change implied by satellite imagery apply to groundbased measurements, i.e., water vapor does not change rapidly from one hour to the next, rather it takes at least a half night to see significant changes. Consequently a near optimum strategy for Gemini would be to select low emissivity nights or half nights, rather than trying to adapt to hourly changes. In the future we will attempt to correlate NOAA water vapor imagery of the central Pacific with CSO measurements (we have not identified a source for southern Pacific or Chilean water vapor imagery yet). If these two techniques prove to be well correlated, it may be possible to predict nights of good or poor atmospheric emissivity.

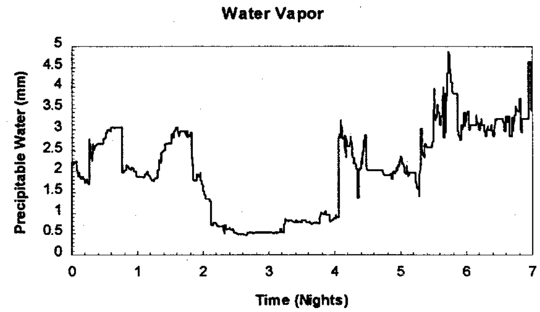


Figure 7. Approximately one week of water vapor measurements made at CSO are shown to illustrate the typical rate of change in atmospheric water vapor as measured on Mauna Kea.

Delivered Image Quality

Unlike the water vapor column density, the contributions to atmospheric seeing come from the turbulence within many atmospheric layers -- though on sites like Mauna Kea, there can be a dominant layer for ~ 60% of the time (Racine 1994). A distribution of measured seeing for Mauna Kea and Cerro Pachon at 550nm is shown in Figure 8.

The image quality delivered at the telescope focal plane can be approximated by delivered 50% encircled energy ~ (atmospheric $50\%^n$ + telescope $50\%^n$) $^{1/n}$, where n ~ 5/3 to 2.

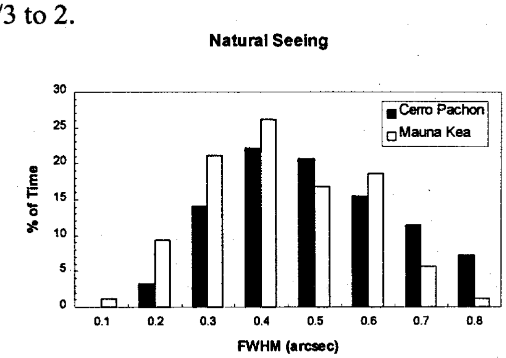


Figure 8. Histograms of intrinsic seeing on Mauna Kea and Cerro Pachon at 550nm from Racine et al (1991) and Suntzeff (1994).

Including the contribution from the telescope other than diffraction to the total delivered image quality can be rather complicated. At 2.2μm, the Gemini image quality requirement represents a 15% increase in the tip/tilt corrected 50% and 85% encircled energy diameters (θ_{50} and θ_{85}). This is equivalent to a quadratic contribution to the θ_{50} of 0.075 arcseconds. Since the Gemini telescopes use stars to provide feedback to the active control system to maintain the telescope alignment and remove tip/tilt effects, as the seeing degrades so does the accuracy of these corrections.

Figure 9 shows the expected distribution of delivered image quality at 0.55μm and 2.2μm for the Gemini telescopes, assuming the intrinsic seeing follows the histogram from Racine et al. (1991), scaling the seeing as $\lambda^{1/5}$ and using Project estimates for the telescope's performance.

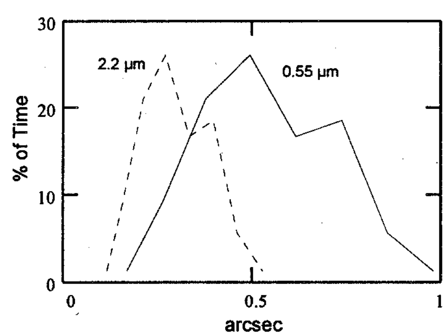


Figure 9. Predicted delivered imaged quality distributions for Gemini at 2.2 and 0.55 μm are shown. Gemini will clearly be much more susceptible to optical than infrared variations.

What will the effect be on a given observation due to changing image quality?

The spatial resolution is of course affected, and if we assume spatial information is proportional to number of resolved pixels across an image, the information content in a given image would scale as θ^{-2}. Alternatively, if the observations are background noise limited, which will be the case for most imaging and median resolution spectroscopy on Gemini, the S/N on compact sources will scale as the θ^{-1}, or the integration time to reach a given signal to noise becomes proportional to θ^2. Consequently for most observations on Gemini, a good relative figure of merit is:

$$\text{information content} \approx \frac{1}{\text{image diameter}^2} \approx \frac{1}{\text{integration time}}$$

Taking Figure 9 and rescaling it to display the variations in integration times, normalized to the median conditions at each wavelength, gives Figure 10. At 10μm, where diffraction is the dominant contributor to the delivered image quality, the integration times are less sensitive to atmospheric seeing variations. What is apparent is that, at shorter wavelengths where telescope diffraction is not a significant contributor, if the goal is to observe small compact objects either with small pixels or small slits, the length of an observation will vary by factors of 4-10 depending on atmospheric conditions.

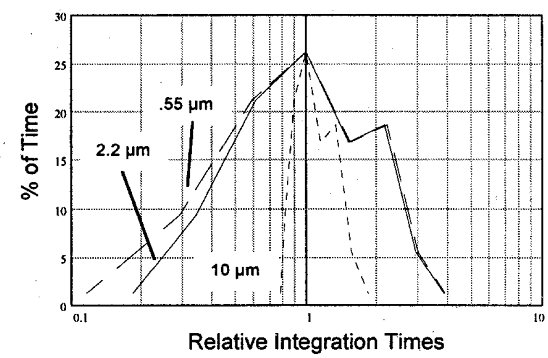


Figure 10. Relative integration times for background limited observations at three wavelengths given the Mauna Kea seeing distribution. Diffraction effects make 10μm imaging least susceptible to variations and optical observations the most affected.

Figure 11 shows a typical run of seeing data taken from the CFHT (Simons 1994). The image quality varies in a fairly chaotic manner, with no real cyclic behavior. Periods of good seeing or bad seeing appear to occur over hours or days. The problem with this data set is that it includes all the effects from telescope optics as well as dome and mirror seeing. In an attempt to look at the behavior of the intrinsic seeing on Mauna Kea, we have begun to investigate the measurements from a 12GHz phase monitor operated by CfA (Masson 1992). The advantage of this "seeing monitor" is that it has been operating on Mauna Kea almost continuously for 2-3 years and would give a good indication of the statistical behavior of seeing, provided the processes that cause the 12Ghz phase variations correlate with the changes in refractive indices at optical and IR wavelengths. A recent study by Simons (1994) has shown that the statistical behavior of the CfA data is remarkably similar to the seeing variations observed at the CFHT (see Figure 12). Hence, though this is not definitive proof of a causal connection, the CfA database appears to provide a good approximation for a seeing "behavioral model" for Mauna Kea and can be used to construct illustrative examples of the effects of seeing variations on potential Gemini observations.

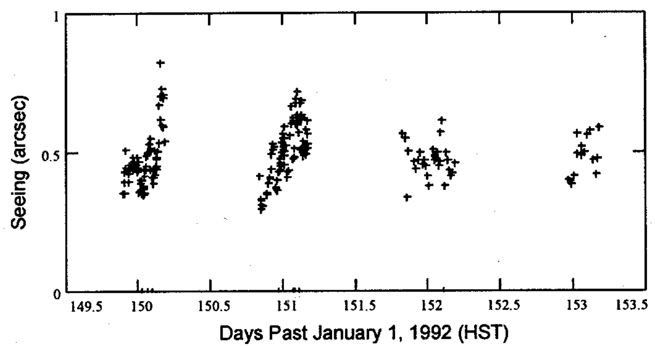


Figure 11. Four consecutive nights of image quality data measured at CFHT with HRCam are shown.

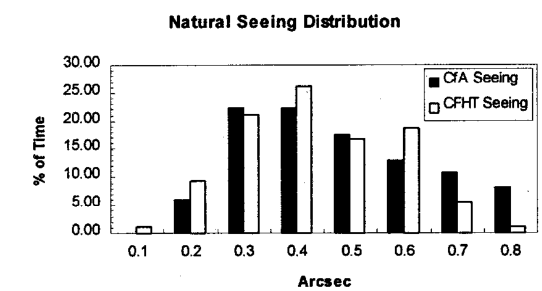


Figure 12. A histogram distribution of seeing at the CfA and the CFHT is shown. Note that although the CfA monitor runs continuously, only night-time measurements are included in this histogram, and the CfA data beyond 0.8" have been clipped to mimic the selection effect evident in the CFHT data (i.e., seeing measurements are only made at night and not made during cloudy conditions).

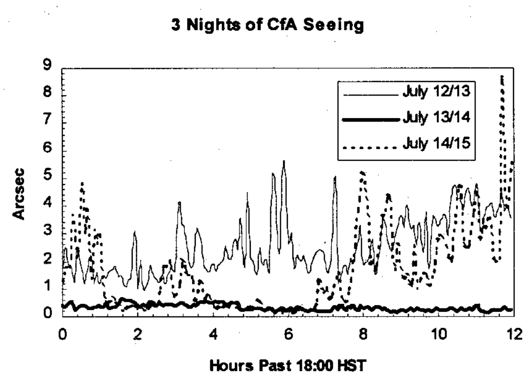


Figure 13. Radio seeing measurements are presented. Note that two of the nights exhibit no changes from dusk to dawn, while the third shows changes on time scales of ~8 hours.

Figure 13 shows a plot of CfA seeing, giving some indication of the possible behavior of optical and IR seeing, over three consecutive nights. Two of the nights exhibit no substantial changes from dusk to dawn, while the third night shows changes on time scales of ~ 8 hours.

Different approaches to observing with the Gemini Telescopes

The data on seeing conditions and H_2O column densities show that for most observations on Gemini, which include those made at Cerro Pachon, the resolution and speed with which we will be able to observe a given object will be intimately linked to the changing properties of the atmosphere. The dynamic range of delivered image quality and infrared background will be far greater than we have previously experienced with conventional ground based telescopes. The variations in integration times on the Gemini Telescopes will be essentially statistical in nature. During a fixed allocation of 2-3 consecutive nights, the probability that an observer will be able to predict the required integration time needed to complete a program to within a factor of 2-10 is small. The probability of utilizing the best conditions with this approach - periods when Gemini will have unchallengeable sensitivities - is vanishingly small.

What is clear is that most effective use of the Gemini telescopes will require that atmospheric conditions be matched to the goals of a specific program. The best method for maximizing the science done on Gemini is to have access to several instruments or modes of observing and couple this versatility with an observing scheme that can adapt to changing conditions. This is at variance with the way most time is allocated on groundbased optical/IR telescopes today. There are two possible ways to try to maximize telescope efficiency. Gemini could require each observing team to arrive at the telescope with a fully structured and responsive program. That is, if the best tenth or twentieth percentile conditions occur, observers will be required to have lists of additional objects that can be done if integration times are 4-5 times faster than anticipated. This raises several problems;

1. Is this additional program of the same scientific merit as the original program? If the observers require the best tenth percentile conditions for their principal program, surely the TAC will require that the back-up

program be of similar merit to allocate any time since the most probable outcome is that the observers will get average conditions.

2. To fully exploit the Gemini telescopes will require a great deal of preparation. As has been described before (Mountain, Gemini Newsletter no. 8), guide stars of adequate brightness and distance from the science object will have to be chosen. The optimum elevations and azimuth tracks will have to be selected to avoid problems with zenith blind spots, cable wraps "over wrapping", wind bounce, lunar scattering and airmass effects. For fully structured and responsive programs observers may require many objects prepared in this way -- a considerable preparation overhead for conditions that may never occur.

3. If an observer or observing team develops and prepares a program that is competitive and responsive to seeing conditions, what happens when the seeing becomes mediocre but the thermal atmospheric emissivity drops below 1%? It is unlikely that an observing team using HROS will have a fully competitive program that can use the 10-20 μm camera under these conditions. In both cases the most likely outcome is that the 10th percentile best conditions will be underutilized.

What becomes apparent is that if we want to fully exploit the unique characteristics of the Gemini telescopes, we may have to explore less traditional ways of allocating observing time. What an observer is really seeking is reliable, competitive data rather than just telescope time.

It is already common to allocate 10% of a semester to service observing, in which pre-planned observations are performed by support astronomers on behalf of proposing astronomers. In the case of UKIRT, this can be quite a responsive program, accepting applications up to 2-3 weeks before the scheduled service run. However, this time is allocated classically, in that it is scheduled in advance into an observing semester. Consequently the probability of a service run getting either the tenth percentile best seeing conditions or 10th percentile best emissivity conditions is $(0.1 \times 0.1) + (0.1 \times 0.1) = 0.02$.

A more radical model is required.

The only pragmatic way to respond to changing atmospheric conditions is find a way of building responsive science programs. One approach is to use an observing queuing system, where several experiments (hence several instruments) are on standby to be switched in as conditions and science objectives demand.

The submillimeter JCMT has already started a few limited experiments with this approach as it has several receivers on continuous standby. The WIYN telescope is considering allocating from the outset a substantial proportion of the available time to queued observations. The WIYN has a fixed instrument complement of an imager and a fiber-fed spectrograph. In a recent simulation using a statistical model of seeing and photometric conditions and three queues (seeing < 0.5 arcseconds, seeing > 0.5 arcseconds and fiber spectroscopy) competing for time, Boroson (1994) found that the real gain was for experiments that required good seeing. In a classical scheduling mode, only 10% of high resolution observations got done while 65% of these observations were carried out in a queued scheme. In addition, since the order of each queue was determined by scientific rank, all the highest ranked programs were executed in the queue-based simulation at the expense of lower ranked programs. In the classical mode, there was no discrimination with scientific rank - both highly ranked and lesser ranked proposals had equal chances of being "weathered out".

Questions concerning queue scheduling include the following:

So what should the mix be between responsive queued observations and classical allocations of fixed duration?

Equally importantly, who should be responsible for executing these programs and how will the proposing astronomer retain ultimate scientific responsibility for their projects ?

Is there a real scientific (as opposed to observational) gain in an allocation model for Gemini based substantially on queued observations?

Will queued observations inhibit experimentation and serendipitous discoveries?

And what is the role of remote observing in this model?

These questions will be at the heart of the debate on operational models for Gemini that will be started at the Gemini Science Committee meeting on 20-21 October. I encourage the Gemini community to debate these issues with their National Science Advisory Committees or contact me directly (mmountain@gemini.edu). I believe we have no alternative - by the 21st Century we must develop different approaches to operating Gemini, if we are to push observational astronomy into the new regimes that have driven this project from its inception.

Some thoughts on the costs of operating Gemini in a queue based mode.

Imagine being on Mauna Kea or Cerro Pachon near the turn of this century when 70% - 80% of the observations are being run by queue scheduling with up to three instruments simultaneously mounted on the telescope. If a fault develops in the 1-5 micron array controller, the astronomer and system operator can take it "off line" and start up the MOS queue or 10 micron camera queue. Once this alternative instrument is "on line", one of the two support staff can try to diagnose what is wrong and log a fault report. Apologies are sent to the remote observers, if connected, and assurances given that they will be called when the problem is fixed -- after all, this program was rated highly and has to be done this semester. Had a fault developed with the AO system, similarly the on-site system operator and astronomer would have the option to switch to an alternative program that did not need AO. Having the freedom to adapt to unpredictable atmospheric conditions means we will also have the freedom to adapt to unpredictable faults.

The following day, the day crew can try (again) to diagnose the fault and determine if it can be properly repaired (a card needs replacing) or requires more specialized help (the observing sequence has unearthed a software bug). Since the telescope has multiple queues, nothing is lost scientifically if the problem takes two to three days to repair -- hence the notorious "quick fix that is never allowed to go away" is no longer a required response.

This should allow the development of a different support model for the Gemini telescopes. The real questions relevant to the costs of queued observing then become:

- If upward of 70% of the telescope time is queued, could we afford to have a less responsive support team in return for guaranteeing that all high priority queued observations will be completed in a given semester?

- Even if we lose the entire telescope for a few days, do we lose anything scientifically if the operations team's principal mission is to complete all the high priority science programs at the expense of the more speculative "look and see" or calibration programs that could be rescheduled the following semester?

- If we have two telescopes which will share identical observing systems, admittedly separated by a continent, are there instances where high priority programs could be transferred to the other telescope (we will have two MOS's, and eventually two 1-5 micron cameras)?

The opportunity queued observations may offer is an escape from the usual frenetic support model, with which many of us are all too familiar, to a more planned and considered approach to getting the best science out of the Gemini telescopes. Nor do we preclude classical observing with this approach since we can now predict with some certainty which telescope time is going to require "frenetic support" and this may only represent 20%-30% of the semester. At the turn of this century, it is likely to be commonplace for teams separated by continents to consult colleagues, discuss problems, and diagnose faults via high bandwidth links. Much of the software on Mauna Kea is already supported and updated remotely. We could consider operating with smaller dedicated support teams and have our "experts" concentrated only at one site rather than requiring two such teams on call at all times. Perhaps adopting a large measure of queued observing on the Gemini Telescopes may lead to a more cost effective operation, and actually return better science to the Gemini partnership.

Acknowledgments

This article is based on a paper being submitted to the Gemini Science Committee, "An Assessment of Optimal

Observing Modes with Gemini" by Mountain, Simons and Boroson. Much of the material in this document is a result of discussions with the Gemini project scientist team and consideration of issues raised at the Gemini System Review. In addition, both Alec Boksenberg (who coined the term "frenetic support model") and Alan Dressler provided useful stimulus and input to this discussion.

-Matt Mountain
International Project Scientist

Systems Engineer's Report

Gemini System Review. Gemini's first System Review was held this past July. A committee was formed consisting of 12 members from partner countries, various universities, observatories, andother telescope projects (ESO, AAT, UKIRT, SOR). The review was chaired by Dr. Robert Gehrz. The primary emphasis was on the software and controls, concentrating upon how we will operate Gemini as a system. The Gemini project scientists also participated in the review, as did various observers in the audience. All provided recommendations and actions for the project to consider (63 in all). We have prepared responses to all recommendations and actions, either directly answering, or outlining our plans for addressing, these suggestions and concerns as the designs progress.

Documentation and Drawing Control. Our documentation and drawing control area and procedures are currently in the process of some changes. A larger "library" area is being organized to allow easier access for on-site personnel to the various released Gemini documents and reference documents. The document log is in the process of some reorganization and is being converted to an Access™ database. All requests for released Gemini Documents should be sent to Ruth Kneale, the Documentation Coordinator.

Gordon Pentland has set up an Access™ drawing database to allow easy tracking of drawings. The first version of this database has been installed on a few PC's in the project office for initial feedback from project personnel. The system allows automatic searching for drawings by number, category, title contents, etc. The latest revision is presented along with release data, contractor responsible for drawing or fabrication, electronic form (AutoCad 12™, etc.), archive data, and various comments. It also can present a "map" of the file storage system to tell the user the file name and where the file is located. Our intent is to provide a similar database for the documents as mentioned above.

Though both of these systems are needed by the project as a tool to aid in tracking and maintaining documents and drawings as a first priority, we will consider how to make such data available to others at some time in the future. At a minimum, we expect to be able to publish listings of available documents on a regular basis. We will continue to list recently produced available documents at the end of each newsletter.

Interfaces. Progress has been made in defining several key interfaces. This includes some changes in previously defined interfaces. The areas which have had recent work include:

- Primary mirror cell-to-telescope structure
  - change in bipod feet location for reduced gravity sag mirror distortions
- Secondary assembly-to-top end mechanical interface
  - preliminary interface defined
- Secondary mirror-to-tip/tilt/focus/chopping mechanism
  - Details defined in support of tip/tilt/focus/chopping RFP
- Primary mirror access (through telescope center section)
  - Larger openings incorporated for initial access into cell through the center section

Interfaces currently in work include:

- Primary mirror-to-coating chamber
- Primary mirror lifting fixture-to:
  - primary mirror
  - coating chamber
  - mirror cell assembly
  - primary mirror support control electronics
- Software and controls interfaces
  - in preparation for a CDR by the controls group

-Jim Oschmann
Systems Engineer

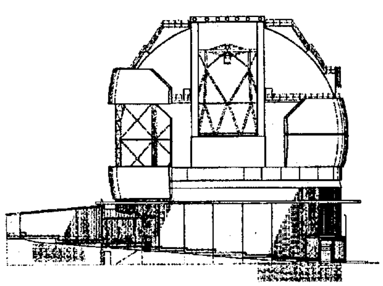
GEMINI GROUP UPDATES

Telescope Structure, Building/Enclosure

Telescope Structure. The design of the main Gemini telescope structure has now been completed. Requests for proposals for the fabrication of the telescope structure were sent to contractors in March 1994. Best and final offers were received on August 25th. The telescope contractor selection process will be completed in October. The telescope azimuth track requests for proposals have also been issued and proposals were received on August 26th. The proposals are currently being evaluated. The telescope bearing specifications have been completed and requests for proposals will be issued soon.

Peter Hatton, who was on secondment from Rutherford Appleton Laboratory (RAL), has now returned to RAL. Peter produced the design drawings of the telescope structure.

Enclosure. Coast Steel has almost completed the design of the enclosure (shown below), and the 80% design review was held on 11th October.



Gemini enclosure

The design of the interfaces between the rotating enclosure and the stationary enclosure base has been completed. This work had to be completed before M3 Engineering could complete their construction documents for the Mauna Kea Support Facility.

Mauna Kea Site Facilities. In October we will start the realignment of the road, relocation of the utilities that currently cross our site, and removal of the 24-inch patrol telescope building.

The Mauna Kea construction documents for the road realignment were submitted to DLNR for final approval (for the Conservation District Use Permit), and also to the County of Hawaii to obtain building permits. We now have both the CDUP and the necessary building permits to start construction on Mauna Kea.

M3 Engineering have completed the construction documents for the Mauna Kea Support Facility. This work will be sent out for bid in September to allow the main construction contract to start at the beginning of the 1995 construction season.

Cerro Pachon Site Facilities. Paul Gillett, the Gemini project site engineer for Chile, relocated from Tucson to Chile with his family in early July. He is now working closely with Enrique Figueroa at CTIO on the Gemini construction program. M3 Engineering started the construction documents for the Cerro Pachon support facility at the beginning of August, working closely with a Chilean architect to ensure that we produce a cost effective design.

Road construction from the Cerro Tololo road to Cerro Pachon started in July and is scheduled to continue through 1994 and 1995. Construction of the commercial power line started in July and will be completed by the end of 1994. Construction of a maintenance road leading from the summit of Cerro Pachon to the water well location has been completed. Excavation of the mountain to the final level of 2715m has been completed. Construction was delayed a few weeks due to snow storms and heavy equipment failures. The final geotechnical borings, being performed by EDIC, have just started.

Coating Plant. Royal Observatories installed a test magnetron in the 4.2m William Herschel Telescope

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coating chamber and have nearly completed the sputtering test program. The test results are encouraging, with emissivities of 2.1% achieved for aluminum coatings. The test program was interrupted by a forest fire that swept up the north side of the mountain and through the Observatory site, necessitating an evacuation of the site.

Protected Silver Coating for the Primary Mirror. Optical Data Associated (ODA) have submitted their third quarterly report on the development and testing of protected silver coatings for the primary mirror. One of ODA's main subcontractors, Airco Coating Technologies, have completed their coating optimization runs of the silicon nitride overcoated silver. The results indicate that silicon nitride protected silver can be deposited by sputtering with an emissivity of 0.8%. Many parameters were varied to optimize the performance of the coating, including the thicknesses of the adhesor, silver, and protective overcoat layers. Results of the hafnia protected silver coatings being developed by Deposition Science, Inc., also under subcontract from ODA, are equally encouraging. Environmental durability, abrasion resistance and adhesion tests are now being performed.

-Keith Raybould
Telescope Structure, Building/Enclosure Manager

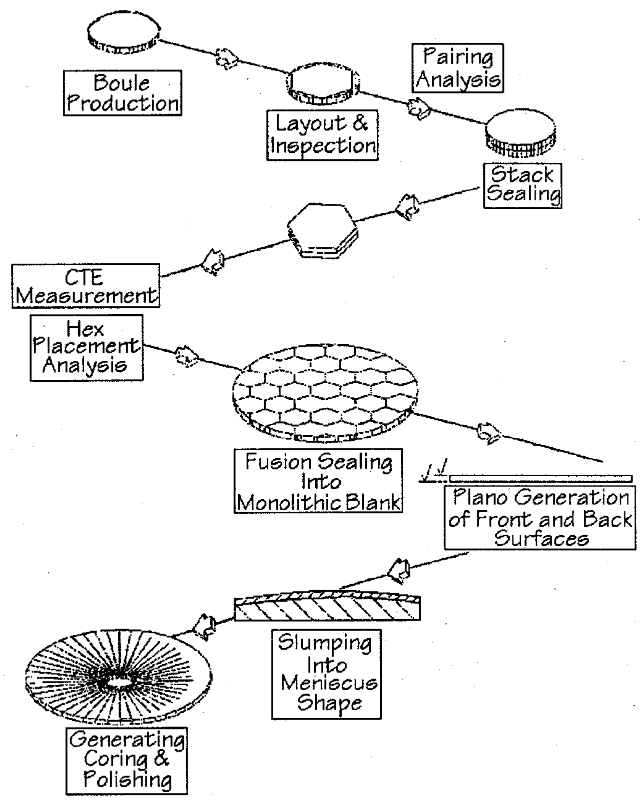

Figure 14. Corning blank fabrication process.

Optics

Primary mirror blanks. Corning, Inc. is on schedule in production of the two Gemini primary mirror blanks. The fabrication stages for the mirror blanks are summarized in Figure 14. All 84 boules of zero-expansion ULE™ glass required for the first mirror blank were created using a proprietary flame- hydrolysis process, inspected, machined, sealed into stacks of the correct thickness, machined into hexagonal blocks, and fused into a monolithic mirror blank. The precise location of each hex in the blank was determined by a detailed analysis and optimization process performed by Myung Cho of the Optics Group, and confirmed by Corning engineers. This optimization will ensure that the locations of the individual hexes in the mirror blank will minimize thermal distortion caused by use of the mirror at temperatures approximately 25°C colder than the optics shop where it is polished and tested. The predicted deformation of the mirror, after active optics correction, is less than 10 nm. The remaining production stages for the first mirror blank are plano generation, slumping over a curved form, and final generation to net shape.

Fabrication of the glass for the second mirror blank is ahead of schedule; 80% of the boules have been produced and have passed inspection. Almost half of the stacks for the second blank have been sealed, and several have now been cut into hexagonal shape.

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The Gemini blanks were preceded in this process by the 8.3-meter primary mirror for the Subaru Project, which has now been delivered to the Japanese by Corning. This blank recently was featured on national news reports in the USA when it was transported by interstate highway to the polishing facility in Pennsylvania.

Primary Mirror Polishing. REOSC Optique is making preparations to polish the Gemini 8-meter primary mirrors. They have developed modifications to their existing 8-meter polishing, testing, and handling equipment to accommodate the Gemini mirrors. They have also completed the design of the shipping container that will be used to transport the mirror blanks from the Corning plant in Canton, New York to the REOSC polishing facility in Saint Pierre du Perray, outside Paris.

The REOSC contract provided a number of options for the metrology mount that will be used to support the mirror during optical testing. Earlier this year, Optics Group staff analyzed the available metrology mount options, with particular attention paid to the avoidance of print-through bumps on the mirror surface above each support point. The configuration selected is somewhat simpler than the concept originally proposed by the project, while still meeting the goal that the metrology mount match the mirror support used in the telescope. Agreement has been reached with REOSC, and the appropriate contract options were exercised in June.

Secondary Mirrors. A number of proposals have been received in response to the RFP for design and fabrication of the secondary mirror tilt systems. We are currently in the process of evaluating these proposals and expect to award a contract by about the first of next year.

A notice has been posted in the Commerce Business Daily announcing the opportunity for firms to express interest in the upcoming request for proposals for fabricating and polishing the secondary mirrors.

Other Optics Group Activities. Ron Price and Dale Circle have developed a preliminary design for the primary mirror lifting fixture, based in large part on the design developed by REOSC for lifting the VLT mirrors.

Eric Hansen has written an optical design summary for the f/16 telescope optics that describes the nominal optical design, its performance over either a curved or flat field of view, the effects of misalignments on the system, and the results of a number of other optical studies related to the Gemini system design. This document is Gemini Report number RPT-O-G0047 and is available on request.

-Larry Stepp
Optics Manager

Controls

The Controls Group has been focused on the following areas since the last newsletter:

- Cleaning up action items from the preliminary design review of the Software Design Description (SDD)
- Participating in the Gemini Systems Review No. 1
- Preparing for the critical design review of the SDD
- Managing and monitoring several work packages
  - standard control system
  - telescope design study
- Preparing to start several work packages:
  - primary support work package
  - mount control work package
- Continuing the servo simulation of the telescope
- Continuing work on EPICS

-R. McGonegal

Preliminary Design Review. The Software Design Description passed its Preliminary Design Review on April 28-29, 1994, and its Critical Design Review took place September 22-23, 1994. The comments that the Preliminary Design Review committee made have all been incorporated. A report has been issued for comment to the review members and is available on request (*sysrick@gemini.edu*).

The major efforts as a result of the PDR were to:

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- Redo the interface between the principal systems
- Emphasize the interfaces between the principal systems
- Continue with more detailed observing scenarios

- R.McGonegal

Gemini Systems Review. The Controls Group played a large part of the first systems review, as the operational concept was a major area of review. In all, the Controls Group made 11 presentations over the three days.

Our vision for the operational concept is as follows:

Provide a versatile observing system that is well matched to the scientific goals of the Gemini user community and that allows, but does not require, that community to fully exploit the potential of both Gemini sites.

We will be working on discharging the action items from this review over the next month.

- R.McGonegal

EPICS. Kim Gillies and Steven Beard attended an EPICS course at the Joint Astronomy Centre, Hilo, Hawaii, during the first week in June. As a result they now better understand the EPICS jargon and appreciate how the system works. The most important thing Kim and Steven learned in that course was that EPICS is configurable. If the existing records cannot be easily used to solve a particular problem, new records can be designed to do the job. Kim has designed Command Input/Output (CIO) and Status/Information (SIR) records to handle the execution of commands and the processing of alarm and status information within an EPICS system. Steven has introduced a new Public Logging Record (PLR) to deal with asynchronous logging events.

-S.Beard, K.Gillies

Software Design Description. The Software Design Description has come a long way since the PDR. The interactions between the Observatory Control System, Telescope Control System, and Data Handling System are now defined explicitly in a collection of Interface Control Documents. The document now includes more walkthroughs of the Gemini Reference Scenarios, and greater depth in the descriptions of the various subsystems.

We are grateful to the ALICE, Michelle, and SCUBA groups at ROE, the Arcon group at CTIO, the DRAMA group at the AAO, our friends at the UK Starlink project, and the data handling groups at CFHT, DAO, JCMT, NOAO, CTIO, UKIRT and WHT who have all replied to our requests for advice, and whose suggestions have found their way into the Data Handling and Instrument Control chapters of the Software Design Description.

The SDD is available via the Gemini gopher server:

gemini.tuc.noao.edu

and through anonymous FTP:

gemini.tuc.noao.edu:~ftp/gemini/SDD

which is a directory containing several different packages for the document. See the Read.Me file in the same directory for details. Be forewarned that the SDD has not grown any smaller. It is best printed out on a duplex (double-sided) printer of reasonably high-speed, or else printed during off-hours .

-S.Wampler

Operational Concept Definition. The operational concept definition (OCD) has been modified to reflect advance in the design of the system. As with the SDD, the OCD is available both through the Gemini gopher server and via anonymous ftp, from the above sources.

-S.Wampler

ESO VLT Software and Gemini. Steve Wampler spent a week during July in Garching, Germany, meeting with the ESO VLT software design team. In addition to giving several presentations on the philosophies and design decisions of the Gemini software, Steve spent a great deal of time talking with ESO staff about their software design issues and solutions, on matters ranging from GUI development to data reduction.

The VLT design shares a number of common characteristics with the Gemini software design - both are

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database driven, distributed systems relying heavily on Unix for top-level control. The VLT uses the commercial system RTAP as a foundation for real-time control, while Gemini has adopted the functionally similar EPICS system.

Both teams expect to make heavy use of the Tcl/Tk language for GUI development, and the VLT team has developed a 'panel editor' for building control screens. The Gemini Controls Group is currently examining this editor for use in the Gemini project.. It is reassuring to see so much similarity in the software designs between the VLT and Gemini projects.

- S.Wampler

Outside Work on Tip/Tilt Systems and Wind Shake. The Controls Group has worked with a number of outside projects including WIYN, CTIO, and UKIRT. By gaining familiarity with the problems facing similar telescopes, we hope to work proactively to avert and minimize problems with Gemini.

- M.Burns

Non-Linear servo simulation. The nonlinear servo control simulation is being prepared for transfer to RGO for use on the mount control work package. This simulation models the interaction of the telescope structure with the servo motors and provides an estimate of image smear due to the various error sources. Among the error sources modeled are bearing friction, angular encoder quantization, D/A conversion errors, CCD centroiding noise, motor torque variation, drive eccentricity, and tachometer errors.

- M.Burns

WORK PACKAGES IN PROGRESS

Standard Control System. The Gemini Standard Controller Work Package passed its PDR, which took place at RGO Cambridge on 28 June 1994. Since the work scope covers a number of independent software deliverables that, due to the use of the EPICS toolkit, are amenable to rapid development and prototyping, it was decided to replace a single Critical Design Review with a series of reviews, each directed at a subset of the work package products. The next review is scheduled for the week of 26 September 1994 at RGO.

Two of the original components of this work package, the updated Stepper Motor Controller record and the DC Servo Controller record, have been dropped after realizing that other sites within the EPICS community are currently developing exactly what Gemini requires.

The first two items to become available to other Gemini Project control system and instrument developers will be the hardware and software installation documents which will define the Gemini standard for EPICS-based applications.

- A.Johnson, RGO

Telescope Control System Design Study. The commands and parameters that will pass between the TCS and each of its subsystems are still being refined. We are currently working through each of the latest SDD chapters identifying areas of uncertainty and drawing up lists of commands and parameters. This interface is baselined to be implemented using EPICS channel access. These interfaces will be input into the TCS Subsystem Interface Control Document. At present we are trying to come up with a viable scheme for implementing the MOVE/STOP /FOLLOW/STOP_FOLLOWING commands which are common to several of the TCS subsystems. An initial state transition diagram has been generated for the states the TCS will pass through in response to the high level OCS sequence commands. A list of low level commands and their parameters has also been generated which correspond to mini-configurations. At present only very rough data flows exist as presented at the System review. These will need refining once the major systems interfaces and subsystem interfaces are clarified.

- C.Mayer, RGO

Work on the TCS in terms of the optics controls and interactions, TCS functions, open-loop control, closed-loop control, and the TCS interfaces and subsystem functions has been underway for several months now. A draft of this work was presented at the July Systems Review.

- R.Laing, RGO

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A large group of observing scenarios has been produced and these are currently being used as the basis for walkthroughs being done by the design group in Tucson.

Work is progressing on the geometry and limits of the telescope and various wraps. These limits are due to the maximum velocities and accelerations within which the telescope meets its imaging requirements. The baseline approach will be to warn the observer, for instance, that the current observation is approaching the 0.5 degree radius area around the zenith where the telescope exceeds its 0.5 deg/sec limit - but we will not prevent the observation from continuing.

- P. Wallace, DRAL

Gemini Simulink Model Verification. A very comprehensive mathematical model of the proposed Gemini telescope has been built by Mike Burns of the *Gemini project. The main purpose of the model* verification work package was to evaluate this model and verify its resemblance to reality.

With no actual hardware yet built, the problem was knowing what to verify the model against. The mechanics of the model are based upon transformations from a finite element analysis model to state-space models. If any discrepancy occurs, it is likely to be with these transformations. It was therefore proposed to build a separate, much simpler, model using the more conventional method of inertias coupled by compliance. This model was not as accurate as the main model as it did not take into account non-free axis movement and did not model as many structural modes. However, the simpler model acted as a yardstick to determine the realism of the main model.

The work was divided into three sections :

- The main model was dissected into the main axes (i.e. altitude drive, azimuth drive, Cassegrain rotator and tip-tilt secondary mirror).
- A yardstick model was constructed for each of the main axes (i.e. altitude drive and azimuth drive). The Cassegrain rotator and secondary mirror sections of the main model were not based on FEA transformations, so constructing a yardstick model of these sections would have been pointless.
- The yardstick models were compared with dissected bits of the main model.

This work is now almost complete, and the overall conclusion is that the match between the models is good. There were a few small discrepancies but these have now been resolved or explained. The work is now being documented and will eventually be part of the Simulation Report.

- J Wilkes, RGO

WORK PACKAGES IN PREPARATION

Mount Control System. Work package development has started for the Mount Control System. The chapter in the Software Design Description has been extensively updated to reflect the current state of the mount design. The work breakdown structure, schedul,e and cost were due at the beginning of September 1994.

- John Wilkes, RGO

Primary Support Control System. Preliminary work has begun on the Primary Mirror Support Control System. The work package definition is now almost complete. This describes the system requirements and includes budget and schedule estimates. The general design of the primary mirror active optics system has been defined. We plan a total of 30 local control units located within the mirror cell that are each responsible for a set of axial (usually 5) or lateral supports. Each local control unit consists of a processor, a number of I/O modules, an analog servo module, jocumatic valves, and the necessary power supplies and cooling systems. Communication between these units and the Primary Mirror Control EPICS system will be accomplished either via Profilbus or (following UKIRT and the Instituto de Astrofisica de Canarias) *CANbus. A review of this work package was held during* the week of 26 September 1994 at RGO.

- J.Maclean, RGO

Core Science Instrument Controller. Steven Beard returned to the Royal Observatory Edinburgh in October 1994 after spending 6 months in Tucson working on the

GEMINI GROUP UPDATES

Software Design Description with Kim Gillies and Steve Wampler. Steven has made major contributions to the overall design and has worked in detail in the areas of Data Handling and Instrument Control.

The project is in the process of defining a work scope that will involve Steven in the development of a core science instrument controller package. This package would provide all of the instrument groups with a skeleton system upon which they could build. We also plan to involve Steven in the definition stages of the Data Handling System and the Observatory Control System.

-R.McGonegal

EPICS CONSORTIUM

EPICS Training in UK. About 15 participants, mostly associated with Gemini, attended a three day course in EPICS held in May at RGO with two instructors from Los Alamos. The course was designed for applications developers and covered the real-time database, the operator interface, the sequencer and design of systems using schematic capture. The use of a schematic capture system, common in electronics design, was perceived as important in developing a properly understood and maintainable system.

-M.Stewart

Astronomical Sites. EPICS-based development is now under way at several other astronomical observatories, in particular UKIRT and WHT. At the UKIRT, EPICS is being used for their upgrades program for control of new instruments, specifically WYFFOS, at the WHT. Discussions concerning the use of EPICS as part of the Keck II control system was one of the topics at the Keck II Software Meeting, which was held in Waimea, 7-9 September 1994.

-P.McGehee

Consortium Meeting. An EPICS consortium meeting was held the week of 19 September 1994 at the Lawrence Berkeley Laboratory in Berkeley, California. This is part of a series of meetings held quarterly at the major EPICS development sites. Representatives from the Gemini Project Office, the Keck Observatories, and Royal Observatory Edinburgh were in attendance.

Of particular interest to Gemini were the discussions concerning the updating and enhancement of the Stepper Motor Controller record being done by the Advanced Photon Source's Controls Group and the design requirements of the DC Servo Controller system, which is a collaboration between Argonne's Structural Biology Center and the Gemini Controls Group. Both of these products had originally been part of the Standard Controller Work Package.

- P.McGehee

Work Package Management. In the United Kingdom Martin Fisher has taken over as Work Package Manager for the Mount Control System and the Primary Support Control System. Malcolm Stewart will continue as Work Package Manager for the Telescope Control System, Standard Control System, Secondary Control System, and Communications System. Now that these packages are close to starting it was felt that having someone at each site as overall work package manager was appropriate.

-M.Stewart

-Rick McGonegal
Controls Manager

Instrumentation

Instrument Rotator and Support Structure (Cassegrain Cluster). The PDR for the Cassegrain Cluster was held on June 15th in Tucson. The committee was comprised of Dan Blanco, WIYN (chair), Donald Pettie, Royal Observatory Edinburgh, Peter Gray, Steward Observatory, and Martin Fisher, Royal Greenwich Observatory. At the PDR, David Montgomery and Susan Wieland presented the work they had been doing in this area over the previous two years. In general the work was well received. There were a number of questions and

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points raised at the PDR, which David and Susan are at present addressing, but overall the committee felt that the present design met the scientific and performance requirements and should continue on through the critical design phase. David and Susan are to be congratulated on their fine efforts.

Now that we are in the critical design phase for this activity the workload has increased beyond the resources available within the Instrumentation Group. We have been negotiating collaboration with NOAO to complete the two systems through to commissioning and have identified the resources we require to achieve this. Consequently, we have engaged the services of a mechanical designer to assist with the mechanical design (at present he is developing the design of the cable wrap); and an electronics engineer to work on the analysis and design of the rotator control system. One more mechanical designer/engineer is required in order for us to work towards the CDR currently scheduled for June 1995.

Acquisition and Guiding. Work continues in the UK on the A&G systems for the two telescopes. Because the team has been built up over the last few months, I thought that it would be useful to introduce some of the main members of the design team. As the system is fairly modular, it has been possible to devide the work among various sub-groups within the UK Observatories. The peripheral wavefront sensor and AO fold mirror (module 1) is primarily being designed at RGO. Richard Bingham has been working on the optical design of the probes, Neil Shallcross on the mechanical design, and Nick Dillon on the detector, controller and processor requirements. The science fold mirror (module 2) is also being designed at RGO with Sue Worswick working on the optical design and Neil on the mechanical design. The third module, which houses the calibration wavefront sensor and the acquisition camera, is being worked on at ROE by Eli Atad and Colin Humphries. John Harris, ROE, has been looking into the design of a facility calibration unit, an activity that is turning out to be quite a challenge. Overall mechanical design responsibility lies with Simon Craig, who has recently joined the project from the Joint Astronomy Center in Hawaii. Simon will be based at RGO. Malcolm Stewart, ROE, has responsibility for the software system design and Charles Jenkins is the Work Package Scientist with overall responsibility for ensuring that the system meets the scientific requirements. David Gellatly is the Work Package Manager with responsibility for managing the activity.

The A&G system has its PDR on November 10-11, and the Tucson Project office will be working closely with the UK design team over the next couple of months to ensure a smooth passage through to the critical design phase.

Adaptive Optics. See the report from the Canadian Gemini Project Office.

INSTRUMENTATION

Since the approval of the Instrumentation Plan at the last Gemini Board meeting in May, things have been heating up on the instrumentation front.

Near IR Imager. A contract has been placed with the University of Hawaii for a conceptual design study of the near IR imager. There will be a meeting of the IR Instrumentation Science Working Group in Tucson on 22-23 September where we will have an opportunity to make an assessment of the current status of this activity. The Conceptual Design Review is scheduled for mid-November, but as things presently stand this also is likely to be postponed till a later date.

Near IR Spectrograph. An announcement of opportunity for the Near IR Spectrograph was released by the US Gemini Project Office to the US community in May. A request for proposals was prepared jointly by the IGPO and the USGPO and released on August 8th. Proposals are due by October 21st. The NSF have set up an independent Evaluation Committee to assess the proposals. After selection and negotiation, the contract is expected to be signed late this year, and the work is scheduled to start in early 1995.

Multi-Object Spectrograph. At its May meeting, the Gemini Board approved a collaborative venture between the UK and Canada to develop two identical MOS instruments for the Northern and Southern Gemini Telescopes. There has been much debate in all the Gemini

GEMINI GROUP UPDATES

communities as to what the science specification for this instrument should be. The UK and Canada have taken the lead in defining the requirements, and the results of those studies were presented to the Optical Instrumentation Science Working Group meeting which took place in Tucson on 28-29 September. The recommendations from the OSWG will be presented at the October meeting of the Gemini Science Committee for endorsement. A management plan for the collaboration has been jointly developed by the UKGPO, the CGPO, and the IGPO. Work on the conceptual design for MOS is scheduled to start in early 1995. The Canadian contribution to the collaboration will come mainly from the Dominion Astrophysical Observatory with the UK's contribution coming jointly from the Royal Observatories and the University of Durham. The Royal Observatories will supply the work package manager and technical expertise, and the University of Durham will supply the UK science input and the instrument science team.

CFHT Fiber Feed. As a means of providing a high 'esolution optical capability at the northern telescope, the project is investigating the feasibility of running a fiber feed from the Cassegrain focus to a coudè spectrograph at the CFHT. For this capability to be competitive with what already can be achieved on 4-meter telescopes, the transmission through the fiber must be good. Because the distance from Gemini to the CFHT is approximately 300 meters, the National Optics Institute in Quebec is at present undertaking a study of fiber transmission vs. fiber length for 2 sets of hydrogen-doped fibers, as well as looking at the feasibility of packaging the fiber bundles to support an integral field mode. Initial results on the transmission tests will be available for the OSWG meeting, and a full report is due later in the year.

-David Robertson
Instrumentation Manager

Reports from the National Project Offices

From the US Project Office

STATUS REPORT ON INSTRUMENTATION ALLOCATED TO THE US

Following the Gemini Board meeting in May, at which the Gemini instrumentation allocations were approved, the US Gemini Project Office accelerated its efforts to provide instrumentation to the Project. The status of these instrument programs follows.

Near-Infrared Spectrograph. The US Gemini Project Office was charged by the National Science Foundation (NSF) to plan and conduct the process to determine who would build the Gemini Near-Infrared Spectrograph. Interest in building this instrument was shown by university and industry groups as well as by the National Optical Astronomy Observatories (NOAO). Several concepts were considered in determining an effective way to draw upon the talents within the United States for providing the most capable instrument possible given the cost constraints. It was concluded that an open competition had the most appeal within the astronomical community. An announcement of opportunity was widely distributed within the industrial and astronomical communities in late May to alert all potentially interested groups of the upcoming request for proposals. The request for proposals was issued in early August and proposals are due in October. As encouragement to bidders to augment the specified $2.2 million price ceiling, the US will allocate twenty nights of US observing time to the successful bidder. An independent committee, appointed and directed by the NSF, will evaluate all proposals and provide a recommendation to the project.

Mid-Infrared Imager. We anticipate that the builder of this instrument will also be chosen through a competitive process. An announcement of opportunity will likely be issued in early 1995.

Near-Infrared Imager. The University of Hawaii will receive the contract for the design and fabrication of this instrument, and at present is just embarking on the initial design study.

IR Arrays and Controllers. It has been deemed appropriate to delay the initiation of the procurement in order to factor in the requirements of the groups building the instruments in which these detectors and controllers would be used. Thus, procurement of the IR arrays and controllers will be started in mid-1995.

Optical Detectors. The optical detectors were directed by the Gemini Board to an international consortium to be organized by the US Gemini Project Office. This consortium was encouraged to involve the international communities in procurement of CCDs through collaborative foundry runs. This effort has been started by forming the consortium, assembling a list of specifications for the large CCDs, and circulating a request for information to CCD vendors.

The consortium includes the following members:

- Todd Boroson (USGPO)
- Jim Beletic (Georgia Tech)
- Kem Cook (Lawrence Livermore)
- John Geary (Harvard Smithsonian Astrophysical Observatory)
- Paul Jorden (Royal Greenwich Observatory, UK)
- Michael Lesser (University of Arizona)
- Gerry Luppino (University of Hawaii)
- Rick Murowinski (Dominion Astrophysical Observatory, Canada)
- Chris Stubbs (University of Washington).

Based on the report of the Optical Imager Working Group and discussions with the International Gemini Project Office, a list of specifications have been drawn up for 2048 X 4096 3-side-buttable CCDs with 15 micron pixels. These arrays will be combined in pairs to provide the focal plane detectors for the three Gemini optical spectrographs. These specifications have been distributed to a number of potential vendors for these devices with a request for information about their capabilities and interest

Reports from the National Project Offices

in working with the consortium to produce such devices. Responses are expected in mid-September.

-Todd Boroson
- Kathy Wood
US Gemini Project Office

GEMINI MODEL

Fred Gillett, Kathy Wood and Todd Boroson are seen in the photo below with the just-delivered model of the Gemini telescope facility. The model, purchased by the US Project Office, is a detailed 1/50th scale depiction of the 8-meter telescope, enclosure, and support facility as it will appear on Mauna Kea. Bob Rice of Tucson spent a year constructing the model, and its identical twin for the UK, with support from Larry Daggert and the Gemini design team. Bob often found himself ahead of (and occasionally driving?) the final design. Look for the model at the Gemini ground-breaking ceremonies, the American Astronomical Society January meeting in Tucson, and at the many Project reviews.

Reports from the National Project Offices

From the Canadian Project Office

The Gemini Adaptive Optics System (GAOS) is a Canadian Workpackage intended to enhance the superb imaging of the Gemini site, telescope, optics, and enclosure.

The Adaptive Optics System is largely contained in the Adaptive Optics module on a side port of the Instrument Support Structure (ISS). The AO module receives the raw telescope beam from a 3 arcminute diameter fold mirror near the top of the ISS and, after improving the image quality, returns it to the central fold mirror in the ISS, which directs the beam to any other instrument port. The goal is to have transparent and user friendly operation. Thus, unlike other adaptive optics systems which magnify, the GAOS preserves the f/16 focal ratio and produces an image at the standard Gemini instrument focal plane location 300 mm outside an ISS face.

The AO module contains a tip/tilt mirror with a higher mechanical bandwidth than the telescope secondary mirror, and a deformable mirror (DM) on an optical trombone. This trombone can move the conjugate height of the deformable mirror from the ground up to the effective height of turbulence without changing optical path length or alignment. By placing the DM conjugate to the optimum height, which Workpackage Scientist, Rene Racine (U. de Montreal) has shown has a median value of 6.5 km, the diameter of the isoplanatic patch should increase by a median value of 1.9 times and occasionally by as much as 15 times compared with conventional AO systems with the DM conjugate to the ground.

The AO module also has provision for a deployable Atmospheric Dispersion Compensator (AtmDC) in case a facility AtmDC is not installed or of sufficient quality to meet the GAOS image specifications. There are also deployable calibration sources for diagnostics of the AO system (not science instruments) and a deployable beam splitter for a facility wavefront sensor for visitor instruments.

Most often, the Phase I natural guide star GAOS will operate from an on-instrument wavefront sensor (WFS), which is in the best position to measure image aberrations because it is nearly on-axis and as close as practical to the focal plane, which minimizes differential flexure and focus drift. Furthermore, since there is no universal guide star pickoff scheme which is compatible with every instrument and science observation, the pickoff will be specific to each instrument and tailored to the science. For example, infrared instruments would probably use a cooled dichroic in a collimated beam inside the dewar and feed visible light back out a window to the WFS. But visible light instruments would more likely use a small guide probe mirror to select a reference star. The pickoff will be designed and built by instrument makers using interface specifications we develop, but the WFS itself is part of the GAOS workpackage.

The basic WFS unit accepts an f/16 visible light beam. IR instruments require an adapter to reimage the collimated light and an Atmospheric Refraction Compensator in the WFS path only, since the guide star sensing and scientific observing are at widely different wavelengths.

The control system concept is based on the standard Gemini Instrument Controller, which is a VME crate running EPICS on VxWorks, probably augmented with additional boards for interfacing WFS and DM's and calculating closed loop corrections rapidly. The plan is to have modal correction of adjustable order so that, depending on the scientific observation, seeing, guide star brightness and location, the system may trade image quality at the guide star against overall size of the isoplanatic patch.

While the initial implementation will be a natural guide star Adaptive Optics System at the Northern Site alone, every effort is being made to accommodate a future upgrade to a laser guide star system without having to replace the GAOS. For example, the facility WFS inside the AO module may be placed conjugate to either stars or a 90 km sodium layer beacon. A clear laser feed path has

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been designed into the telescope structure and enclosure to allow generating a beacon in the support facility and launching it from behind the secondary mirror. The optical trombone has the capability of holding dual deformable mirrors. Finally, there are provisions in the AO control system for extra computation of higher order corrections.

-Glen Herriot
GAOS Workpackage Manager

The Gemini International Project on the World-Wide-Web

As some readers may know by now, the Gemini Project has a World-Wide-Web (WWW) home page available to the public. The WWW is a constantly-increasing, ever-changing source of information, and most Web documents are written in HyperText Manipulation Language (HTML). These 'hyperdocuments' can have embedded hyperlinks to any combination of other documents, from text to images, sound, and movies.

The WWW can be accessed by many different Web programs; two of the more popular are NCSA Mosaic and EINet's WinWeb application. NCSA applications are available via anonymous FTP to *ftp.ncsa.uiuc.edu* in /Mosaic: Mosaic for the X Windows system is in /Unix; MacMosaic is in /Mac, and WinMosaic is in /Windows. EINet's WinWeb is available via anonymous ftp to *ftp.einet.net*, in /einet/pc/winweb. There are also many other Web-walking programs available, such as Lynx from the University of Kansas (available via anonymous ftp to *ftp2.cc.ukans.edu*, in /pub/lynx).

If you are just starting to explore the Web, a suggestion would be to start at the World-Wide-Web Home Page, located at CERN (the originators of the WWW). Open a Universal Resource Locator (URL) to http://info.cern.ch. This will give you a good overview. To access the Gemini home page, open a URL to http://www.gemini.edu. At that point, several highlighted entries (usually blue, and sometimes underlined, depending on the program you are using) are available to connect to other parts of the hyperdocument - just follow the hyperlinks.

There are sections in the home page for each of the International Project Groups, for recent announcements and milestones for the project, and many other areas of interest.

If you have any comments, suggestions, or corrections to the Gemini Home Page (for example, new URL information) please contact me at *rkneale@gemini.edu*.

-Ruth A. Kneale

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The following technical documents have been published by the Gemini Project since the last edition of the Gemini Newsletter (June 1994). Copies of these and other publications are available on request by contacting the Gemini Project at the above address, Fax number, or by E-mail (rkneale@gemini.edu), attention: Ruth Kneale, Documentation Coordinator. Specific report numbers are listed following the author(s) name in parenthesis.

Theoretical Active Optics Performance of the Gemini 8m Primary Mirror, Revision 1. M. Cho and R. Price, November 1993. (RPT-O-G0032)

Preliminary Design for the Cassegrain Assembly. S. Wieland, June 1994. (RPT-I-G0044)

f/16 IR Secondary Structural Analysis Results. E. Hansen, June 1994. (RPT-O-G0046)

Optical Design Summary. E. Hansen, July 1994. (RPT-O-G0047)

Gemini System Review No. 1 Presentations. July 1994. (REV-S-G0009) A limited number of copies are available. WARNING: The document is over 500 pages.

As a reminder, effective May 23, 1994, the Internet address for all Gemini Project personnel became:

name@gemini.edu.

E-mail addressed as (name@noao.edu) will still reach the project.