GEMINI PROJECT
NEWSLETTER

THE GEMINI 8-METER TELESCOPES PROJECT works in conjunction with the Association of Universities for Research in Astronomy under a cooperative agreement with the National Science Foundation.

May 1992 / Number 2

AURA NEWS

Acting Project Director Named

Sidney Wolff has been named Acting Gemini Project Director until December 31, 1992, and during this time she will take leave from her position as Director of NOAO. The Interim Gemini Board approved her appointment at its May 1-2 meeting. **Richard Green** of the Kitt Peak staff will serve as Acting Director of NOAO.

Project Scientist Search Continues

A search committee is working to recruit a permanent Gemini (international) project scientist. In the meantime, **Pat Osmer** continues as the Acting Project Scientist. Each country has its own project scientist to work with Pat. They are: **Roger Davies** for the United Kingdom, **Gordon Walker** for Canada, and **Richard Green** for the United States.

- Goetz Oertel
President, AURA
- Lorraine Reams
Director of Corporate Relations

PERSPECTIVE OF THE PROJECT MANAGER

The Project has now recruited most of the staff needed for the many tasks that must be tightly coordinated at the initial definition stages of a project. In fact, the staff is now at the highest level planned for any period during the project. Our partner countries in this enterprise are organizing their project offices in preparation for the large amount of work that they will be asked to do, and the full meaning of "international collaboration" will soon be experienced by those who have felt they have not yet been a part of the project.

The science requirements, while not in final form, are guiding the concepts being developed by the staff, and baseline designs are being used to define the project. The next six months will see a majority of the tasks that make up the project defined in their final form. After that, designs will be frozen, and the engineering being done by the project, our partners and contractors will then be directed toward the requirements of the specific designs we have chosen.

The cost estimates and the schedule, which use as a baseline the engineering concepts now being developed, will be modified as more detailed estimates of the tasks to be accomplished are known and manufacturers can be asked to quote on cost. The development of the current cost estimates will go on into the fall of the year. The project will work with the scientists in order to make the appropriate budget tradeoffs and to optimize the telescopes we build. The schedule will be constrained by how fast detail design and fabrication work can be accomplished and will also depend on the profile of the funding available to pay the bills. We plan to have all of the pieces in place before the end of the year so we will have a firm plan for what we are building, how much it will cost, and when it will be completed.

- L.K. Randall
Project Manager

GEMINI

GEMINI SCIENCE COMMITTEE MEETING

Patrick S. Osmer
Interim Project Scientist

The Gemini Science Committee met March 14-15, 1992 at the Cosener's House, Abingdon, U.K. As reported in more detail elsewhere in this newsletter, the committee heard status reports from the Optics Working Group and the Telescope Working Group; reports on the case for UV science, results of APART calculations and direct measures of telescope and mirror emissivities, and measures of the sky emissivity at Mauna Kea were also presented.

Main topics of discussion were: 1) the new, lightweight telescope concept; 2) plans for instrument procurement; and 3) selection of instruments for the Gemini telescopes.

Telescope Concept

The committee commended Keith Raybould and the Telescope Group for their rapid development and description of the lightweight concept, which is described in a separate article. The reduction in total mass and particularly in the mass above the primary mirror offered by the new concept are striking. The committee agreed that the concept should be pursued and requested additional information or effort on the following points:

1. Additional thermal modeling to understand the effects on seeing caused by the telescope structure.
2. The expected pointing and tracking performance of the new concept and its resistance to wind buffeting.
3. The impact on the performance of a high resolution optical spectrometer if it had to be mounted at Cassegrain.
4. The feasibility of introducing a Nasmyth focus with a 1 arcmin field for science observations.

The committee also recognized that issues of flexibility and versatility for the mounting and selection of instruments at the Cassegrain focus need to be investigated, as do the operational consequences of the new concept.

Subsequent to the meeting, the Telescope Group has produced a design that provides for a four-mirror Nasmyth configuration, in which the tertiary directs light along the elevation axis to the fourth mirror, which sends the beam vertically downward. While this approach has an extra reflection, it offers a gravity-stable configuration in which field rotation is corrected by rotation about the vertical axis, thereby eliminating the need for an optical derotator. This concept is now being explored. The committee recognized that the confocal requirement between Cassegrain and Nasmyth of the draft Science Requirements could be relaxed in this case.

Plans for Instrument Procurement

David Robertson, Instrument Manager, presented the proposed plan for instrument procurement. Instruments are to be obtained on a competitive basis from institutions in the partner countries. Instrument teams are to be science-led and have a scientist as P.I. The Requests for Proposal (RFP) are to contain functional requirements written in a manner that permits innovative responses in instrument design.

A related issue is the award of guaranteed observing time to the instrument teams as an incentive for their work. A majority of the Science Committee favored the concept but noted that the time should be drawn from the total pool, not from a partner country's share.

The Science Committee supported the proposed plan. It will recommend the selection of instrument functions to the Gemini Board and approve the instrument RFPs.

Draft Selection of Instrumentation

After discussing the outcome of the three national science committee meetings on instrumentation, the Gemini Science Committee proposed the following groupings as a first step in selecting instruments to be built. The plan is based on the f/16 IR secondary being implemented first on the Mauna Kea telescope and the f/6 secondary being first on the southern telescope. The f/6 secondary would then be commissioned second on the northern telescope and the f/16 second on the southern telescope.

The following capabilities are needed for testing and commissioning the telescopes and to allow for subsequent instrumentation:

- Acquisition and guiding unit
- Wavefront sensor
- Tip-tilt correction capability
- Space to locate a higher-order adaptive optics unit
- f/6-16 optical imager (4096x4096 CCD)
- High resolution imagers covering the 0.4 to 5 micron band and the 8 to 30 micron band

Instruments for the first science programs with the telescopes would be selected from, in no particular order:

- Faint object, medium resolution optical spectrograph (with long slit/multislit capabilities)
- Fiber-fed spectrograph
- High resolution optical spectrograph
- Low - medium resolution 1 - 5 micron spectrometer
- Higher-order adaptive optics system

Instruments for subsequent science programs would be, also in no particular order:

- High resolution infrared spectrometer
- 5 - 30 micron spectrometer

Finally, the need for more specialized capabilities was recognized, some of which might be incorporated into instruments listed above:

- UV imager
- Speckle camera
- Coronagraph
- Fabry Perot

The committee also encouraged the Project to explore how to obtain infrared array detectors that will be needed for the instruments, possibly through Gemini supported efforts.

The next steps in instrument planning are to refine the groupings, develop the functional requirements for the different instruments, and select the instruments for the definitive science requirements document. This process is described in an accompanying article.

Report from the UK Science Advisory Committee

The UK SAC has met 3 times since it formed last October, most recently on April 14 in London soon after the international GEMINI Science Committee meeting held in Abingdon. The members (listed in the last Newsletter) represent a wide cross-section of the UK community and are now fully up to speed on the project.

The UK SAC has been debating 3 main issues. The question of balancing the requirements for ultraviolet scientific applications with a desire for high performance at infrared wavelengths led to the review of UV programmes discussed elsewhere in this issue by Max Pettini (RGO). We consider it important to establish at the outset the distinction between a versatile telescope, capable of a broad suite of scientific goals, and a telescope highly tuned to a few areas. The UK community views their share of GEMINI as fulfilling the need for a wide range of opportunities across the UV to IR spectrum, and is optimistic the design work being undertaken in Tucson and elsewhere will meet this demanding goal.

UK universities and observatories have a strong tradition in supplying state-of-the-art instrumentation for their national optical and infrared telescopes (AAT, UKIRT and WHT). With the approval of the international Science Committee, the UK SAC is undertaking a review of the spectroscopic aspects of the instrumentation package, taking into account the diverse requirements for high resolution, long-slit, fibre-fed and multi-slit applications. Whereas a broad range of instrument functions has already been agreed by the project, packaging these functions into individual instruments is an important precursor to more detailed design work.

The UK SAC has also responded positively to the new telescope designs discussed in detail in this issue. The baseline design, which includes access to Nasmyth platforms, is similar in many ways to the design adopted for the 4.2m Herschel telescope. Many UK astronomers can appreciate the distinct advantages of Nasmyth foci from direct experience. The UK SAC believes it is important to maintain more than one focal station, not just for mounting additional complex instruments (such as the high resolution optical spectrograph), but also for retaining flexibility for occasions when new instruments are brought to the telescope for testing, and possibly in changing weather or instrument/detector circumstances. Following our discussions, the UK SAC is preparing a paper on this issue which we will bring to the international Science Committee shortly.

*- **Richard Ellis***
Chairman UK SAC

Note: We regret the omission of Simon White (Cambridge) and Andy Lawrence (QMW, London) from the membership list of the UK Science Advisory Committee in the March 1992 issue of the Gemini Project Newsletter.

U.S. Community Input to Gemini Instrumentation Program

It is the intention of the Gemini Project to engage the full participation of the partner communities in defining the scientific requirements of the telescope and its instrument complement. One vehicle for giving input to the U.S. members of the Gemini Science Advisory Committee (SAC) has been a pair of subcommittees for optical and infrared telescope and instrument performance. A committee composed of members of the two subcommittees then meets to reconcile the two sets of recommendations. The groups have met twice, once in July, 1991, and again in February, 1992. The first meeting was concerned with telescope and system issues, the second with instrument functions and priorities. The SAC members from the U.S. consider the outcome of these subcommittee deliberations as reflecting the U.S. community's desires when working toward a consensus position for the full international project.

We would like your feedback to gain a wider perspective on the plans for using the Gemini telescopes and to make sure that the committee deliberations reflect your desires for the project. The philosophy behind the U.S. committee's approach is based on the NOAO proposal, as augmented by the recommendations of the Astronomy and Astrophysics Survey (Bahcall) Committee report. The goal is to have access to the full celestial sphere with 8-meter telescopes that meet the needs of a broad community of users; at the same time, the telescope design and implementation will emphasize excellent image quality (for all wavelengths) and the capability of low emissivity, thus fulfilling the mandate for infrared optimization.

The SAC is currently deliberating on the priorities for various instrumental functions for the telescopes. These include a complement of IR instruments for the f/16 Cassegrain focus: a 1-5 micron imager, an 8-30 micron diffraction-limited imager, a 1-5 micron low to moderate resolution spectrograph, and high resolution IR spectroscopic capabilities. Optical instrumentation includes imaging, high resolution spectroscopy, wide-field fiber-fed spectroscopy, and moderate field beam-fed spectroscopy. High resolution spectroscopy may be accomplished at a Nasmyth focal station for invariant gravity load, while the other spectrographs will be fed by a wide-field f/6 secondary. The issues under consideration are the order of commissioning of the focal stations and instruments on each telescope, the role of adaptive optics with the instrument complement, and the balance of the program at the end of the commissioning phase.]

Your opinions on the scientific priorities of the telescope configurations and the instrument development provide vital input to the project. There will be a large telescopes session at the upcoming American Astronomical Society meeting in Columbus, at which the Gemini Project will be making a presentation, followed by discussion. The Acting Project Scientist, Patrick Osmer, will be at the meeting and available to hear your reactions. I would be pleased to receive your opinions by electronic mail at rgreen@noao.edu or noao::rgreen. We are approaching a critical phase of the scientific planning for the project, and your timely input will have maximum impact now.

- Richard Green
U.S. Project Scientist

SCIENTIFIC OPPORTUNITIES IN THE ULTRAVIOLET

One of the requirements for the Gemini telescopes is to achieve a very high performance at infrared wavelengths. To this end, the possibility is being considered to coat the primary mirror with protected silver, because of its extremely low infrared emissivity. However, the reflectance of silver drops rapidly below that of the more conventional aluminum coating at wavelengths shorter than 3600 Å; consequently, if the telescopes were optimized to achieve the highest possible efficiency in the infrared, their performance in the ultraviolet would be compromised.

Would this matter? After all, the loss of a mere 600 Å-wide portion of the optical spectrum (from 3600 Å to the atmospheric cut-off at 3000 Å) may at first sight seem a relatively minor issue. To address this question, I took a fresh look at scientific programmes which **REQUIRE** access to ultraviolet wavelengths.

The conclusion I reached is that this wavelength region is in fact essential for many observations which have been identified by the US, UK and Canadian communities as constituting top level science requirements for the Gemini telescopes. In this article I highlight some of the most obvious examples. In every case, the light-gathering power of the 8-m telescopes and the excellent ultraviolet properties of the Mauna Kea site are the two key factors which make these observations possible.

PRIMORDIAL NUCLEOSYNTHESIS

Measurements of the Be II doublet lines at $\lambda\lambda$3130.42, 3131.06 Å in stars of low metallicity will show whether there is indeed a cosmological source of this element, as suggested by recent work on the few such stars that can be accessed with 4-m class telescopes. A primordial abundance of beryllium as high as these measurements indicate would point to significant inhomogeneities in the baryon density in the early universe. Such inhomogeneities may help reconcile the primordial abundances of light elements with high values of the density of the universe. To make progress in this area it will be necessary to measure the abundance of beryllium in many stars of near primordial composition; despite the very topical nature of this work, progress is impeded by the fact that such stars are simply too faint to be studied with present means.

Most of the observational effort aimed at determining primordial abundances has so far been focused on helium; while more difficult to measure, the abundance of deuterium is in principle a more sensitive test of the standard model. The most effective way to tackle this problem is to search for the isotope shift in high-order Lyman lines in the spectra of QSOs with `damped Lyα systems', which are thought to be high-redshift galaxies and are known to be chemically unevolved. Because of confusion with other lines in the Lyα forest, an unequivocal identification of deuterium can only be achieved by observing the same feature in several lines of the Lyman series --- hence the need for UV coverage.

CHEMICAL EVOLUTION OF GALAXIES

Observations of OH lines in the UV are the only way to measure the abundance of oxygen in very metal-poor stars, since the more commonly used [O I] doublet lines at λλ6300.31, 6363.79 Å become vanishingly small for metallicities lower than about 1/100 solar. Oxygen is thought to be produced mainly by massive stars and is therefore a critical tracer of the early star-formation history of the Galaxy, as well as providing the `baseline' against which the abundances of other elements are normally measured.

A novel way to address the question of the early chemical evolution of galaxies will be to measure the pattern of element abundances in the interstellar medium of young, high-redshift galaxies traced by the damped Lyα systems. The vast majority of the important absorption lines of CNO elements, r- and s- process elements, as well as those in the iron peak, occur at wavelengths between 1000 and 1300 Å in the rest frame. These lines are therefore observed between 3000 and 4500 Å at the redshifts (z = 2-2.5) where most of the known damped systems are found. Within this interval, the UV region is the most important, because of the significantly lower density of lines from the Lyα forest, which can confuse the interpretation of the metal absorptions.

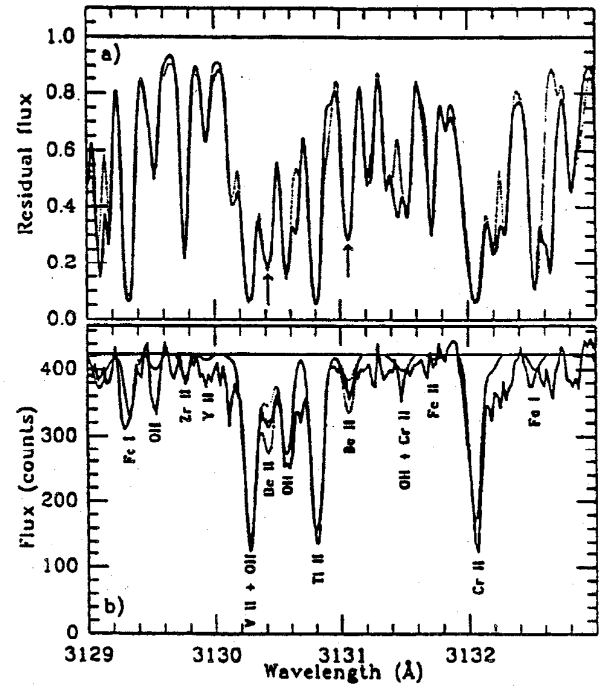

Figure 1. *Top: The observed solar spectrum in the region of the Be II lines (arrowed).*

Bottom: spectrum of the metal-poor star HD 140283 obtained with the echelle spectrograph of the Anglo-Australian Telescope; in this star metals are 400 times less abundant than in the Sun. The thin and broken lines are synthetic spectra for three different values of the Be abundance, log Be/H = -12.6, -12.8 and -13.0 . The data show that log Be/H = -12.8, approximately three orders of magnitude greater than the primordial value predicted in the standard model of light element nucleosynthesis (reproduced from Gilmore et al. 1991, Ap.J, 378, 17).

Recent results have shown that the damped Lyα galaxies, as well as those producing Lyman Limit systems, can be successfully imaged despite their enormous distances by appropriately targeted UV observations. This pioneering work is providing the first data on stellar populations and star formation in `normal' galaxies in the young universe, but only with the advent of the next generation of telescopes will the novel observational techniques be used to full advantage.

THE INTERGALACTIC MEDIUM AT HIGH REDSHIFTS

High-resolution observations of high-order lines in the Lyman forest of QSOs will clarify current uncertainties about the temperature and physical conditions of the Lyα clouds. The UV region is crucial here for separating hydrogen and metal lines, and for extending the range of column densities that can be measured.

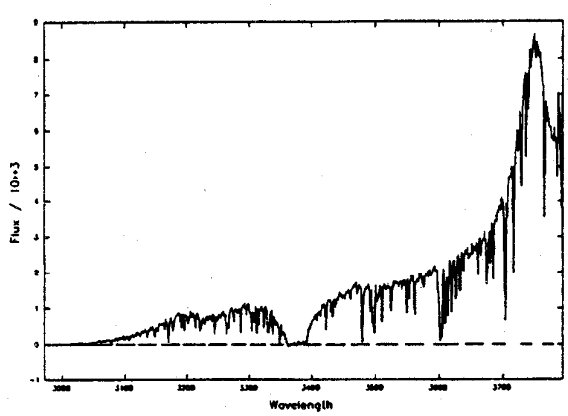

Figure 2. *Ultraviolet spectrum of the QSO 1331+170, obtained with the William Herschel Telescope on La Palma, showing the damped Lya line at 3375 Å (z = 1.7764). Such 'damped Lya systems' give us a unique view of primordial galaxies (reproduced from Pettini et al. 1992, in preparation).*

Information on the spatial extent of QSO absorbers and on their clustering properties perpendicular to the line of sight can only be obtained from observations of close QSO pairs and groupings. Whether due to gravitational lenses or chanced occurrences, such closely spaced sight-lines are rare, and their study invariably involves observations of faint QSOs. Consequently, this is an area of work which has been relatively little exploited up to now (given the potential rewards of such observations) and where the Gemini telescopes will make a particularly impressive impact. Access to the UV region is essential; without it, it would not be possible to exploit some of the most suitable QSO pairs and groupings known, which include one or more members at redshifts less than 2.

TESTING THE ^{56}Ni HYPOTHESIS FOR TYPE IA SUPERNOVAE

Examining the time-evolution of the 3250 Å absorption feature in Type Ia supernovae for about 100 days after maximum light will test current ideas of the physical processes producing the explosion and powering the light-curve.

HIGH IONIZATION REGIONS IN ACTIVE GALACTIC NUCLEI AND PLANETARY NEBULAE

The UV region includes important transitions of [NeV] at 3426 and 3346 Å; coverage of these lines is necessary to map highly ionised gas in AGNs and PNs and to measure the abundance of neon in such regions.

It is clear, even from this brief selection of highlights, that access to the 3000 - 3600 Å region is essential for some of the most exciting science to come from the Gemini telescopes. It is with these considerations in mind that the Gemini project is now exploring ways to provide coating facilities which would allow BOTH aluminium and silver coating, depending on the scientific needs of the observations scheduled.

- Max Pettini

DEFINING THE SCIENCE REQUIREMENTS FOR GEMINI

The draft science requirements document prepared last October represents the scientific goals of the science communities in the three partner countries. The document has been widely circulated in the past months and has been the basis for much of the project work to date.

It is now time to begin the preparation of the definitive science requirements. The project staff is assembling new cost estimates based on the draft science requirements. It is also preparing the error budget for achieving the image quality goal. This information and other technical feedback from the project staff will enable the Gemini Science Committee to develop a package of science requirements that is consistent with the budget estimates and achievable technical performance. This will involve setting of priorities and agreeing on capabilities the telescopes and instruments must have.

The schedule for the process is:

June 16-17 Gemini Science Committee Meeting. The committee will have a first discussion of the budget and technical information.

July - August. Discussions by the national science committees on the development of definitive science requirements.

August 25-26 Gemini Science Committee Meeting. The committee should agree on the science requirements.

September. Drafting of the science requirements document.

November. Presentation of the science requirements to the Gemini Board.

Comments and suggestions from the science communities on the science requirements are welcome. They may come through the national science committees, to members of the Gemini Science Committee (listed below), or to the Project Scientist office in Tucson.

*- **Patrick Osmer***
Interim Project Scientist

GEMINI Science Committee

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GEMINI GROUP UPDATES

ADMINISTRATIVE MANAGEMENT GROUP

The Administrative Management Group's primary goal is to support the Project Manager and the Group Managers in carrying out their tasks related to the Gemini Project. The group's primary focus has been on the development of workable contracting, supply and purchasing and travel procedures and on preparing the solicitation for the 8-m mirror. The following have been the key milestones of the Administrative Management Group since the last newsletter:

- Contracts have been distributed to the Group Managers. The procedures cover all aspects of the planned solicitations within the Gemini Project. The Contracts Procedures pertain to all portions of the solicitation process from presolicitation through the awards process. Once the MOU with the three participating countries is signed, it's provisions will be incorporated into the procedures.

- Procedures for travel and supply have also been completed for Gemini; the supply and purchasing procedures were distributed in April. The travel procedures were issued on 20 May 1992.

- The Financial Administrator, Mr. Don Ferris, joined the Gemini team on 11 May 1992. He will assist the Administrative Manager and the Project Manager in preparation of the Gemini budget and the reports related to the financial tracking of the Gemini Project.

- The Primary Mirror Request for Proposal (RFP) was issued on 6 May 1992. Proposals are due 19 June 1992. As soon as the proposals arrive, the Source Selection Evaluation Board (SSEB) will be called into session and the proposals will be evaluated. The Preliminary Evaluation Report (PER) will be completed by 2 July 1992 and will be submitted to the Project Manager and the Source Selection Advisory Council (SSAC) for their review. The Project Manager will submit the PER to the Interim Gemini Board for their comments during the Gemini Board Meeting in July.

- Jack Morton
Administrative Manager

BUILDING ENCLOSURE GROUP

The primary thrust of the **Building/Enclosure Group** has been to develop the Project Description. The preliminary civil engineering and site configuration are redefined for the Hawaii Conservation District Use Permit Application. This effort has progressed in concert with the Institute for Astronomy at the University of Hawaii. Don Hall, Bob McLaren and their staff have been most helpful in guiding us through this complex task. It appears the final document will be ready for submittal near the end of June.

The Preliminary Design Review was held with IFA regarding the design of the Hale Pohaku Construction Camp cabins and infrastructure. The next design phase is currently a collaborative effort with the Japanese National Telescope Project. We expect to have the construction documentation in the hands of Hawaii County building officials near July 1, 1992.

A conceptual thermal management and dissipation system design for the enclosure is under way. A report is expected to be presented to the Project manager in mid June.

Several enclosure related work packages have been defined and are soon to be released as RFPs.

The site soils investigation is underway at Mauna Kea. Currently we are performing the non-invasive phase. The data derived from this phase will provide direction for the coring operation. The coring contractor is scheduled to mobilize on Mauna Kea this summer.

A new meteorological tower has been purchased and delivered to Hilo. (The IFA staff deemed the existing tower unsafe for further use. Our inspection led us to concur.) The tower erection is underway and we will begin taking data in early June.

- Henry Blair
Building Manager

Controls Group

Current Work

The work of the Controls Group has been concentrated in the following areas since the last newsletter:

- evaluation of tracking performance due to
  - telescope inertia
  - wind loading
  - pier-soil instability
- contracting out initial servo design study
- staffing controls group
- becoming and remaining current in software and controls areas

Effect of Telescope Inertia

The two current telescope concepts differ markedly in the inertia of the structures about the altitude and azimuth axes. Given that we know that high inertia structures reject external disturbances better than low inertia structures the question has been asked -- why build a low inertia structure?

Investigations into other effects on tracking performance, most notably the pier-soil instability, lead one to pick structures with lower inertias. This is due to the "battleship" effect. Consider a gun turret on a battle ship afloat on the ocean - the inertia of the gun turret had better be less than the effective inertia of the ship or the ship will move when the gun turret rotates. This analogy can be extended to a telescope (gun turret) mounted on a pier (battle ship) located on the soil (ocean). If larger and larger inertia structures are chosen then the mass in the pier must be increased by corresponding factors. At a cost of some $550 per cubic yard for in place concrete on Mauna Kea this makes for an extremely expensive, very low tech, attempt to solve the problem of wind loading.

Effect of Wind Loading

One of the main obstacles to meeting the tracking requirements for the telescope will be the effect of wind on the telescope structure. This is especially true for the open loop requirements where there is no star to "encode" the upper end of the telescope. In the absence of top end gyroscopes, the only measure of the position of the top of the telescope must be extrapolated from the encoders which are effectively on the bottom of the telescope. Thus the wind loading can generate both a static offset and a dynamic component which will only be partially measured by the encoders.

Effect of Pier-Soil Instability

A further obstacle to meeting the requirements may be the soil properties on Mauna Kea. If, as expected, they give rise to soil-pier frequencies in the 1-10 Hz range then this will cause pointing and tracking errors which cannot be measured without some form of inertial encoding either by using a star or gyroscopes.

Servo Design Study

The effects of wind loading on extremely simplified telescope structures with basic control systems has been explored in order to put bounds on the problem. A servo design study which will use a reduced FEA model of the telescope to examine the effects of both wind loading and the pier-soil instability has been placed with ASA Automation in Sydney, British Columbia.

Staffing Controls Group

Three positions have been advertised within the group and 125 applications have been received. This has been reduced to a short list of some 25 candidates. We are currently conducting telephone interviews and hope to have the positions filled by the end of July.

Becoming Current in Controls/Software Area

There are a number of large telescope projects and large software projects either already completed or in various stages of construction. I have been spending a significant amount of time obtaining and reading the different technical reports issued by these groups and attending conferences and workshops in order to meet with my counter parts in these projects.

Future Work and Schedules

We hope to have the scientific requirements for the software and controls area in first draft by July of this year. This will be forwarded to the project scientist for comment and used as input to the design requirements documents.

The current schedule calls for a preliminary design review at the end of 1992 and a critical design review during the last quarter of 1993. In order to meet these milestones most of the group's activities over the next 1+ years will be devoted to the design requirements, interface control, and the studies needed to proceed with critical design. As a large part of this work will be carried out by the communities, we would appreciate input on those areas which are of of interest to the different groups in the partner countries.

- Richard McGonegal
Controls Manager

Computer and Control Working Group Meeting

The first meeting of the this working group was held on 24 April 1992. The meeting had been preceded by a lot of preparation work by the members, mostly via email. Those attending the meeting were:

Jeremy Allington-Smith
Richard Murowinski (chair)
Todd Boroson
Pat Osmer
Carol Christian
Keith Raybould (observing)
John Kerr
Steve Ridgway (observing)
Steve Grandi
Steve Unger
Tom Ingerson
Patrick Wallace
Rick McGonegal
Richard Wolff

The purpose of this meeting was to better establish the Scientific Requirements for the computers and control areas of the project. The result of this meeting will be a report forwarded to the project scientist for consideration for inclusion in the Science Requirements document.

Following are some of the highlights of the meeting. A detailed compilation of the recommendations will follow when it is ready. If any one in the community has or wishes to have input on any of the items discussed here (or omitted !!) they are encouraged to contact Rick McGonegal via email (rmcgonegal@noao.edu).

Project Status

Pat Osmer provided an overview of the project status to date. There were some questions about the ease with which information is exchanged and received within the working group, particularly as the telescope concept continues to evolve. Keith Raybould said that the telescope concept will be fixed at the end of June.

Controls Group Status

R. McGonegal presented some of the results from a simple model of the telescope. The telescope tracking performance will be limited by wind but information was not available (at the meeting) as to what the dome would do to the wind velocities at the telescope, nor the statistics of wind at Mauna Kea. The pier resonant frequency is a function of telescope mass but also strongly a function of pier height (Raybould).

There was a general disagreement about the importance and detail to which standards should be set, with about the same level of feeling on both sides.

Telescope Pointing

Pat Wallace presented some ideas and suggested requirements and goals for telescope pointing. He pointed out that the difference between measured (a posteriori) and in-service (a priori) pointing is generally a factor of two. The proposal was that the in-service requirement would be 3 arc seconds with 1 arc second as a goal. Pat cautioned the telescope group that low "Q" non-metallic telescope structural members could be subject to hysteresis and seriously impact pointing.

There is a need to set standards for how much time is spent on pointing tests each night, etc. Pat recommends that 10 minutes each night and 30 minutes each month will suffice for the proposed requirements.

The topic of offset guiding needs more discussion as it was unclear what the science driver was for the existing requirement, and there was an extended discussion as to the impact of this requirement on different observing scenarios.

Telescope Tracking

Richard Wolff presented suggestions for a better set of goals and requirements for telescope tracking. The existing requirements were reformulated as rms values and maximum excursion values were added. In addition testing methodologies were proposed.

Some discussion of performance in wind converged on the requirement that the telescope meet the stated tracking requirement in at least 70% of the clear weather.

The group feels that it needs more detail on the need for tip/tilt correction at optical wavelengths as it is unclear how to obtain the stated performance in the absence of tip/tilt capability.

Time Services

Rick Murowinski discussed the scientific requirement for time services. It was agreed that the telescope standard will be international atomic time. Relatively inexpensive commercial (GPS) time standards will give more than adequate accuracy for general observatory use; experiments or user instruments that need better time will have to provide their own source. The most exacting requirement for coordinating telescope systems would be that of generating artificial stars with lasers or other telescope activities on the order of atmosphere coherence times (a few msec).

Remote Observing

John Kerr led a discussion on the requirement for remote observing. It was generally agreed by the group that remote observing is a natural result when the telescope and software are built with well defined interfaces and as networks evolve. Initial capability should be provided for remote observing from Cerro Tololo and Hale Pohaku.

The telescope will need a weather estimate (unbiased) in order to validate changing programs.

It is not clear what remote support for visitor instruments will be given.

System Breakdown/Interfaces

Steve Unger proposed a (computer and control) system breakdown and discussed the interfaces between the components. He pointed out the need to make special consideration of time critical links as these generally require a custom solution.

Archiving

Carol Christian discussed archives for Gemini. We should plan for an observatory permanent data storage facility, perhaps with a database catalog of recorded information. The more ambitious cross referencing and automated retrieval might be studied in the longer term.

It was agreed that the data should be archivable. This puts rather stringent requirements on the encoding of observatory status.

Data Acquisition System

Todd Boroson discussed the requirements for data acquisition systems. There was some disagreement about role of large memory displays. Carol Christian pointed out that MIDAS, IRAF and ADAM were all evolving to work with parameter sets -- something in common which could be accessible through a GUI.

Software Tools and Environment

Steve Grandi presented ideas on software tools and environments. The suggestion was made that no money be spent on code development until the design is approved.

The only reason for investing large amounts of money and time up front in the design process (via Case, etc) is to minimize the chance of failure. The only reason to make this investment is if cost of failure is too high - in general, astronomy has not made this up front investment as the general consensus has been that failure (system does not perform to spec) is not too high (software is rewritten). The general feeling of the group was that Gemini should encourage the use of such techniques but not require them.

Storage Requirements

Jeremy Allington-Smith presented requirements for Disk and Tape storage. There was some discussion of the topology of the data and whether the necessary extensible data sets could be accommodated within FITS. It was agreed that the standard for data transport would be FITS.

There is still disagreement about necessity for HDS type formats. Although the need to support error and quality information is recognized it is not clear that HDS is the required or desired solution.

INSTRUMENTATION GROUP

Who's Who in the Gemini Instrumentation Group

The Gemini Instrumentation Group is now up to full complement and we thought it would be a good idea to introduce ourselves to the Gemini community.

David Robertson is the Instrumentation Group Manager for Gemini. He came to the project from the Royal Observatory Edinburgh in Scotland where he worked mainly on infrared instrument development. He was at ROE for fourteen years prior to joining Gemini, except for a period of two years when he was in Hawaii for the commissioning of UKIRT. His last project was the very successful cooled grating spectrometer for UKIRT, *CGS4*, on which he was project manager. He can be reached at **drobertson@noao.edu.**

David Montgomery, Engineering Supervisor for instrumentation, came to Gemini four months ago also from the Royal Observatory Edinburgh. He is a mechanical design engineer with broad experience in the design and construction of instrumentation for UKIRT and JCMT. His most recent position was as Senior Mechanical design Engineer for*CGS4*. His responsibilities for Gemini include all mechanical aspects relating to Gemini instrumentation, design of the cassegrain derotator and the Nasmyth and Cassegrain focal stations. He can be reached at **dmontgomery@noao.edu.**

Susan Wieland is the Instrument Systems Engineer for the Gemini Project. She was a Captain in the US Air Force where she worked as a project manager for the Strategic Defense Initiative, Air Defense Initiative, and Anti-Satellite Intelligence Contracts. She has experience in electronic system design, software development, and R&D project and contract management. On Gemini, she will be responsible for overseeing the electronic and computing systems aspects related to instrument procurement. She can be reached at: **sweiland@noao.edu.**

Stephen Pompea is the Infrared Instrument Scientist for Gemini. His training is in physics, space physics, and astronomy, with a doctorate in extragalactic infrared astronomy from the University of Arizona. He worked on a number of space instruments at Martin Marietta, Denver, participated in several shuttle experiments, and was NICMOS instrument scientist at the University of Arizona prior to coming to Gemini. He has worked on stray light analysis of space and ground based telescopes , contamination issues in optical systems, and is the inventor of several patented ultra-black surfaces for use on baffles. His responsibilities with Gemini center around infrared detector development, infrared instrument development, infrared instrument science requirements, active and adaptive optics, and stray light and contamination issues. He can be reached at: **spompea@noao.edu.**

Bill Weller is the Optical Instrument Scientist for Gemini and has been associated with building astronomical instruments since his undergraduate days. He received his Ph.D. from the Centre for Research in Experimental Space Science at York University in Toronto. At David Dunlap Observatory at the University of Toronto, he worked on modern detectors for use at the 1.88 metre telescope and helped support the University's Southern Observatory at Las Campanas, Chile. From DDO he moved to Cerro Tololo InterAmerican Observatory, where he was a Support Scientist for 7 years prior to coming to Gemini. In this position, he was the scientific advisor for the maintenance and improvement of the CTIO facility telescopes. His Gemini responsibilities include monitoring progress in CCD development, acquisition and guidance systems development, and optical instrument development. He can be reached at **wweller@noao.edu.**

Current Activities of the Instrumentation Group

The Gemini Instrumentation Group has the responsibility for the management of the Instrumentation Program for the Gemini Telescopes Project. The current responsibilities include Infrared and Optical/UV instruments, Acquisition and Guiding and Active/Adaptive Optics sensors.

Although the group is responsible for the program management, it is expected that each of the individual instrument projects shall be subcontracted out to instrument building groups. This will make best use of the extensive base of knowledge and expertise that resides throughout the partner countries.

At present the group is involved in a variety of ongoing efforts, including mechanical design, acquisition and guiding, infrared array development, instrument program planning activities, active and adaptive optics, and stray light and contamination control. The group is working closely with the science groups from the partner countries, who are defining the science requirements for the telescope system and for the optical and infrared instruments in particular.

On the mechanical side of things, the group has produced design concepts for several configurations for the Cassegrain instrument area. These designs are being analyzed using solid modelling to verify the instrument space envelopes and to discuss the utility of the designs. Of particular importance is the creation of an instrument area where Gemini-sized instruments can be efficiently operated, maintained, and interchanged. Over half a dozen instrument changeout concepts have been developed and preliminary evaluations have been done within the project. The Cassegrain derotator also has a preliminary mechanical design, and its performance requirements are being defined and evaluated. The requirements for the A&G unit are being developed for the optical and visible, with particular emphasis on how the A&G can be coordinated with active and adaptive optics. We are borrowing on the experiences of A&G units built in recent years and the lessons learned from them.

The group is also coordinating an instrument infrared array development effort for the 1-5 micron region. The goal is to procure arrays that are buttable and can be assembled into a 1024 X 1024 class focal plane, if a monolithic array of this size is not viable. An announcement of opportunity is impending for cooperative work between an astronomy group or groups and industry partners with expertise in near infrared array development. Many of the array development and testing groups in the astronomical community and in industry have been contacted to obtain their expressions of interest in this project. Visits to major IR array development companies are planned for late May to determine their level of interest. In a similar vein, CCD detector development is also being examined, though at this time the IR array development is considered more pressing.

A detailed draft instrument procurement schedule has been produced for generic types of instruments, to give a feel for the planning and budget required for logical instrument development. A draft instrument functional requirements document has been produced and is being reviewed. The instrumentation group is also working with, and reviewing requirements documents from, the other Gemini groups, e.g. Computers and Controls.

The areas of active and adaptive optics are being addressed by the instrumentation group. Although no development work is presently being done by the Instrumentation Group in this area, the group is tracking current developments in this area. Our intent is to use the most appropriate technology to meet the performance requirements of the telescopes, without committing ourselves at this time to a particular approach that may be obsolete by the commissioning phase. The immediate goal in this area is the implementation of an effective tip/tilt correction for the infrared observations and to provide the wavefront sensing for the active control of the primary mirror.

In our commitment to image quality and low emissivity, the group is aiding the Optics Group in examining stray radiations issues for the telescope system. The stray radiation analysis of the telescope (in progress) is being examined in detail to determine a baseline emissivity under different configurations and cleanliness levels. Of particular importance in meeting our goals is the prevention and removal of particles and films that raise the telescope emissivity and decrease image quality. Experiments are being designed to characterize actual particle distributions on mirrors on Mauna Kea, so that computer models can more realistically determine the emissivity and scatter levels. These experiments will then provide a firm basis for future decisions on cleaning strategies.

- Gemini Instrumentation Group

U.S. Participation in Gemini Instrumentation Effort

The Gemini Project anticipates that instruments for the Gemini telescopes will be developed by teams based in institutions in the partner countries. The opportunities to work on instrumentation for the Project are likely to be funded based on responses to widely distributed requests for proposals, with competitive evaluations based on preestablished criteria.

Instrumental functions that may be supported include infrared detectors for the range 1-30 microns, optical array detectors, optical and infrared imaging cameras, infrared spectroscopy at low to moderate resolution for the 1-5 micron range, high-resolution infrared spectroscopy, high-resolution optical spectroscopy, wide-field fiber-fed optical spectroscopy, and moderate-field beam-fed optical spectroscopy.

There will be a more formal solicitation for letters of intent to propose as specific opportunities arise, but the Gemini Instrumentation Group would like to establish closer communication with U.S. astronomers and their groups who would be interested in learning more about participation in the Gemini instrumentation program. The Instrumentation Group has already made a similar effort with groups in the other partner countries. Please contact either of us directly by electronic mail as rgreen or drobertson @noao.edu. A Gemini U.S. Project Office is being set up at NOAO to coordinate U.S. participation in the project more closely. Please don't hesitate to contact that office through rgreen@noao.edu with suggestions or requests.

*- **Richard Green***
U.S. Project Scientist
*- **David Robertson***
Gemini Instrumentation Manager

OPTICS GROUP

This quarter the **Optics Group** has been involved in a variety of different tasks, and at the same time we are still working to improve our planning and organization. A more detailed Work Breakdown Structure (WBS) has been prepared, and we are refining plans for delegating work packages to other organizations in the three partner countries. The Optics Group schedule, budget, and accounting structure have been organized along the lines of the detailed WBS.

In addition to financial budgets, we are also working on error budgets for: image quality, pointing, tracking, emissivity and stray light. Much more work on these remains to be done.

The Optics Working Group had its first meeting March 6. At this meeting Jack Morton, Pat Osmer, Ron Price and I gave presentations describing current activities and plans of the Optics Group. Several good suggestions were made by Working Group members, particularly with regard to improvements in the study of optical effects of primary mirror print-through. This study is now being extended to incorporate these suggestions.

Much of our time this quarter was spent on the primary mirror blank solicitation. This has been difficult for a number of reasons. Three good sources for 8-meter mirror blanks were identified last year by the Gemini Primary Mirror Review Committee, but each produces a different product. Choosing among these is like comparing apples and oranges and watermelons. The primary mirror Source Selection Evaluation Board worked hard to prepare a request for proposal that does not put one or another of the suppliers at a disadvantage. The technical and scientific issues are tricky as well. Each of the three suppliers currently has at least one contract to produce the mirror blank for a large telescope project, and each is making good progress toward producing 8-meter mirrors. We are fortunate to be able to profit from the technical work already done by these other projects -- their studies give us confidence that all three mirror types have merit. However, studying their reports, and conducting our own studies, leads to the conclusion that significant problems remain to be solved before any of the three can perform as required by the Gemini Science Requirements. In our evaluation we must decide which set of unsolved problems is most tractable.

Part of our technical evaluation involves the study of support systems for 8-meter mirrors. Eugene Huang and Myung Cho have evaluated back supports and lateral supports for structured and meniscus mirrors and have achieved encouraging results for both mirror types. As part of their work, they have written routines to link the different finite-element and optical design programs we use.

They are also evaluating active optics capabilities. Before the Gemini Project began, Myung and I worked on the active optics system for the 3.5-meter WIYN Telescope, and we have continued to work closely with NOAO as they have tested that system. So far, the NOAO results have been excellent, in close agreement with the performance we predicted.

We have also been in contact with other optical organizations and vendors that we may call upon as subcontractors. This quarter Optics Group engineers visited Carl Zeiss, Contraves, Eastman Kodak, Hughes Danbury, Litton Itek, REOSC Optique, Royal Greenwich Observatory, Rutherford

Appleton Laboratory, University College of London, University of Arizona Mirror Laboratory, Wangsness Optics and Zygo. These organizations have been helpful in advising us about their technical capabilities, preferred forms for specifications, and ways to improve quality and lower cost in optical fabrication.

Frank Bull helped us link our PCs and SUN workstations together so that all our engineers can use Code V for optical analysis. Ron Price spent a week in California attending a Code V training seminar, and since then has been helping the rest of us. This quarter Eugene Huang and Eric Hansen have done a study of pointing errors caused by rigid body motions of the optical elements. John Roberts has evaluated the diffraction effects of the central obscuration and spider vanes. Eric has performed tolerance analyses of possible null lens designs, to determine the fraction of the error budget that must be allocated to optical testing errors, and has collaborated with NOAO and University of Arizona groups doing similar work.

Other activities include design studies for the IR and visible F/16 secondary mirrors, and investigations of commercially available broad band coatings for the corrector lenses. Charles Harmer has continued optical design studies for the Gemini wide-field corrector, and Ann Dinger has continued emissivity analyses of the IR mode.

- Larry Stepp
Optics Manager

TELESCOPE GROUP

The telescope design has evolved to a lightweight structure, which dramatically reduces the structural mass in front of and around the primary mirror surface. This reduces local seeing effects associated with temperature differences between the ambient air and the telescope structure. This has been achieved by using composite materials for the top-end structure. Higher damping associated with the composites will reduce dynamic wind induced excitations and vibrations generated by the articulated secondary. The new telescope design is capable of supporting large instruments at the Nasmyth position. Mechanically rotating the instruments around a vertical axis eliminates the need for an optical de-rotator and provides a stable gravity environment.

The friction driven encoder test set-up is near completion and will be delivered the week beginning 18 May. Work is continuing on the design of a disk-guided friction driven encoder.

- Keith Raybould
Telescope Manager

Sky Noise Characteristics on Mauna Kea

In order to determine chopping requirements at infrared wavelengths on the Gemini telescopes, a program of sky noise measurements has been initiated at existing telescopes on Mauna Kea. Unfortunately the time allocated at UKIRT so far has suffered from unfavourable weather and only very limited measurements have been possible. Nonetheless, measurements obtained to date demonstrate that the static atmospheric emissivity in the 10 micron window is in good agreement with that predicted by atmospheric models, confirming that the atmospheric emissivity is very low (<1%) in the best parts of the K, L and N windows for a significant fraction of the time.

C. Telesco has just completed a successful run on the IRTF with his bolometer array camera "Big Mac". Several sets of comprehensive sky noise measurements covering a range of chopper throw, airmass and wavelength were obtained for the Gemini Project. The cooperation and support of Charlie and the IRTF staff in this endeavor is much appreciated.

The 225 GHz monitor operated by the Caltech Submillimetre Observatory shows that very dry atmospheric conditions tend to occur over periods of several days, the timescale for moist and dry airmasses to move over the island. This suggests that changes in observing programmes during the night will not be required to take advantage of the best thermal-IR conditions. (This contrasts with atmospheric seeing, where the evidence gained with the CFHT suggests that the best seeing conditions tend to occur for periods of typically about 1 hr).

Continuing programmes of sky noise measurements with infrared cameras are planned at both the UKIRT and the IRTF to establish the sky noise frequency spectrum and the spatial correlation. These will provide essential input data for atmospheric sky noise models which the project will use to determine the chopping requirements.

- P. F. Roche
- F. Gillett

Update on Telescope Emissivity

Telescope Emissivity Calculations

The Initial APART calculations indicate that the goal of 2% telescope emissivity for the Gemini IR configuration can be achieved. The preliminary IR configuration with clean, high performance silver mirror coatings yielded a calculated emissivity of 2.2% at 2.3 and 3.8μm and 2.0% at 11μm. IR configuration modifications are under consideration that would further reduce the emission from the secondary support struts and the edges of the secondary mirror and could reduce the calculated telescope emissivity to around 1.6%.

These results highlight the need to minimize contamination of the mirror surfaces, and work continues in the direction of characterization of likely contamination on Mauna Kea and methods for frequent cleaning of the mirror surfaces in order to prevent buildup of contamination.

Mirror Coating Development

The project has contracted with Mike Jacobson of Optical Data Associates for a literature search to identify candidate sputtered protected silver coatings for use on the Gemini telescope mirrors. High quality sputtered coatings of Aluminum and Silver are very nearly as good as the best evaporated coatings and promising candidates for sputtered protective overcoats include Si_3N_4, HfO_2 and Y_2O_3. The final report for this phase of the development program is due in mid-June.

IR emissivity measurements

Laboratory Measurements

The emissivity of mirror samples was determined using the "Blue Toad" InSb single channel photometer to measure direct thermal emission from the mirror surface. Sample Aluminium, Gold and protected Silver coatings produced in the NOAO Coating Lab evaporation facility yield emissivities of around1.92(Al), 0.81(Au) and 0.71($Ag+ThF_4$) percent at 3.96 μm compared to the reported emissivity of fresh Ultra High Vacuum evaporated surfaces of 1.74(Al), 0.62(Au) and 0.56(Ag) percent at 4 μm. Thus coatings with very good IR performance, within about 0.2 percent of the best evaporated surfaces, can be obtained with fairly standard evaporation techniques, and protected silver coatings can maintain very good emissivity performance for long periods of time if they are not mistreated (the silver and aluminium samples were produced about 2 years prior to the measurements reported here).

KPNO 1.3m Measurements

An NOAO laboratory test dewar, equipped with a 256x256 PtSi array was modified in order to form a 4μm image of the 1.3m secondary mirror on the array. The test was carried out one day after the primary and secondary mirrors were realuminized. ***Figure 3*** shows one of the images obtained during this test.

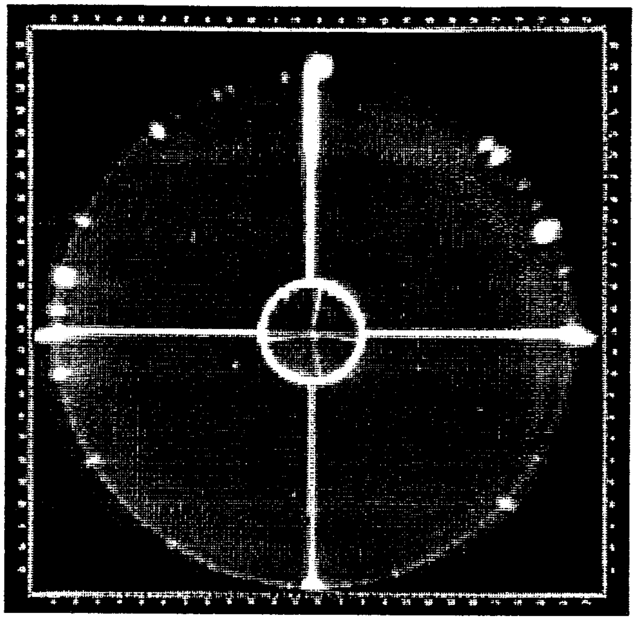

Figure 3.

- The bright central ring is the edge of the reflecting cone on the secondary mirror. Non-radial bright lines within the cone are secondary support struts seen in reflection off the cone (slightly misaligned) and primary mirror.

- The bright radial strips are secondary support struts seen in reflection off the secondary and primary mirrors.

- Brighter regions at the outer ends of struts are images of secondary support struts seen directly by the detector past the edge of the secondary mirror. The secondary mirror was slightly tilted with respect to its collimated position, so direct strut images do not line up well with reflected struts. The direct strut emission and sky background are cut off by a cold internal Lyot stop.

- Bright spots around the circumference of the secondary mirror are small chips.

A preliminary analysis of the observed contributions to telescope emissivity is the following;

KPNO 1.3m Telescope Emissivity Contributions

	Mirror Surfaces	Struts (Reflected)	Outer Edge	Central Cone	TOTAL
(%) Observed	3.90	0.64	0.43	0.69	5.66
(%) Predicted	3.70(1)	0.82(2)	- (3)	0.20(4) 1.0 (5)	4.81

NOTES:

(1) Two witness samples from realuminizing run were measured with the "Blue Toad", yielding 3.96 μm emissivity of 1.82 and 1.85%. Prediction assumes no scattering.

(2) Assuming black struts.

(3) The design intent was to minimize the outer bevel. The resulting sharp edge is very susceptible to chipping and has been dinged up over the years. A 0.5mm bevel would contribute 1.0%.

(4) Assuming a cone surface with the same emissivity as the secondary and cone reimages primary.

(5) During the test, it was realized that the cone was a) slightly undersized and b) was threaded on the OD. A rough revised emissivity contribution is indicated.

There appear to be no significant emissivity contributions that cannot be understood in a straightforward fashion. In particular there does not appear to be a significant scattering contribution to the measured emissivity of the clean mirrors.

The APART calculation results, together with the laboratory measurements of sample mirror coatings and the measurements of emissivity contributions at the KPNO 1.3m telescope, provide strong support and encouragement that the goal of 2% emissivity for the IR configuration of the Gemini telescopes can be achieved.

- Fred Gillett