

# Gemini Board Endorses Project Plan

**After its most recent meeting, the Gemini Board issued the following statement:**

**T**he Gemini Board, at its meeting from November 9 through 11, 1992, was presented by the Gemini Project Team with a complete conceptual design for the two 8-meter Gemini telescopes. This design meets the scientific specifications endorsed by the astronomical communities of the international partners in this project. These specifications are explained and justified in the Science Requirements Document. This document itself is the result of extensive discussion and debate within and between the U.S., U.K., and Canadian communities over a period of several years. The Project Team has carefully assessed and reviewed, using appropriate independent input, the costs associated with their design. These remain within the \$176 million limit with an adequate allowance for contingencies.

The Board strongly endorsed this package and directed the Project Team, working with the National Project Offices, to continue with the more detailed design and modeling necessary for the first preliminary design reviews to take place on schedule during 1993.

The Board reviewed the imaging performance expected from the proposed optical system, including the results of extensive simulations and calculations, and satisfied itself that the scientific requirements would indeed be met.

The Board noted that innovative solutions were necessary for some critical design aspects. It was encouraged by the approaches put forward by the Project

Team, and has established short-term review and monitoring processes. The Project Team was also encouraged to work closely with other international projects addressing similar problems.

The Board was impressed by the progress made in all aspects of the project design and definition since it last met in July, and expressed its confidence in the capabilities of the Project Team. The international partners reaffirmed their commitment to the project and their conviction that the Gemini telescopes will provide their communities with unique full sky observational capabilities well into the 21st century.

*— Robert C. Bless  
Chair, Gemini Board*

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# Gemini Project Plan

**A**t its meeting in November, the Gemini Board accepted a project definition for the two Gemini Telescopes. The project plan, and the designs currently being developed, meet the requirements for infrared optimization, which is the highest priority for the IR community in the U.S., while permitting the full range of optical capabilities desired by the broader communities in all of the partner countries.

At first light, and within the total project cost of \$176M, the project will provide near infrared imaging at or near the diffraction limit, near infrared spectroscopy, optical imaging, and multi-aperture and high resolution optical spectroscopy. The telescopes will provide full sky coverage, but at first light the instrumental capabilities will differ in the two hemispheres. The Mauna Kea telescope will emphasize infrared astronomy, while providing some optical instrumentation. The telescope at Cerro Pachon will emphasize optical work, while providing some infrared capability. Over time, the Gemini Science Committee would like to see the capabilities of both telescopes enhanced to provide all of the facilities called for in the Science Requirements Document.

Provision will be made so that, at some later time, Nasmyth and wide-field optical trains could be added at either or both telescopes. The primary requirement for IR-optimization is superb image quality, and this requirement has been the strongest driver on telescope design. Superb image quality is, of course, a major asset for both optical astronomy and infrared astronomy. The telescopes are also being designed to have very low emissivity (4 percent as a requirement, 2 percent as a goal).

More specifically, the project plan includes the following capabilities:

## Mauna Kea Telescope

- f/16 + Tip/tilt secondary
- 1-5  $\mu\text{m}$  Imager
- Optical Imager (required for commissioning)
- 1-5  $\mu\text{m}$  Spectrometer
- Adaptive Optics and Guiding/Wavefront Sensing
- Subarcsecond Imaging Spectrograph
- In Situ Cleaning of Primary Mirror

## Cerro Pachon Telescope

- f/16 + Tip/tilt Secondary

- Optical Imager
- Guiding and Wavefront Sensing
- High Resolution Optical Spectrograph
- IR Imager (To be borrowed from CTIO)
- In Situ Cleaning of Primary Mirror

The base budget includes funds to develop the processes required to deposit protected silver coatings on the primary mirror of the Mauna Kea telescope and to provide a coating chamber that can deposit an aluminum coating (base budget) and can be upgraded to provide the capability for protected silver coatings. The Gemini Board has agreed to consider including the upgrade to the coating chamber in the Gemini budget after technical feasibility is established.

The base budget includes all necessary site development with the exception of the sea-level facilities in Hawaii. The scope of the sea-level development in Hawaii depends on the degree to which it is possible to share facilities with the existing Joint Astronomy Center in Hilo.

If the full contingency of approximately \$12.5M, which is included in the base budget, is not required, the following are additional capabilities that are high priority for inclusion at first light:

Upgrade of Coating Chamber	\$1.0M
Nasmyth Secondary	\$1.5M
Tertiary	\$0.9M
Nasmyth Acquisition/Guiding	\$0.8M
Nasmyth Rotator	\$0.6M
f/6 Secondary	\$5.3M
Narrow Field Corrector	\$0.3M
Multi-Object Spectrograph	\$2.0M

The Nasmyth secondary would be placed on the Cerro Pachon telescope. The Gemini Science Committee has not agreed on the preferred location for the f/6 secondary. The relative priority of the options listed above has not been established by the Gemini Science Committee.

According to the Gemini Project Plan, the Mauna Kea telescope will be completed first.

— Sidney Wolff  
Project Director

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# *Perspective of the Project Manager*

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**O**n a day-to-day basis the project team is a lot like your family. You don't notice the subtle but very definite changes and growth that are happening. But you can't miss it when you see the team in action at one of the never ending committee presentations and reviews. All of a sudden, I realize that the Gemini Project really acts as a team. We all know each other's strengths and weaknesses and with the help of fellow team members, the weaknesses are seldom given a chance to show through.

I knew that the project had purchased good analytical software and computers; the thing that has astounded me is how proficient the project staff is in using them. Time after time it has been necessary to supply detailed analytical backup for the design concepts we have put forth. Usually within 2 hours we have the answer, and I can't think of a time that it has ever taken more than 24 hours.

Most of the time the people who do the work never get to present it. I feel like the actor William Hurt in the movie *Broadcast News*. Hurt plays the role of an anchorman who must depend on those around him to do his job. The particular line I always remember is from one of the station research staff who says, "I say it here and it comes out there." I just hope that all of us who do the presentations do the staff work justice. The constant and unrelenting reviews the project is subject to could not have been successfully handled without the cohesive nature of the talented team we have in Tucson.

I hope the current phase of the project's activities will soon change so we can involve the partner country project offices in all of our activities. We are now at the point of sending the project offices on a weekly

basis the mountain of information that flows internally in the project. What we are not able to do, of course, is get assistance from the project offices in a timely way for all the short-fuse answers we must supply. We do plan to depend on the project offices a great deal more in the future with regard to the work packages. Their commitment to Gemini and the geographical location of the UK and Canadian offices will provide an extension of the project's capabilities that would be difficult—and very expensive—to accomplish without them.

— *L.K. Randall*  
*Project Manager*

# *Project Scientist's Outlook*

**T**hree things struck me when I started working with the Gemini Project in Tucson. Firstly, how much work has actually been done by the Project Team. When I was asked to give a "Gemini talk" to the Hawaii Astronomy Neighborhood meeting in November, I had a problem deciding what to leave out from the array of material from design studies, Board presentations and what simply emerges from an enthusiastic group! Secondly, it is clear how much work and dedication Pat Osmer has contributed just to get the project to this state. And thirdly, the realization that 1998, the projected first-light date for the Mauna Kea telescope is not so far away.

It is the last point that is brought sharply into focus when you start counting backward from 1998 to determine when the Project and its partners need to start building instruments to use on the first Gemini telescope. The answer is 1994 — next year. There are some instrument descriptions in the Science Requirements Document (Version 1.1) but there are still quite a number of scientific and technical issues to sort out. Some examples follow:

- Should the High Resolution Optical Spectrograph (HROS) be a Nasmyth or possibly a Cassegrain instrument?
- Can we use UV fibers?
- What are the characteristics of the F/16 multi-object visible spectrograph. Is it a sub-arcsecond imaging spectrograph (SIS) or should it resemble the F/6 WiFOS (Wide Field Optical Spectrograph)?
- Should we be considering multi-object IR spectroscopy?
- How much spectroscopic capability, if any, should be incorporated into the IR imagers and how would this impact the IR spectrograph specifications?
- What IR focal plane array and CCD formats should the Project adopt?

- Are there 'creative' approaches to providing a 8-30 micron capability in the initial instrument suite?

To try to resolve these types of questions, we have set up Instrument Working Groups (IWGs) to work through 1993 to come up with instrument concepts and designs (see the article by David Robertson this issue). The idea is to reach as much of the community as possible. There is already a healthy EMAIL debate underway and I would encourage everybody to contact their National Project Offices or Working Group Chairs with ideas, input and criticisms. As part of this process we have a number of articles from the project and partner countries in this Newsletter:

"High Resolution Spectroscopy for the Gemini 8-meters - Cassegrain Option" by William Weller.

"The Cassegrain Instrument Rotator Concept" by David Montgomery.

"Adaptive Optics - A Design from the Canadian Project Office for a System That Can Feed Any of the Cassegrain Instrument Ports", described by David Robertson.

"Survey Spectroscopy with Gemini", from Jeremy Allington-Smith.

"The UK Project Office Explores Adaptive Optics Possibilities", again by Jeremy Allington-Smith.

In addition to the above, William Weller has made the Gemini Science Requirements Document available to all Working Group Members via ftp. (See note on the back page of this newsletter for general access information).

I hope that in future issues we will get many more articles, and I will certainly be using the Gemini Project Newsletter to try to keep our whole community up to date.

—*Matt Mountain*  
Project Scientist

## GEMINI GROUP UPDATES

## Telescope Structure, Building/Enclosure Group

### *Telescope Design*

**O**n Dec 8th we held the telescope Preliminary Design Review. The review committee was chaired by Tony Abraham of KPNO. Other members attending were Dan Blanco (WIYN), Hans Boesgaard (Keck), Walter Grundmann (DAO), Neil Parker (RGO), Donald Pettie (ROE), and Steve Sheckman (Magellan). Jerry Sovka (CFHT) was unable to attend due to other commitments. The national project offices were represented by Mike Morris (RAL) and Andy Woodsworth (DAO). Larry Daggert, from NOAO, was unable to attend. Matt Mountain, the project scientist, represented the interests of the scientific community. Following the telescope PDR, we held an informal review of the building and enclosure. A report on the telescope PDR is being assembled by Tony Abraham.

Since the design review we have continued to develop the telescope design. In particular we have worked on decreasing the image degradation caused by the relative tilt between the secondary mirror support structure and the primary mirror under wind loading. This has reduced the bandwidth requirements for the  $f/16$  secondary to the bandwidth required for atmospheric wavefront tilt compensation on Mauna Kea. We are also continuing to develop the design of the telescope drive system, primary mirror covers, the mount and handling arrangements. The testing of the WIYN friction driven encoder will be completed by the end of January.

The PDR report RPT-TE-G0005 describes the design development that has led to features that are truly unique to the Gemini telescope design. These features are briefly outlined here. In the early telescope designs, prior to January 1992, a dominating feature was a large structural mass (in some cases exceeding 100,000 kg) above the primary mirror. Thermal analysis identified the structural mass in front of the primary mirror surface as a major contributor to image degradation. We then developed the IR-only tele-

scope, which had less than 5 tons of composite structure in front of the primary mirror, and reduced the image degradation to a negligible level (well below the allocated error budget). However, the dynamic response of the telescope to wind gusts was degraded due to the lightweight, relatively low stiffness structure. To improve the telescope performance under wind loading, and to allow a beam to be fed to Nasmyth foci, the primary mirror was lowered. We still kept the center section below the primary mirror surface to minimize the effect of the telescope structure on the seeing. With the correct adjustment of the height of the primary mirror relative to the altitude axis, we have minimized the combined contribution of both windshake and local thermal seeing effects to the image degradation. This design strategy has resulted in a unique telescope design, which has been driven from image quality considerations, and is not to be found in any other large telescope design.

A question often asked is "how do the Nasmyth platforms affect the telescope design, in particular the image quality?" The current position of the primary mirror relative to the altitude axis now allows a 3 arc minute beam to feed the Nasmyth platforms. We have included a unique feature for supporting the Nasmyth instruments that both increases throughput and minimizes the additional mass in the telescope mount to support the instrument by rotating the instrument about a vertical axis. This provides field derotation yet maintains a constant gravity experienced by the instrument. This may be important for high resolution spectrographs and provides versatility for accommodating visiting astronomers' instrumentation. The method of support is extremely efficient; to support a 4,000 kg instrument requires an additional 2,000 kg of mass in the telescope mount (this mass is well below the primary mirror surface and does not contribute significantly to image degradation). Therefore, the impact on the telescope design of providing a Nasmyth instrument location is minimal.

Another frequently asked question is "how does the F/6 secondary affect the telescope design?". The Gemini project initially investigated the feasibility of exchanging modules to change between  $f/6$  and  $f/IR$  secondaries. This work is also described in the PDR report. We rapidly discovered that this approach, although elegant, severely affected the performance of the telescope top-end from both an emissivity and an image quality perspective. With a modular system, the vanes supporting the secondary frame cannot be tensioned to provide stress stiffening. As a result, thicker vanes would be required which would increase emissiv-

## GEMINI GROUP UPDATES

ity. The solution adopted has been to provide exchangeable top-end rings. Both the  $f/6$  and  $f/16$  top-end structures can now be optimized for their individual applications. In addition, future upgrades will be more practical with the facility to exchange top-ends. Thus by providing exchangeable top-ends, we have provided the ability to optimize both the IR  $f/16$  and optical  $f/6$  configurations and can allow for future upgrades, without significantly affecting the image quality of the IR configuration.

### *Building and Enclosure Design*

**W**e have selected a baseline design for the enclosure and support facility based on several criteria that are critical to minimizing the effect of "dome seeing". On December 9, the building, enclosure, and site plans were presented to the telescope PDR committee for review.

We are undertaking, or are about to start, several parallel analysis and test programs to evaluate the effect of the enclosure on seeing and to optimize the design:

- Computer flow simulations at the San Diego Supercomputer Center are being undertaken to determine the interaction of the thermal boundary layer and the enclosure on Mauna Kea with different wind directions and speeds.
- Other computer flow simulations at the San Diego Supercomputer Center will be performed to determine the most efficient methods for flushing the enclosure under different wind/shutter opening orientations. These simulations will enable the project to select the most appropriate flushing arrangements to avoid stagnation pockets inside the enclosure. The simulations will include the effect of the local topography and will be run at the correct Reynolds number to ensure correct dynamic similarity. The difficulty with this form of analysis is the inability to quickly modify the grid and *investigate alternative options as the analysis proceeds*. This flexibility can be provided by water tunnel tests.
- Water tunnel tests. These tests will achieve two objectives. First, they will provide a back up to the computer numerical modelling. Second, they provide excellent visual flow simulations to enable

different configurations and arrangements to be tested. Previous work at the University of Washington water tunnel indicated that flushing efficiency was a key parameter to the performance of the enclosure—not the geometric shape. Our testing will build on the University of Washington work and will start with the selected Gemini structure to investigate flows through and around the enclosure under different vent configurations. Our design strategy will be to provide sufficient flushing under all orientations of the wind relative to the shutter opening under different wind speeds. In addition, the vent configurations must also be capable of providing adequate protection to the telescope. These two requirements must be met from low ambient wind velocities where active flushing may be required, to higher wind speeds where modulation of the vents may be necessary to reduce telescope windshake. The tests will also provide an indication of the wind velocities in the vicinity of critical areas, specifically the telescope structural members, which are dominant in inducing wind shake and the area above the primary mirror.

- Thermal modelling of the enclosure. We are undertaking thermal modelling within the project to determine the requirements for the enclosure thermal system. The effects of many parameters are being evaluated, including: the effect of thermal mass, flushing velocities, where to use insulation efficiently, the effect of IR emissivity and solar absorptivity of the outer skin, thermal shields inside the enclosure, active flushing, and daytime air conditioning. The models predict the heat transfer from the enclosure to the ambient air as the air passes through the enclosure. The water tunnel tests will provide an indication of the effective wind speeds inside the enclosure under different operating conditions. This information will be used in the thermal analysis to determine how much heat is transferred from the enclosure structure to the ambient air as the flushing air passes through the enclosure. This can then be used to evaluate the effect on the image quality. Preliminary results (see RPT-TE-0006) indicate that the flushing performance of the enclosure will be the dominant feature for controlling "dome seeing".

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- Finite element analysis of the structure.

We have also completed site layouts for Mauna Kea and are planning to undertake further wind tests on Cerro Pachon. We are also planning to undertake computer flow simulations to evaluate the wind flow characteristics of the Cerro Pachon prime and an alternative west site.

— *Keith Raybould*

*Telescope Structure, Building/Enclosure Manager*

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## Optics Group

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**R**ecent efforts of the Optics Group have concentrated on the primary mirror assembly and the f/16 secondary mirror assembly. In December we added two design draftsmen to the group, Dale Circle and Joe DeVries, and their principal responsibilities in the coming months will be conceptual design layouts for these two assemblies.

### *Primary Mirror Assembly*

Since the last Gemini newsletter the contract with Corning for fabrication of the 8-meter primary mirrors has been finalized and approved. Ron Price and Ken Krohn attended a "kick-off" meeting at Corning's Canton, NY, plant in November, to meet the personnel who will be working on our contract. Corning is making good progress and has already produced 16 boules of ULE™ glass that meet the tight Gemini specification.

We are in the process of preparing the Request for Proposal for polishing the primary mirrors. Optics Group members have recently met with representatives from most of the potentially qualified optical firms, to discuss polishing and testing capabilities. The recommendations of these polishers are being considered as we finalize the specifications in the RFP.

Conceptual design work on the primary mirror assembly is progressing well. Eugene Huang has developed a

mirror cell structural design that has excellent stiffness properties. He is working with Mike Sheehan and Peter Hatton to define the interface to the telescope structure, and with David Montgomery to define the interface with Cassegrain instrumentation. Ron Price has been working with Dale Circle to develop the mechanical design of the mirror cell components, particularly mirror support mechanisms.

Myung Cho has continued finite-element analysis of the meniscus mirrors, investigating the effects of random force errors, uneven wind loading, and possible stresses in the glass resulting from worst-case control malfunctions. He has also modeled the active optics performance of the mirrors. His analysis indicates the active optics system will be able to compensate for gravity-induced flexure of the secondary mirror, and can correct matching error between the primary and secondary mirrors, if it occurs.

Myung and Eugene have investigated a number of different configurations for the axial and lateral supports. The current design has 120 axial supports, and 72 lateral supports, with the majority of the mirror weight at zenith pointing carried on a controlled air pressure system. A new design for the mirror defining system, that employs a slight amount of overconstraint, shows promise of significantly reducing the sensitivity of the mirror to force errors and uneven wind loads.

More work remains to be done, but all studies to date indicate the primary mirror will meet the Gemini error budget, and no "show-stoppers" have been found so far in any of the analyses.

### *Secondary Mirror Assembly*

John Roberts and Joe DeVries have been developing conceptual designs for the f/16 secondary mirror assembly. John has developed several candidate articulation mechanisms, and has been investigating actuators and position sensors.

Eric Hansen has performed finite-element analysis of the secondary mirror design. This includes design optimization studies, gravity-induced deflections, effects of non-uniform temperatures, and the dynamic "ringing" distortions that occur during the dwell periods of the chopping cycle. The mirror performance appears to be excellent, and it is within the error budget in all cases.

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We have consulted with potential fabricators of the silicon carbide secondary mirror blanks, and it appears there will be no problem getting affordable fixed-price bids for the blanks.

### *Other Activities*

Myung and John have continued to improve our analysis capabilities with custom programs that allow us to take full advantage of the commercial software we have. We now routinely analyze mirror deformations with the I-DEAS finite-element software, post process the data (for example to take out piston, tilt or focus, or to superimpose data from different analysis cases) and then transfer this information to CODE V for optical analysis. We have also been running parametric studies to help define specifications for image quality, image motion, and optical surface accuracy.

—Larry Stepp  
*Optics Manager*

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## Controls Group

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**T**he major effort within the Controls Group since the last newsletter has been to expand the base for successful subcontracting of the work packages.

### *Electronic Design Specification*

ASA Automation was awarded a contract to produce an Electronic Design Specification document to be used both internally by Gemini personnel and externally by Gemini Contractors. This document, similar to the CFHT Instrument Design Specification, is intended to be part of the requirements for all equipment supplied to the Gemini Project. Our goal is not to make an onerous document but rather to establish sensible standards and guidelines so that all equipment is of a uniform high quality that will meet the rigorous demands of Mauna Kea and Cerro Pachon. Preliminary versions of this document will become avail-

able in the Gemini ftp area in the near future. Contact syrick@noao.edu for more information.

### *Real Time Operating Systems*

The group has decided that the real time operating system of choice is Wind River Systems' VxWorks. The primary concerns were the current level of support among industry hardware and software vendors, the power of the development environment, and wide acceptance in the astronomical community. We have purchased a system to be used by the Project—this system will be used to demo systems which require VxWorks, as a control system for the Friction Driven Test Rig, and as a means for Gemini personnel to become familiar with VxWorks. Contact pmcgee@noao.edu for a copy of the report justifying this choice.

### *Visualization Products*

The examination of the product PV-Wave from Visual Numerics (the recent merger of Precision Visuals and IMSL) has been completed. The system was generally well-received and has a reasonable pricing structure. Although it lacks the more specialized astronomical data reduction capabilities of packages like IRAF, its ease of use, flexibility, and ease of incorporating user-written procedures makes it applicable for most signal and image display and analysis tasks. We intend to adopt PV-Wave for both in-house and project real-time visualization needs.

### *Operator Interface and Real Time Database*

Besides the evaluation of Hewlett Packard product RTAP (see October 1992 Newsletter), the group is actively investigating the EPICS (Experimental Physics and Industrial Control System) package that was co-developed by the Los Alamos and Argonne National Laboratories for their Linear Accelerator programs.

EPICS is widely used at the Los Alamos, Argonne, Livermore and Berkeley laboratories as well as at the Superconducting Super Collider Project (SSC) in Texas. Its authors are arranging with several prospective industrial partners to turn EPICS into a fully-supported commercial product.



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This system is designed to work with the VxWorks real time operating system and includes the following features:

- it provides an inherently distributed real time database
- it provides a complete user interface
- it provides support for a variety of VMEbus devices
- it provides for archival and monitoring of database values
- it provides for the graphical display of either archived or real time database contents

Once the VxWorks system is set up, the group will be running EPICS on it for a trial demonstration of its capabilities. The first trial will be using EPICS state notation compiler to create a complete simulation of a CCD Controller. The second trial will be to run the friction test rig using the Delta-Tau VME control board.

Once the EPICS evaluation is complete, the Project will be making a choice between RTAP and EPICS as the basis for the Gemini Software system.

### *VMEbus Board Selection*

The process of defining standard boards to populate the control system's VMEbus instrumentation crates has begun. Our first selection is of the Motorola MVME-147 for primary crate controller and VxWorks target. For subsystems like active optics that require rapid computational rates an as yet unspecified RISC processor may be substituted.

A list of standard boards for performing basic control functions (like analog input/output, binary input/output, stepper motor controller) is being compiled. Board performance, as well as the presence of VxWorks driver software, are both issues to be considered. This list will become part of the Electronic Design Specification.

### *Fieldbus Solutions*

For certain telescope subsystems that only require simple, low-bandwidth control solutions it may not be necessary to dedicate an entire VMEbus crate for the task. As a low power use alternative we are investigating several

fieldbus technologies, primarily BitBus, CanBus, and Profibus. Factors under consideration include:

- the existence of VMEbus based controllers for each
- the existence of support software for the controllers in the VxWorks environment
- data transmission rates
- power requirements

### *Future Work*

The group continues to define the hardware and software framework in which the Gemini control system will be built. By creating definitions for all levels of the project we intend to standardize the components of the subcontracted work packages.

—*Peregrine M. McGehee*  
*Instrument Control Software Engineer*

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## Instrumentation Group

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### *Gemini Instrument Working Groups*

**A** plan for the development of the Gemini Instrumentation Program was approved at the last Gemini Board meeting in November.

The plan involves setting up instrument working groups for each of the areas consisting of scientific and technical representatives from each of the partner countries. The charge to each of these groups is to provide the scientific definition for each of the instrument functions and present their recommendations to the Gemini Science Committee (GSC) in March.

A period of more detailed definition will follow, culminating in an instrumentation plan to be presented to the GSC in September or October 1993 and to the Gemini Board in November 1993.

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Each of the partner country project offices proposed their representatives for the working groups; full membership of each group is given below.

Anyone from the Gemini partner communities who wishes to provide input into the Gemini Instrumentation Program should contact either the chair of the relevant group or their National Project Office. General information on the Gemini Instrumentation Program can be obtained from the Tucson project office.

### IR Imaging & Arrays

Jay Frogel (Ohio State University) -- Chair  
 James Graham (UC Berkeley)  
 Klaus Hodapp (University of Hawaii)  
 Phil Puxley (Royal Observatory Edinburgh)  
 Neil Rowlands (Universit  de Montreal)  
 Tom Soifer (Caltech)

### IR Spectroscopy

Pat Roche (University of Oxford) -- Chair  
 Jay Elias (CTIO)  
 Tim Davidge (Dominion Astrophysical Observatory)  
 Tom Geballe (Joint Astronomy Centre)  
 Paul Harvey (University of Texas)

### Adaptive Optics

Rene Racine (Universit  de Montreal) -- Chair  
 Richard Myers (University of Durham)  
 Don McCarthy (University of Arizona)  
 Steve Ridgway (NOAO)  
 Francois Roddier (University of Hawaii)

### Acquisition & Guiding and Active Wavefront Sensing

Charles Jenkins (Royal Greenwich Observatory) -- Chair  
 Jim Beletic (Georgia Tech)  
 Paul Hickson (University of British Columbia)  
 Robert Laing (Royal Greenwich Observatory)  
 Bruce Woodgate (NASA Goddard)

### Visible imaging and CCD's

Gerri Luppino (University of Hawaii) -- Chair  
 Jim Beletic (Georgia Tech)  
 Todd Boroson (NOAO)  
 John Geary (Harvard)

Paul Hickson (University of British Columbia)  
 Mike Irwin (Royal Greenwich Observatory)

### Multi-Object Spectroscopy

Pat Osmer (NOAO) -- Chair  
 Jeremy Allington-Smith (Oxford University)  
 David Crampton (Dominion Astrophysical Observatory)  
 John Huchra (Harvard)  
 Bob Schommer (CTIO)

### High Resolution Optical Spectroscopy

Caty Pilachowski (NOAO) -- Chair  
 John Landstreet (University of Western Ontario)  
 Max Pettini (Royal Greenwich Observatory)  
 David Walker (University College London)  
 Don York (University Of Chicago)

— *David J. Robertson*  
*Gemini Instrumentation Manager*

## *High Resolution Spectroscopy for the Gemini 8-Meters*

The Gemini Project Office, in consultation with David Walker at UCL, has been developing preliminary conceptual designs for the High Resolution Optical Spectrograph as a starting point for the newly formed working group. At this early stage in the design we are confronted with two possible schemes to implement high resolution spectroscopy. The first is to build an instrument at one of the Nasmyth foci. The second is to build an instrument to be used primarily at the Cassegrain focus. There are arguments pro and con for each of these alternatives.

One of the important considerations is the stability of the wavelength calibration. The Nasmyth mounted instrument would be in a constant gravity field, but would be very large and subject to accelerations as the entire instrument is rotated to follow the field rotation. On the other hand, the Cassegrain alternative would be more compact—and hence stiffer—but would be subject to a changing gravity vector. An important consideration in the Cassegrain case is the possibility of removing the instrument to a stable mount off the telescope and feeding it with an optical fiber. This would yield the highest stability at the expense of some light loss to the fiber.

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The elimination of the Nasmyth tertiary and quaternary mirrors would lead both to better throughput and better polarization characteristics, but this would be partially offset by the need to fold the optical path in some way for the Cassegrain system.

On the operational side, the changeover from high resolution spectrometry to other modes would be much facilitated in the Cassegrain case, since the Nasmyth changeover is seen at this point to be a daytime operation. It would involve both a change of the secondary mirror and the removal or insertion of the tertiary.

Finally, there are the cost implications. The Cassegrain mode has the potential for using the Adaptive Optics capability in the appropriate wavelength range, and this implies the possibility of a smaller beam size and hence a smaller instrument in general. Furthermore, there would be savings initially since there would not be a need at first light to have acquisition and guiding capabilities at the Nasmyth focus, or for the secondary and tertiary mirrors.

These and other questions will be addressed by the newly constituted working group, and we look forward to their report.

— William Weller  
Gemini Instrumentation Group

### *Cassegrain Rotator*

Of all the areas on a telescope, the Cassegrain focus has traditionally been the one which is modified and updated the most. Not that the original designs were too limited in scope, but rather they were overtaken by developments in instrument technology which have led to much larger and heavier instruments. There is also the diversity of instruments developed—typically over many years—which must be interchangeable at some level. With the Gemini Telescopes this trend will continue. There is a suite of Cassegrain instruments planned, covering wavelength ranges from 0.3 microns to 30 microns and fields from a few arcseconds to 45 arcmin. Most will have to be accommodated on the Cassegrain instrument rotator in various combinations. This calls for a versatile and adaptable structure which, in addition, must meet the requirements of calibration, active optics, adaptive optics and very demanding image quality.

### General Concept

Starting at the telescope interface beneath the mirror cell, the rotator consists of a large diameter bearing (*see figure 1*). The outer bearing is attached to the mirror cell, and the instrument support structure, which is attached to the inner bearing revolves beneath. The instrument support structure is roughly cubic on the outside with a cylindrical cavity inside. The instruments attach to the faces of the cube, one upward-looking and up to two side-looking with all the faces identical in terms of hole sizes, pitches etc. An articulating mirror assembly retained within the box feeds the side-looking instruments. This meets the science requirements calling for one upward looking instrument and one side-looking, addressable in a few minutes.

### Bearing

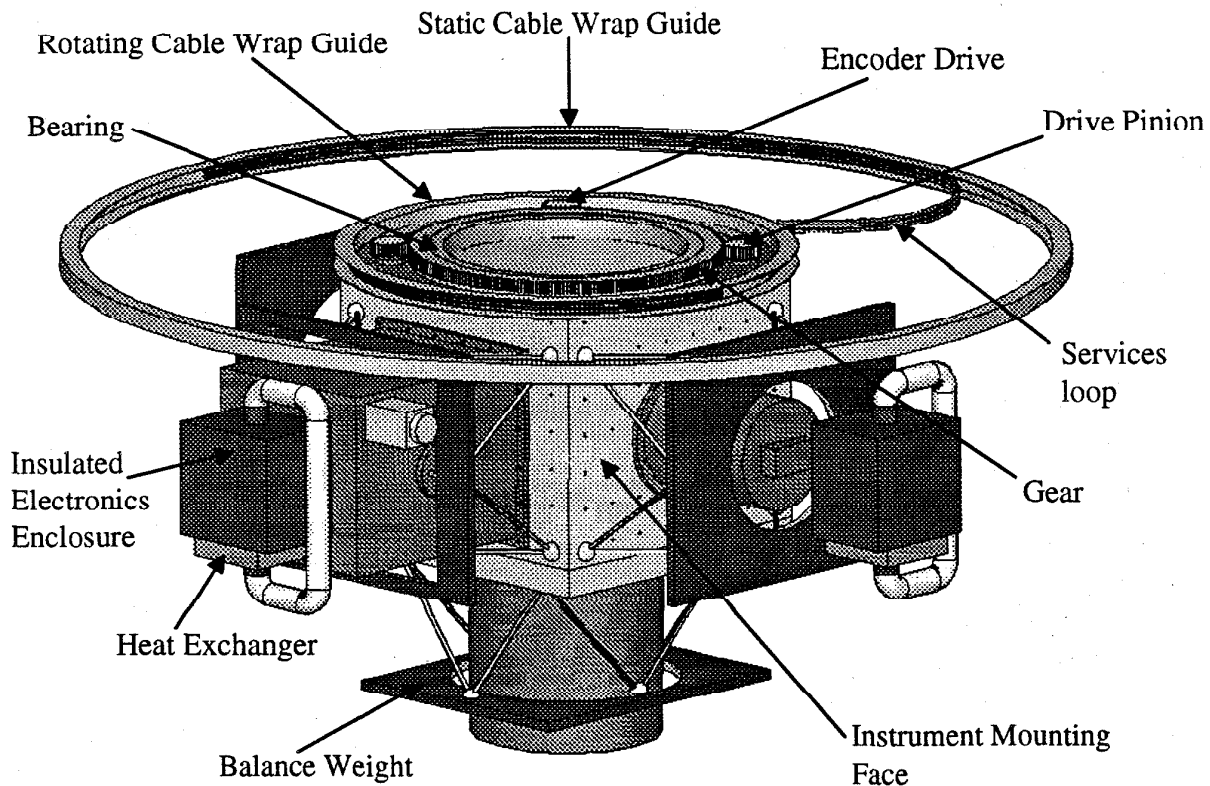
The rotator will use a large rolling element bearing (1500 mm dia.). At present, preliminary investigation has identified the need for either a crossed roller or a three-row roller bearing. This bearing has quite different load bearing duties compared to the other telescope drive bearings. It must support radial, axial, and moment loads that vary in magnitude and direction depending on telescope attitude. Unlike the other telescope drive bearings, which are hydrostatic, the Cassegrain rotator bearing will have significant frictional torque that is dealt with by the drive system.

### Drive System

The rotator drive is the third axis controlled on the telescope, after the azimuth and altitude. As such, the rotation accuracy is set by a fraction of the total pointing error budget, and the tracking accuracy is set by a fraction of the total image quality budget. This means that the rotator positioning and tracking must be better than 0.004 degrees.

There are two main contenders for the mechanical linkages between the servomotors and the rotator that are under investigation. The first is a conventional spur gear drive. The servomotor, through a reduction gearbox, drives a small pinion gear which in turn drives against the large stationary ring gear. The pinion gears must work in pairs to eliminate backlash. The second method involves the use of a cable wrap traction drive (*see figure 2*). Multiple cables are wrapped around a stationary cylindrical drum and a smaller capstan in a figure of eight. As the capstan is turned the cable wraps off it and onto the drum, and the capstan proceeds around the drum diameter. This has the advantage of freedom from backlash and smooth motion.

## GEMINI GROUP UPDATES



*Figure 1. Cassegrain Rotator Layout.*

Both of these drives will require position feedback to the servomotors, and methods of doing this are under investigation. Of particular interest is the work undertaken by the telescope group on the azimuth and altitude drive encoders.

### Instrument Support Structure

The instrument support structure is roughly cubic in shape, 1600 mm per side. An instrument can be supported on each of the four faces, fed by an articulating flat. Two of the port faces will be occupied with facility instruments, i.e. an imager for acquisition and a calibration unit. Inside the cube there is a cylindrical cavity, which will house an adaptive optics module, capable of 'switching in' and feeding an upward looking or side looking instrument. Recent work at DAO with a preliminary design to do this has been encouraging.

The instrument support structure will weigh around 3 tonnes. Each port face will be capable of supporting an instrument of 800 Kg. with an unrestricted space envelope of around 1600 mm cubed with a larger restricted envelope, which will depend on instrument shape and orientation.

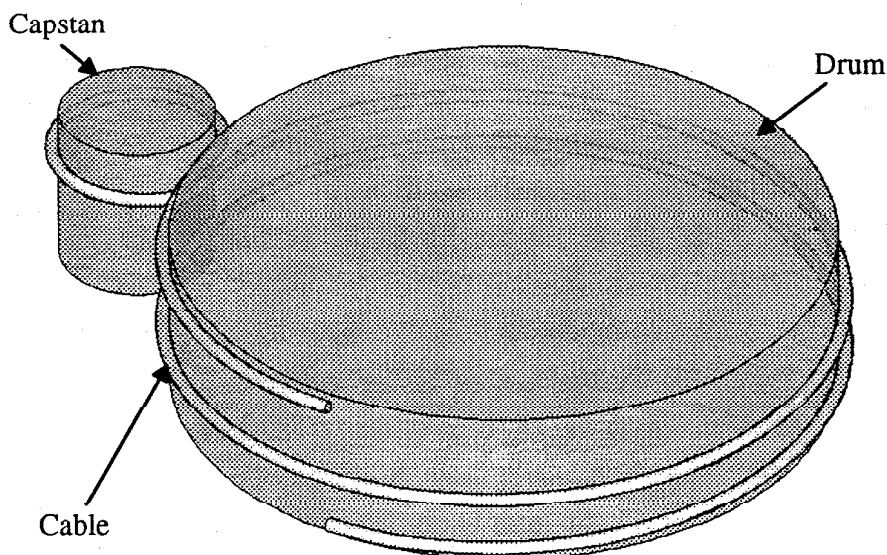
It is unlikely that the Cassegrain rotator will fulfill all the demands placed on it in the long term. Who can predict what type of science the Gemini Telescopes will be doing in 2020? However, the demands which this design will place on the telescope and mirror cell will leave a very useful interface, capable of supporting a substantial instrument 'payload' in terms of mass and volume for future re-configuration of the bottom end.

— *David Montgomery*  
Gemini Instrumentation Group

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**GEMINI GROUP UPDATES**

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**Figure 2.** Typical Cable Wrap for Multiple Turn Cable Drive.

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### *Adaptive Optics*

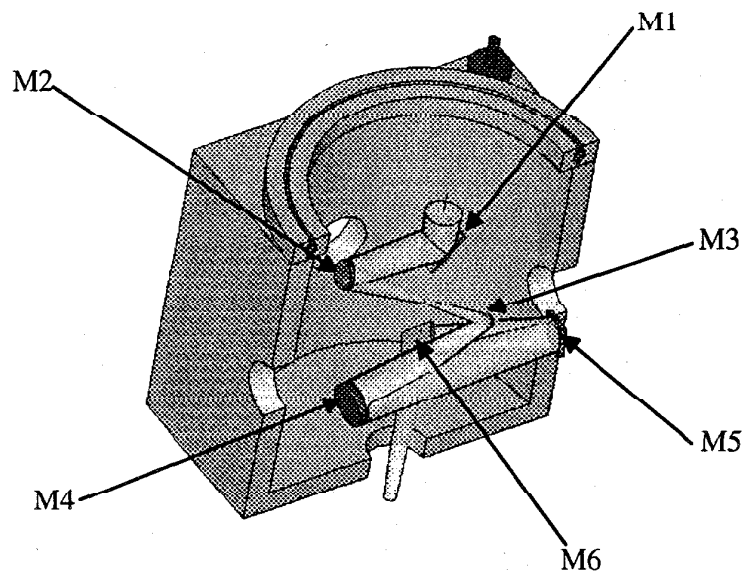
At the request of the Gemini Canada Project Office, Harvey Richardson (Univ. of Victoria) has produced a preliminary concept design for a low-order AO system for Gemini (*see figure 3*). The system mounts within the space envelope of the instrument mounting unit. In accordance with the Gemini Science Requirements, the AO unit must be addressable (i.e., easily switched in) without changing the properties of the  $f/16$  beam. This is achieved by inserting mirrors M1 and M6. Additionally, by rotating M6 the beam can be steered to one of the side looking ports allowing for more than one instrument to be addressable by the unit.

This concept will be presented at the meeting of the AO working group at the end of January and should serve as the starting point for a full AO design study later this year.

— *David J. Robertson*  
*Gemini Instrumentation Manager*

## GEMINI GROUP UPDATES

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- M1 Folding Flat 216 x 153 mm  
 M2 Off-axis Concave Hyperboloidal Mirror 128 x 124 mm  
 M3 Deformable Mirror 65 x 60 mm  
 M4 Off-axis Concave Ellipsoidal Mirror 206 x 209 mm  
 M5 Folding Flat 151 x 153 mm  
 M6 Flat Diagonal Mirror-Beamsplitter 159 x 114 mm

*Figure 3.* Preliminary Optical Design of Gemini Adaptive Optics Module.

## Administrative Management Group

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**T**he Administrative Management Group has been involved in four key areas of responsibility in support of the Gemini Project: (1) contract solicitation and management, (2) budget preparation, (3) cost tracking, and (4) project scheduling. Budget preparation and project scheduling are worked on both a yearly and a long-term project basis. Much has been accomplished in all four areas over the past four months thanks to a team effort by

the Administrative Management Group and the other Group Managers.

Since the last newsletter, the Administrative Management group has been assigned the responsibility for project scheduling. In September 1992, Dan Eklund joined the Gemini team as Project Scheduler. Dan came to us from the University of Arizona Optical Sciences Department and was quick to grasp the process required for developing an overall project schedule for Gemini. On his arrival, he immediately began reviewing the project goals, tasks, and organizational structure to formulate how he thought the schedule should be developed. With the help of the Gemini managers, Dan came up with the preliminary criteria and format. In a very short time he had selected the software and began inputting data from the Group Managers. In December 1992, Dan printed out the first PERT schedule for Project Gemini with over 400 separate tasks shown over the various schedule paths. Although this schedule current-

## GEMINI GROUP UPDATES

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ly shows only a small number of the total project tasks, it is a start in the right direction for development of a final project schedule. Dan's next tasks are to refine the current schedule and to develop the critical path for the project. As with any complex task, no one can do it alone. Dan was—and still is—heavily dependent on the project Group Managers' and the Financial Administrator's inputs for development and maintenance of the project schedule. It has been a team effort. Dan, in addition to his scheduling duties, is also working with the various Group Managers to develop databases which will supply additional data for the schedule and will also be utilized for reports to assist the Group Managers.

The Financial Administrator recently implemented a Financial Management Reporting System. This system receives data input from the NOAO Accounting System based on NOAO's fiscal year and converts the data to Gemini's calendar year for reporting purposes. The converted data is then used to produce various internal and external management reports for financial tracking. The Financial Management Reporting System provides the flexibility to tailor management reports to specific needs and will provide improved responsiveness to "ad hoc" reporting requirements. Several standard reporting formats have already been developed, and Group Managers should see the full complement of these reports when the December 31, 1992 books are closed. Suggested enhancements to these formats are always welcome. These reports will also be reviewed by the Gemini Board Finance Committee.

In addition to the Financial Management Reporting System, NOAO is providing the Gemini offices with a real-time link to their accounting system. This will provide on-line query capability to determine status of Gemini accounts (e.g., expenditures, commitments, budget balance available), and the status of purchase orders and contracts. Currently, only the Financial Administrator has this query capability; but the licensing software for 10 Gemini users is on its way and will be installed soon. This will allow other Gemini Managers to access the system and to utilize the available information for planning purposes.

Making final revisions to the '93 Budget has received much priority in the past several weeks. In addition, a major effort has been expended to simultaneously develop the project's long-range spend/commit forecast. The Administrative Management Group appreciates the many hours the

other Groups have devoted to the drudgery of forecasting funding requirements.

The past four months have been a busy time for Ken Krohn, the Contract Administrator. We still have thirty-four (34) active contracts that are managed by the Administrative Management Group with the help of the representatives of the various groups within Project Gemini. The active contracts are proceeding well thanks to the help of our secretary, Jean Pelz, and project secretary, Pat Baker. The contractual and legal side of the contracts process can only go well if the associated administrative duties are performed properly.

We recently closed out twenty contracts, most of which were in the Telescopes and Enclosure Group. Several others were terminated for convenience, and three were cancelled. The future looks busy for Ken as he is preparing to write the Request for Proposal for the 8-m mirror polishing contract. This will be another team effort between Ken and the Optics Group Manager and his people. There is no specific time yet when this task will be completed or when a contract will be let.

In addition to the other tasks performed in the Administrative Management Group, the group recently completed a draft agreement between AURA and the Canadian Commercial Corporation (CCC). The CCC will let contracts in Canada as requested by Gemini once the agreement is final and has been signed by AURA and an official of the CCC. We previously completed a draft agreement with the Science and Engineering Research Council (SERC) for processing and completing work packages in the UK. We are awaiting comments from the UK on that proposed agreement. Ken Krohn recently completed the revised Gemini Contracting Procedures; these are currently being reviewed prior to forwarding to AURA for review and approval. 1993 is expected to be a busy year, but the Administrative Group is looking ahead to the new year with great expectations for helping to move the project forward.

— Jack Morton  
Administrative Manager

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*Reports from the National Project Offices*

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## Notes from the U.S. Project Office

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**O**n February 1st, Fred Gillett of NOAO became the Acting U.S. Gemini Project Scientist. Fred chaired the Infrared Panel of the Astronomy and Astrophysics Survey (Bahcall) Committee, leads the IR Subcommittee of the U.S. Gemini Science Advisory Committee, and serves on the international Gemini Science Committee. Fred and his subcommittee produced the performance requirements document that serves as the basis for the imaging specification of the telescopes, as well as defining the thermal emissivity goals. Fred interacts with the Project on an almost daily basis, working with the various group engineers and Matt Mountain to assure that the design will meet the stringent performance standards. Richard Green has relinquished the national project scientist duties on an interim basis to concentrate on NOAO responsibilities while Sidney Wolff serves as Acting Gemini Director.

As discussed in this Newsletter, the Instrument Working Groups are now in the process of defining performance requirements and identifying potential participants in the process of designing and building the first-light instrument complement. In order to function efficiently, the working groups were purposely chosen to be small, but the U.S. participants take seriously their roles of representing the larger U.S. community. Now is the time! If you want to be part of the process of defining the performance of a particular instrument, or wish you and your group to be considered as suppliers of an instrument or partners in a joint development program, please contact the appropriate U.S. working group member. They intend to develop an email network of interested participants, and will consider your input carefully in their deliberations.

List of U.S. Instrument Working Group contacts:

Adaptive Optics: Steve Ridgway  
sridgway@noao.edu

Guiding and Active Wavefront Sensing: James Beletic  
beletic@gtri.gatech.edu

OUV Multi Object Spectroscopy: Pat Osmer (chair)  
posmer@noao.edu

Visible Imaging, CCD's: Gerry Luppino (chair)  
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OUV High Resolution Spectroscopy: Caty Pilachowski  
(chair)  
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IR Imaging and Arrays: Jay Frogel (chair)  
frogel@payne.mps.ohio-state.edu

IR Spectroscopy: Jay Elias  
jelias@ctio.noao.edu

Fred and I are also happy to talk with you any time about the Gemini instrumentation program.

*—Richard Green  
U.S. Project Scientist*



## Reports from the National Project Offices

# Survey Spectroscopy with Gemini

—by *Jeremy Allington-Smith*  
*Oxford University*

To decide on the instrument package for each telescope, working groups have been set up in each instrument area with one group looking specifically at multiobject spectrographs working in the optical and near-UV. So far, discussions within the project have centered around two instrument concepts provisionally named WIFOS and SIS. These offer different tradeoffs between field of view and spatial resolution which results in a different scientific emphasis for each. This article discusses some key scientific objectives which these instruments should address.

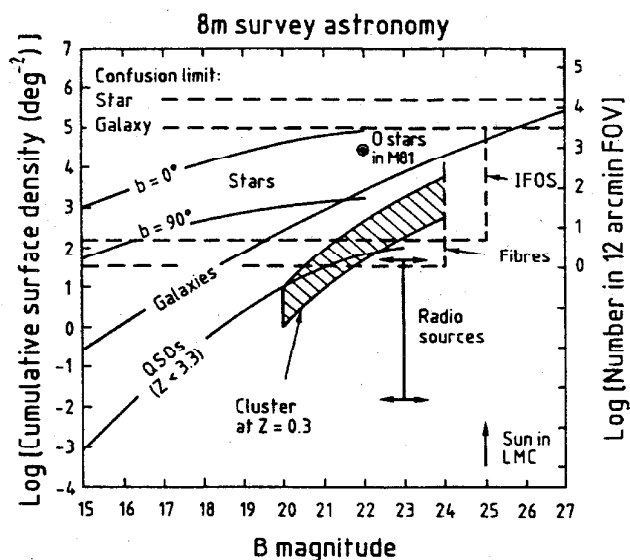
### Extragalactic Survey Astronomy

One of the main scientific aims of Gemini is to study the evolution and formation of galaxies. Together with detailed studies of processes in nearby galaxies, this requires integrated spectroscopy of large numbers of normal galaxies and rarer objects such as QSOs to significant look-back times (at  $z = 1$  the universe is 1/2 to 1/3 of its present age depending on cosmological model). Here I discuss some of the issues related to surveys of cosmologically significant populations. Of course there are many other programmes, such as studies of star clusters and stars and HII regions associated with nearby galaxies, which also require a multi-object capability, but I will not discuss these here.

Figure 1 shows the surface density of important classes of extragalactic objects: field galaxies, QSOs and extragalactic radio sources. The diagram also shows the numbers which would be found within a circle of diameter 12 arcmin which is the field of view proposed in a design study for the Imaging Faint Object Spectrograph (IFOS)[1]. Also shown is the region occupied by galaxies in clusters and groups at  $z = 0.3$  on the assumption that the spectrograph is appropriately targeted. At this redshift, the spectrograph field of view corresponds to a diameter of

$\sim 2 h_{100}^{-1} \text{ Mpc}$  which is a good match to the full extent of a rich cluster.

The figure also shows the area of the diagram in which a multiaperture spectrograph is competitive with single-object instrumentation. This assumes that the minimum useful multiplex gain is five (5). The maximum gain depends on the spectral format but is generally 50-100. The maximum permissible object density is set by the confusion limit at which too many objects crowd the slit to allow



**Figure 1.** The cumulative surface density as a function of magnitude for galaxies[6], QSOs with  $z < 3.3$ [7] and galactic stars for  $b = 0^\circ$  and  $b = 90^\circ$ . The range of surface density for extragalactic radio sources with 408-MHz flux density between 1mJy and 10Jy is indicated. The numbers to be found in a circle of diameter 12 arcmin (the proposed field of view of IFOS[1]) are shown on the right-hand scale. The numbers of galaxies with  $M_v < -19$  found in such an area in clusters with richness intermediate between Abell class 2 and the poor groups associated with radio galaxies[8] at  $z = 0.3$  are shown as the hatched region. The position on the diagram of O-stars in M81 is also indicated. The regions of greatest efficiency for a multiaperture spectrograph similar to IFOS[1] and for a multifibre system are indicated by dashed lines and labeled *IFOS* and *Fibres* respectively. The confusion limits for unresolved and extended objects (size  $\sim 3$  arcsec) are also shown.

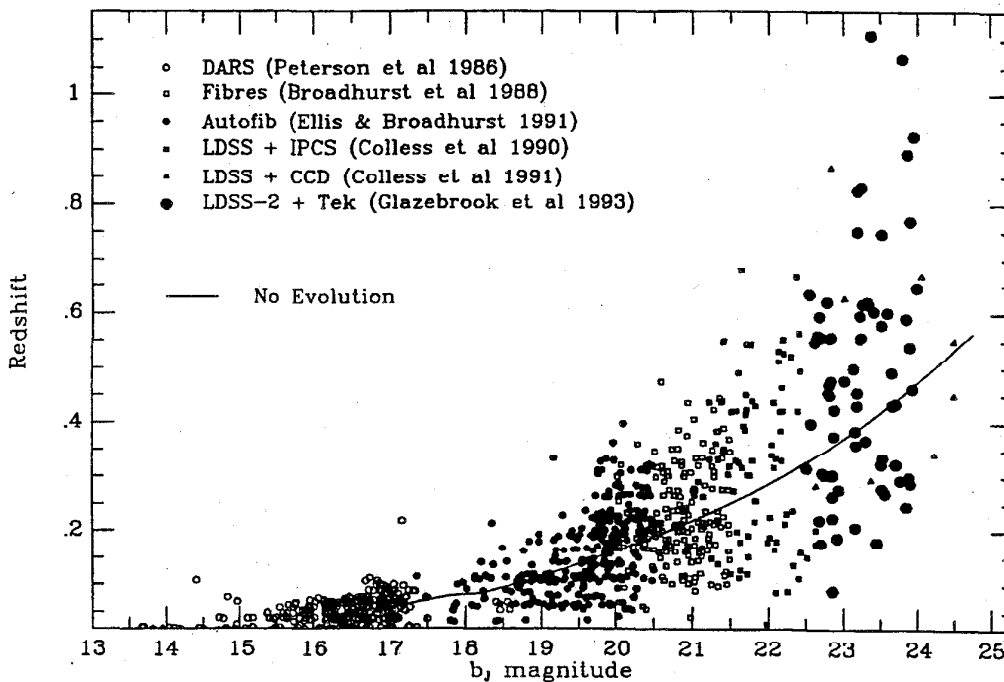
## Reports from the National Project Offices

proper sky-subtraction. The limiting magnitude may be estimated from the performance of the recently-completed Low Dispersion Survey Spectrograph (LDSS-2)[2] on the 4.2m William Herschel Telescope on La Palma. **Figure 2** shows some results from a field galaxy redshift survey to  $B = 24$  carried out during commissioning. The limit shown in Figure 1 is based on an extrapolation to an 8-m telescope with an exposure time of approximately six hours.

The great advantage of multiaperture spectroscopy is that it is possible to subtract the sky spectrum very accurately using the contiguous sky information available from each slit. Because fibres do not provide this information, the accuracy of sky-subtraction is reduced leading to a brighter limiting magnitude. Experience with the long-term programme of Figure 2 suggests that this limit is  $\sim 1$  mag brighter than for multiaperture instrumentation. However, the greater field of view available to fibres (45 arcmin at

f/6) offers the opportunity to survey objects with a lower surface density.

Figure 1 shows that multiaperture spectroscopy is most efficient for field galaxies with  $B > 19$  but less good for intrinsically rare objects such as QSOs—although a search for primeval galaxies with  $z > 3.3$  would be efficient since these would appear in Figure 1 between the QSO and galaxy curves at  $B > 22$ . Clusters at low and intermediate redshifts are also most practicable with a multiaperture system although, at  $z > 0.3$ , the efficiency drops as the cluster underfills the field of view and the density of targets in the core increases. Fibres are better suited to brighter and rarer objects such as the brighter QSOs and field galaxies in surveys of large scale structure which place emphasis on large areal coverage rather than depth.



**Figure 2.** The magnitude—redshift diagram for surveys of field galaxies. The solid dots are for a sample defined by  $B < 24$  observed with LDSS-2 during commissioning in April 1992. Three fields were observed with typical exposure times of 4 hours. Secure redshifts were obtained for  $\sim 80\%$  of the sample. Despite the steeply rising blue galaxy counts reported by other workers, the best fit to these data (solid curve) is a model in which there is no active evolution of the stellar populations.

## Reports from the National Project Offices

### Field of View and Spatial Resolution

It is clear that field of view is the most important criterion for surveys of cosmological populations. Current optical designs (such as that of LDSS[3]) permit a maximum of 12 arcmin diameter. However, the spectral and spatial sampling is also very important, especially for unresolved objects where it is desirable to exploit the excellent image quality that the Gemini telescopes will deliver.

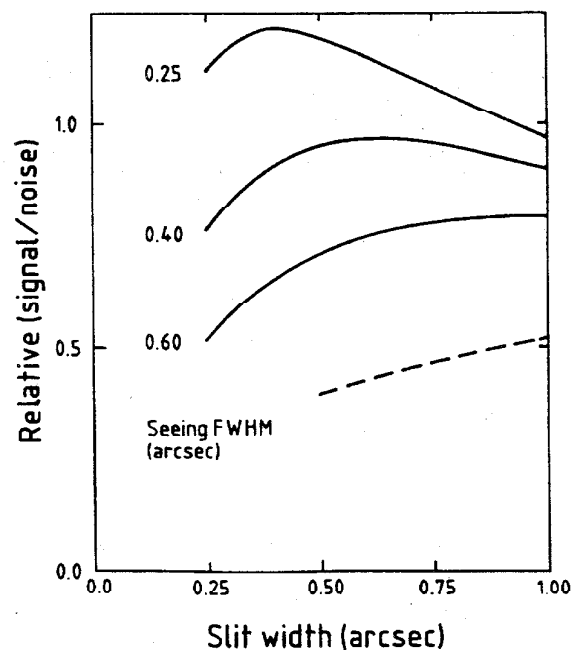
Many extragalactic survey targets will be faint galaxies of typical size 3 arcsec for which the signal/noise for detection is optimized with slits wider than 1 arcsec. Unresolved objects will require narrower slits in order to increase detection signal/noise by rejecting the background. *Figure 3* shows that in median Mauna Kea *free-atmosphere seeing* (0.4 arcsec FWHM), the optimum slit width for detection of *unresolved* objects is  $\sim 0.6$  arcsec. If we design the spectrograph for the best (10th percentile) free-atmosphere seeing at Mauna Kea, 0.25 arcsec FWHM, the optimum slit width for detection is 0.4 arcsec which implies detector pixel sizes of 0.1-0.2 arcsec for spectroscopy.

If the pixel size is made smaller than necessary, problems with oversampling when working with a wide slit will result and the detector cost will be increased unnecessarily. Note that a single 4096 x 4096 array would match a 12 arcmin field of view with a pixel size of 0.18 arcsec. But there is another tradeoff between field and spatial resolution which may be more important. It is hard to design a wide-field spectrograph with excellent image quality unless the input focal ratio is slow. But a slow focal ratio also implies a very large collimator pupil-relay lens which may limit the field of view. The choice of field of view versus spatial resolution should be based on the scientific objectives of the project but will also be dictated by the optical configurations of the telescopes.

Only at  $f/6$  will it be possible to have the large field of view required for cosmological studies ( $\sim 12$  arcmin diameter) while at  $f/16$  the field will be limited by the size of pupil-relay lens (possibly 6-8 arcmin). However, the latter configuration offers the compensation of higher spatial resolution, tilting the scientific emphasis away from cosmology towards spatially-resolved studies of brighter objects. These contrasting instrument concepts have been designated WIFOS (Wide-field Imaging Faint Object Spec-

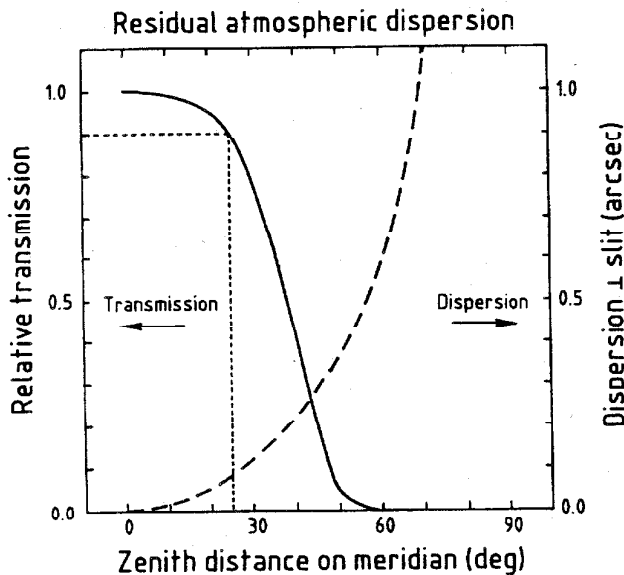
trograph) and SIS (Subarcsecond Imaging Spectrograph) respectively.

Atmospheric dispersion is a particular problem for multiaperture spectroscopy especially at high spatial resolution. This is because exposure times on faint survey targets are likely to be very long and because a multiaperture mask can only operate at the position angle for which it was designed. Thus, even if the slits are at the parallactic angle at the midpoint of an sequence of observations, they will be misaligned at the beginning and end of that time leading to light at the extreme wavelengths missing the slit. From *Figure 4*, it can be seen that this effect will cause unacceptable slit losses at high spatial resolution unless atmospheric dispersion compensation is provided.



**Figure 3.** The solid curves show the relative signal/noise for the detection of unresolved objects in different seeing assuming a Moffat profile with  $\beta = 2.5$  where it is assumed that the noise signal increases in direct proportion to slit width (appropriate for background- and readout noise-limited cases). The dashed curve is for a resolved object with an  $r^{1/4}$  profile with  $r_c = 1.5$  arcsec. This illustrates that the optimum slit width for the detection of an unresolved object in the best (10th percentile) natural seeing at Mauna Kea is 0.4 arcsec.

## Reports from the National Project Offices



**Figure 4.** The dashed curve shows the amount of residual dispersion perpendicular to the slit axis between wavelengths of either 350 or 900nm when guiding at 480nm as a function of zenith distance on the meridian for an observation of 4 hours for which the slit is aligned with the parallactic angle at the midpoint of the observation at transit. The solid curve shows the estimated slit transmission at the start and end of the observing sequence at the extreme wavelengths for an observation of an unresolved object in seeing of 0.25 arcsec FWHM with a slit width of 0.4 arcsec.

### Spectral Resolution and Wavelength Range

For cosmological surveys, the required resolving power is typically  $R \equiv \lambda/\Delta\lambda \sim 500$ . This gives sufficient precision in the redshift measurement, allows the object to be classified on the basis of its spectrum, and permits good subtraction of night sky emission lines longward of 700nm. For studies of galaxies in clusters or groups (or singly), it is important to obtain information on the stellar populations from emission lines and absorption features and to determine velocity dispersions and study kinematic features.  $R = 2000$  allows velocities to be measured to  $\pm 15$  km/s for signal/noise  $\sim 10$  and velocity dispersions to  $\pm 60$  km/s ( $\pm 20\%$ ). This can easily be achieved with a grism spectrograph with a pupil of  $\sim 120$ mm and a slit width of 0.5 arcsec.

For high-redshift applications, the wavelength range should ideally ensure that either [OII] $\lambda 3727$  or Ly $\alpha$  is always in the observed window, which implies a wavelength range of 370-1100nm. This is at the extreme limit of the capabilities of CCDs and would be hard to achieve with a single-channel optical design. Extension further into the near-infrared (as would be desirable to observe key spectral features at high redshift[4] and to exploit adaptive correction) to the maximum wavelength at which the background from an uncooled spectrograph becomes an appreciable fraction of the sky background ( $\sim 1.4\mu\text{m}$ [5]) could probably only be achieved with a separate optical system and detector.

### Versatility

To carry out these programmes, it is clear that the spectrographs must be highly versatile. The multiobject capability demands an imaging mode for target acquisition and possibly to generate target positions in near real-time. Such an instrument could also double as a wide-field imager with some compromise in throughput compared with a dedicated instrument. The wide range of resolving power ( $200 < R \leq 2000$ ) requires interchangeable dispersing elements and the wide wavelength range may in practice require a dual-channel optical system which might fortuitously pay dividends in terms of operational flexibility. Finally, it should be possible to reconfigure the multi-aperture system rapidly in response to changing sky conditions either by using an automated multislit unit or with on-site mask manufacture.

### References

- [1] Allington-Smith *et al.*, UK Large Telescope Project Technical Report No. 20 (ed. R L Davies).
- [2] Allington-Smith *et al.*, proceedings of the ESO conference on *Telescope and Instrumentation Technologies*, ed M-H. Ulrich, ESO, p671.
- [3] Wynne & Worswick, *The Observatory*, **108**, 161 (1988).
- [4] Rawlings *et al.*, *Mon. Not. R. astr. Soc.*, **251**, 17p (1991).
- [5] Roche & Glasse, UK Large Telescope Project report (3 May 1990) and P. Roche, private communication.
- [6] Broadhurst *et al.*, *Nature*, **355**, 55 (1992).
- [7] Hartwick & Schade, *Ann. Rev. Astr. Astrophys.*, **28**, 437 (1990).
- [8] Allington-Smith *et al.*, *Astrophys. J.*, in press.

## *Reports from the National Project Offices*

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### UK Project Office Explores Adaptive Optics Possibilities

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**L**ast year a working group was set up by the UK project Office to identify the measures needed to prepare the UK community for using AO on Gemini. The group was asked to review the current state of wavefront correction on existing telescopes, produce an assessment of the technical feasibility and scientific gains of various levels of wavefront correction, explore the various methods for providing the phase reference (including laser beacons), examine methods of wavefront sensing and other critical technical issues and, finally, to formulate a plan to develop the UK potential for contribution to adaptive optics for the Gemini telescopes.

The members of the group were:

Justin Greenhalgh, Oxford/RAL, UK Project engineer  
 Chris Haniff, MRAO  
 Charles Jenkins, RGO  
 Robert Laing, RGO  
 Terry Lee (Chair), ROE, UK Project manager  
 Lance Miller (Secretary), ROE  
 Richard Myers, Durham

Their report was produced at the end of last year and widely distributed in the UK. From this, a programme to be funded by the UK Project Office has been formulated. Briefly, this includes:

(1) Measurement of infrared atmospheric properties on Mauna Kea using UKIRT. This will give the coherence time and correlation length for various weather conditions using IRCAM equipped with a 4-hole aperture plate located at an image of the pupil so that the differential motion of the sub-images can be tracked at a rate of 100Hz.

(2) Tip/tilt stabilization for UKIRT. A prototype tip-tilt system with a bandwidth of at least 100Hz equipped with a quadrant wavefront sensor will be installed to feed IRCAM.

(3) Use of Martini with an IR camera at the WHT. The upgrade of IRCAM on UKIRT will release a 58x62 element InSb array for use on La Palma. This will be interfaced with a 6-mirror Martini system to produce near-IR images with FWHM in the range 0.2-0.3 arcsec, approaching the diffraction limit under the best conditions.

(4) Improvements in wavefront sensors for use on UKIRT and the WHT. New wave-front sensors will be investigated, such as APD quadrants and fast-readout CCDs (using a transputer-based readout system developed at ROE). The plan is to use an APD sensor with (2) and also to upgrade the Martini wavefront sensor which is currently an IPD. This should improve the limiting magnitude by a flux factor of 10-100.

The first two of these items will be carried out by ROE with the measurements for (1) and (2) expected early this year. A programme to implement (3) in late 1993 has been put together involving ROE, RGO, Oxford and Durham. Further stages are envisaged to evaluate the results of these four programme items and to plan for more advanced systems.

— *Jeremy Allington-Smith*  
*Oxford University*



# GEMINI

## 8-M Telescopes Project

950 N. Cherry Avenue  
P.O. Box 26732  
Tucson, Arizona 85726-6732  
Fax: (602) 322-8590

The activity of the Gemini 8-M Telescopes Project to date is documented in the following list of technical reports. Copies of these publications are available on request by contacting the Gemini Project at the above address or Fax number, attention: Linda Friedman, Documentation Coordinator. Specific report numbers are listed following the author(s) name in parenthesis.

### Technical Reports

12/91 — Theoretical Study of the Image Quality of an 8M Primary Mirror Having Print-Through Undulations over the Mirror Surface, G.Catalan, C.M. Humphries, & E. Atad-Ettdedgui. (RPT-O-G0001)

2/14/92 — Progress Report for March 9, 1992, Informal Telescope Review Meeting, P. Gillett. (RPT-TE-G0002)

5/29/92 — Interim Telescope Structural Analysis Report, Comparison of the Baseline and New Top End Design Concepts, M. Sheehan. (RPT-TE-G0003)

7/28/92 — Interim Servo System Performance Analysis Report, R. McGonegal. (RPT-C-G0004)

11/11/92 — Gemini Science Requirements, P. Osmer. (SPE-PS-G0001)

**NOTE:** There is now a copy of the most recent Gemini Science Requirements document available via ftp. To access this document ftp to [gemini.tuc.noao.edu](ftp://gemini.tuc.noao.edu) and change directories to <ftp://pub/gemini>. There are two versions of the file, compressed and not compressed. The uncompressed version is called `science_reqs.ps`, and is ~250Kbytes long. This can be printed directly on any PostScript printer. The compressed version is called `science_reqs.ps.Z` and is ~87Kbytes long. Use `unix uncompress` to turn it into a PostScript file and print as above.

After you successfully connect to "[gemini.tuc.noao.edu](ftp://gemini.tuc.noao.edu)", please use "anonymous" as your login name, and your name as the password. The commands to retrieve the file are:

```
cd pub/gemini
get science_req.ps  (or get science_req.ps.Z)
quit
```

11/19/92 — Gemini 8M Telescope Design Requirements Document: Revision 1, Telescope Structure, Building & Enclosure Group. (SPE-TE-G0002)

12/9/92 — Gemini 8M Telescope Preliminary Design Review, P. Gillett et al. (RPT-TE-G0005)

12/9/92 — Progress Report for December 9, 1992, Informal Building, Enclosure and Site Plan Review Meeting, R. Ford et al. (RPT-TE-G0006)

12/2/92 — Gemini 8M Mauna Kea Preliminary Construction Plan, P. Gillett & G. Pentland. (RPT-TE-G0007)

7/21/92 — Engineering Geophysical Survey of the Gemini Site, Mauna Kea, Lepley & Associates. (RPT-LEP-G0008)

*In progress* — Active Sources Dissipating Power with the Gemini Facility, R. Ford. (RPT-TE-G0009)

1/15/93 — The Thermal Performance of Variable Diameter Flushing Enclosures, R. Ford. (RPT-TE-G0010)