GEMINI
8-M Telescopes
Project

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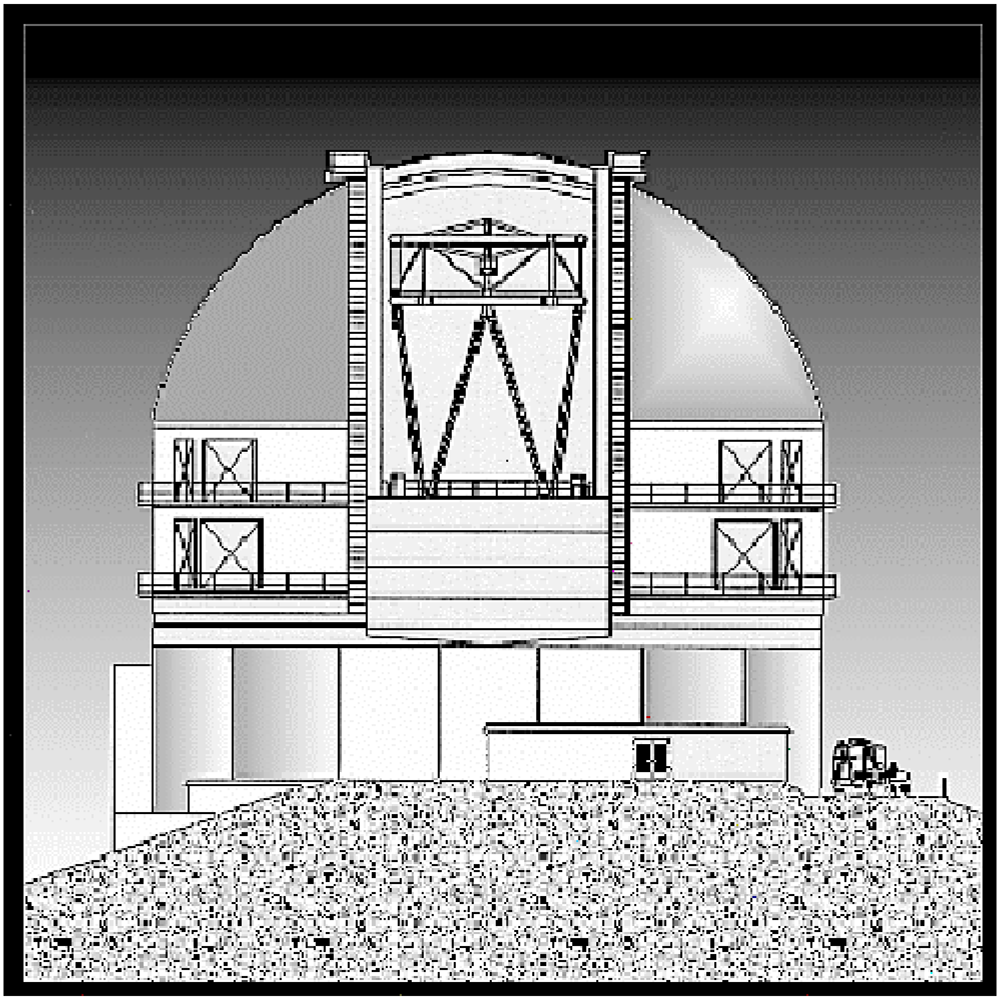
Report of the GMOS PDR Review Committee



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Report of the GMOS PDR Review Committee

and

Annotated Responses

The GMOS PDR was held at the DAO on March 26-27, 1996. The instrument scientists, managers, and many team members were present, as were the National Project Scientists and the Gemini Project Scientist. The committee consisted of Dave Cowley (DEIMOS Project Mgr. at Lick), Richard Green (NOAO, Chair), Tom Ingerson (CTIO), Craig Mackay (Cambridge), Jim Oschmann (IGPO), and Doug Simons (IGPO). The committee heard a half day of presentations from the team on changes to the design since the CoDR; the subsequent two half days were spent discussing the preliminary design on the basis of the documentation presented for the review. Committee deliberations were followed by a discussion of preliminary findings.

The overall conclusion was that the design was sufficiently well developed to give confidence that the ambitious scientific objectives of the team and the Project would be met. The designs presented in the documentation were produced with skill and imagination. The committee was particularly impressed with the degree of communication and coordination among the groups in Canada and the UK. The committee felt that the project was well on track, and that the comments presented here are recommendations for increased emphasis rather than concern that any areas require major rework.

The committee was given a charge to review the documentation and comment on five points. The questions and response are as follows:

1) Is the GMOS design at a suitable state of development? Are there areas which need more attention at this time? and
5) Is the main spectrograph optical design sufficiently developed that glasses can be now purchased with acceptably small risk? If not, what else need(s) to be done?

The committee addressed these questions by major subsystem:

<u>Optics</u>: The design appears to be a robust and ably developed compromise among the conflicting demands of wide field, wide wavelength coverage, and superb image quality. No major concerns are present, but three steps should be completed before glasses are purchased for the collimator and camera lens groups. **The major one is to complete the tolerancing analysis**. **It is important to verify that there are no extremely sensitive elements in the chain, and that manufacturability and assembly can meet the tolerances without extraordinary and unduly expensive procedures**.

This is now done and available from Chris Morbey. Nothing was found to cause real concern. Jim Oschmann has looked at the tolerancing and found it to be acceptable.

Another step will be to verify the prescription with an alternate raytracing program, for an extra degree of assurance prior to a major investment and freezing of the configuration.

An earlier version of our Zemax design has already been compared with another program, finding no significant differences. E. Harvey Richardson was contracted to evaluate some cases of this design using CodeV software. The results at standard temperature and pressure are in complete agreement. CodeV and Zemax differ slightly in the predicted change of performance with temperature. The difference is small, but it appears from comparison with manual calculations that Zemax is closer to the correct value.

The temperature sensitivity should be looked at once more, particularly with regard to plate scale changes on refocus.

An analysis of the temperature sensitivity for the case of all-steel support has been performed. The analysis shows that image quality changes with temperature remain within the image quality spec. Image motion resulting from plate scale changes with temperature are not significant for Mauna Kea but become comparable to the flexure spec in the most extreme hourly temperature changes expected at Cerro Pachon. It may be necessary to restrict exposure length and calibrate more frequently if highest resolution is expected during these nights.

The committee notes that the dispersion correction optics and field flattener/corrector require further work, particularly the examination of new glass choices for the prisms. Two recommendations are offered for this subsystem: **leave an air gap between the two rotating surfaces to avoid mechanical difficulties with optical couplants**.

An air gap is now in the baseline design.

Investigate the possibility of taking advantage of the air/glass surfaces of the ADC and the air gap and incorporating the corrector and field flattening function into the ADC. This approach offers the potential of reducing the number of large elements and air/glass surfaces in the system.

This will be considered during the coming ADC redesign work.

Mechanical: The design clearly represents the work of a good team with a strong heritage in modern instrumentation. The level of detail presented was appropriate for PDR. Two types of more detailed analysis are recommended for the upcoming CDR. **A system-level model should be produced that shows the impact of flexures and displacements on delivered image quality. The virtue of such an effort is to identify the points of greatest sensitivity and to add stiffening as necessary before metal is cut**.

R. Murowinski has assumed system engineering responsibilities, and will continue the error budget and system design work.

The system analysis should also include a dynamic component with relatively faithful representation of welds and attachments. The lowest resonant frequencies should be comfortably above 5-7 Hz.

This will be done in Critical Design phase.

Electronics and Controls: Again, this section reflected a good level of thinking for a preliminary design review. By CDR, the committee would expect a more detailed look at instrument safety issues and potential failure modes. **Hardware limit switches are essential, and will save more time than they cost operationally in preventing damage to a mechanical or optical element**.

Hardware limit switches have been added to the electrical design wherever there is room to accommodate them (i.e. in almost all locations).

The overall electrical environment must be considered from the point of view of RFI for the very low-noise CCDs,

Other than by continuing to follow good basic design practices, this area is one which is hard to control since it is difficult and time-consuming to model. The largest uncertainty and risk is seen as being the stepper motors and their drivers. In order to test whether the selected components will be a problem, one stepper motor and driver pair will be set up and run near a low noise lab CCD. This experiment, which is now underway, should set a limit on any potential noise problem and allow us to design accordingly during the critical design phase.

and the team must work with the project to define an adequate grounding scheme that addresses safety and noise performance.

This has been done and will form part of the ICD 1.5.2/1.9 (Cass Cable Wrap to Science Instruments) or ICD 1.9/3.8 (Science Instruments to System Cables).

Integration and Test: Preparation for the review was clearly beneficial in initiating planning for these activities. The expectation for CDR is a more integrated plan with a significantly greater level of detail. **The committee recommends that the team consider carefully now the toolkit they will need for optical alignment and focus, both with and without the Gemini-supplied science detector**. **Eyepieces and TV cameras on precision stages, frame grabbing and quick-look analysis software must be provided by the team and included in early planning.**

Yes, we will consider what tools and techniques will be necessary well in advance.

The need for a calibration unit simulator must also be considered.

Calibration requirements during testing and integration have been planned for.

2) Are the Scientific Requirements, as described by the Functional Requirements Document, expected to be met?

The committee felt that the few top-level requirements are likely to be met if they are properly defined. **Further work is required to define the flow-down from the science requirements to the functional performance requirements through the error budget. The bottom-up work on tolerancing will then lead to a re-partitioning of the error budget with more realistic goals for the mechanical and optical subsystems. The Team and the Project should work together soon to close this loop.**

Agreed. Both we and IGPO need to work together on this.

As noted in the discussions during PDR, several requirements in the FRD should actually be moved to system performance trades to meet the higher level specification. The desire to achieve 1 km/s accuracy at spectral resolution 5000 over a wide field of view clearly puts tight tolerances on many subsystems.

We shall adjust the documents accordingly.

The data requirements should be quantitatively modeled based on collimator illumination through slits passing realistic image energy distributions. Flat fielding and stability requirements should be revisited on the basis of this model and any new requirements communicated to the Project by April 30 as the facility calibration unit is now in a key costing/design phase.

The stability and flat-field requirements are completely different.

Stability requirements: The FRD contains a spec for the motion of the image of the slit on the detector which is driven by the desire to locate the centroid of a single spectral feature to the accuracy corresponding to 2km/s. This is independent of how the image of a point source feeds through the slit. The 'collimator illumination' will affect the width and shape of the image of the slit on the detector (presumably via diffraction). The velocity accuracy that can be obtained depends not only on the width of this image but also on the signal/noise which tells us to what fraction of the PSF width the peak of the light distribution can be located. We feel it would take a lot of very detailed simulation including consideration of noise sources) to improve on the spec already derived. Effects like the re-distribution of errors in a dynamic error budget are likely to be far more important. In any case the spec will be determined by the 'top-level' science requirements on what the velocity accuracy obtainable for each line should be. We conclude that this analysis, although interesting, would not be a valid use of our limited resources.

Flat fielding: We feel that we've already provided in an email to Susan Ramsey (15 Feb '96) what are acceptable requirements on the Facility Calibration Unit.

3) What are the significant risks, and how can they be controlled?

The committee felt that optical coatings currently pose the greatest performance risk. Because the choice was made to optimize the image quality for the best seeing conditions, there are a large number of air/glass surfaces. The throughput then becomes critically dependent on coating transmission efficiency. From the information presented at PDR, the technical risks associated with using Sol-Gel coatings appear to be durability and controlling thickness and uniformity tightly enough to tune the wavelength response. **The team must understand and evaluate Sol-Gel coatings by CDR to address the issues of lifetime, causes of deterioration, techniques for coating interior surfaces, and operational plans for recoating. A demonstration coating should be produced for CDR with adequate transmission at the blue wavelength limit and near-IR. If Sol-Gel presents too many performance or operational difficulties, an alternative coating plan should be offered at CDR that addresses the same issues more adequately.**

A sol-gel development plan is being prepared which will allow us to monitor the development progress. Demonstration coatings at CDR are a goal in that plan.

The greatest schedule and cost risk (exclusive of optics manufacturing) was considered to be the IFU. Meeting the performance goal will require skilled assembly and high-precision repeatability in the fiber mounting structure. **The committee suggests that every effort be made to meet the performance goal, but if "descope" is required to stay within budget and schedule, then we may be forced to accept somewhat lower quality than ultimately desired.**

We concur with this analysis.

Higher percentage fiber breakage or poorer pitch uniformity in sampling the contiguous field diminishes the performance only a small amount on this otherwise unique and valuable capability. **The committee recommends investigating a modular approach to interchangeable projection optics to provide scales other than 0.2"/lenslet (particularly 0.1"/lenslet) without requiring additional complex fiber assemblies. To assist with adherence to schedule, the IGP is willing to help with milestone reviews, based on technical developments from related projects for other telescopes.**

*The present design allows the **potential** to change the enlarger to give 0.1 sampling but the design is not optimised for this. To do so would require a different tradeoff analysis. Since the 0.1 arcsec option is not part of the baseline, we feel that we would have to be ask for extra resources to do this. Informally we can try to make sure we don't close off this option but it requires very real and time-consuming work to do a proper job. Note that, even if we were able to optimise the design for **both 0.1 and 0.2 arcsec** it is likely that both modes would be compromised to a certain extent. It is also likely to be true that, whatever optimisation is performed, the 0.1 arcsec mode will have worse thoughput and/or spectral resolution compared with the 0.2 arcsec mode. GMOS has at present the capability to carry different IFUs and we see this as the best route to ensure that a 0.1 arcsec capability can be provided - at the expense of manufacturing a completely separate IFU optimised for that scale.*

Unless directed otherwise by IGPO, we will continue on the above course.

4) What other areas or options need to be investigated?

The committee did not feel certain about the trouble-free operation of the proposed mechanisms for manipulating masks and IFUs from the cassette into the focal plane. It is a complex and novel system, and has employed some differences in approach from other systems' mask manipulation hardware. **The committee recommends mitigating risk by building the system as soon as the GMOS schedule permits after a CDR-level design has been approved. Tests in actual operation will indicate any potential operational difficulties, and will allow time for small revisions in components or in detailed approach if necessary**.

A prototype is now being designed and built. The final fabrication work will be rescheduled as suggested.

The committee suggests that serious consideration be given to incorporating a registration mechanism for final positioning of the masks in the focal plane.

We feel that the current design will meet the registration specification, but this will soon be confirmed by the prototype.

Other general comments:

Both spectrographs require ADC optics to meet their scientific performance goals; budgetary issues must not preclude their implementation with the instruments.

We appreciate and agree with the scientific need for ADCs. The ADC design presented at the PDR is very expensive, and we are beginning now to seek less expensive (albeit lower performance) ADC solutions. It is still our goal to find a solution which meets at least the minimum scientific need while fitting within the current budget, although this may not ultimately be possible.

Several details of the Onboard Wavefront Sensor System should be examined. The pointing accuracy should be improved to under 0.5" rms, so that a faster pickup of the guide star will not be routinely required.

This should not be a problem, and will be implemented.

The resonances of the beryllium arm should be calculated and the shape should be adjusted if necessary to assure an acceptably high frequency first harmonic.

The lowest eigenfrequency of the arm is calculated to be about 1KHz.

The mounting position of the base should be adjusted to patrol the center of the field more effectively. Consider moving such that the entire central 3 arcmin diameter can be

covered. Patrol area on the OIWFS does not currently cover all of this area. Emphasis on guiding in the center of the field would lower anisoplanatic effects across the field.

Yes, we will consider the consequences of doing so and will implement same if there is no problem.

Try to tilt the rotation axis(es) for the OIWFS probe arm (as done for the A&G) to minimize the need for refocus (possibly eliminating the need for refocus or at least reducing defocus measurement range needed). This may allow for a stable pupil on the lenslet array also. Without the field flatener, one would point the rotation axis toward the secondary mirror. With the field flatener, the angle may be somewhat different.

The mechanical design has been changed so that the axis of the OIWFS points to the exit pupil. This angle partially compensates for focus changes.

The team should address their opinions and concerns about the cooling of the CCD to the Project. The committee noted the flexible glycol line near sensitive optics.

No response needed. IGPO is aware of the situation, and also of the operations consequences of a glycol failure. They will direct the WFS workpackage however they feel is appropriate.

The team should also tell the Project what new constraints the WFS should meet in order to remove from the system the lens preceding the pickoff mirror.

Increasing the size of the lenslet aperture from 3mm has already been discussed with IGPO. During the 13 April review of the WFS workpackage, it was decided that there is a very strong preference for maintaining this pupil at its current diameter.

As the pace of producing documents and drawings picks up toward CDR, it is very important to have a workable system of document and configuration control. Single-point sign-off on changes is an important element of this overall control.

A document and change control system has been discussed within GMOS team and is being implemented.

Active management of the interfaces internal to the instrument seems to be quite successful, but requires continued vigilance.

Operation in the high thermal background of the long-wavelength side of the H band could use further investigation. In particular, the committee feels that if materials with appropriate viscosity and coupling characteristics cannot be found with good transmission in the 1.7 micron range, it would be acceptable to use optical couplants that limit the performance in the H band. Every effort should be exerted to find broad band materials that support the H-band extension.

Noted.

The team should define the on-line data reduction tools necessary for the Project to provide for data quality assurance. If IRAF is the package of choice, the team should say so.

Noted.

The overall design must address the issue of environmental cleanliness during routine operation. The optical coatings may be somewhat more fragile than optimum, making frequent cleaning undesirable. Dust and other particulates will have serious effects on the performance of slit masks, especially with narrow slits. The use of observatory-supplied dry air may be crucial to mitigate against dust and humidity inside the spectrograph enclosure.

This design objective is noted and measures to ensure instrument cleanliness during operation will be addressed as part of the critical design phase.

Detailed Comments and Action Items:

The team must provide a mechanical space envelope for accommodation of a polarization analyzer to Jim Hough.

We feel that a clear science case that points to a specific design needs to be developed before proceeding further, and to our knowledge this has not been done. If the IGPO would like to pass our PDR documents to Jim Hough and ask how he recommends implementing a polarizer within the GMOS space constraints, they are of course welcome to do so.

When is the mask maker required during the integration and test period?

This is answered in the GMOS management plan, but we will review it to see if an earlier date might be more appropriate.

The location of the mask makers and cassette loading areas within the facility must be worked out with the Project soon.

This has been addressed in a document delivered to IGPO, GMOS Off-Telescope Facilities Requirements.

The CCD Mosaic dimensional stability should be included in the performance calculation.

Noted.

The CCD work package group needs a specification on the alignment of rows and columns of the different CCDs within the Mosaic.

This spec exists, GMOS will ensure that Todd Boroson has it.

Action on the Project to work with the Team to update the FRD for final closure with the GSC:

- Wavelength coverage requirement and goal.
- Discussion of H-band science in high background regime and priority relative to other capabilities.
- Development of a strawman plan for taking the baseline GMOS to a NIR GMOS, including listing implications for space/balance with a new detector, lower emissivity mask material, controls, etc.
- Brief discussion of operational impact of limitation to three gratings.
- Re-examination of assumption that imaging through the camera is a requirement for producing accurate masks.
- Limit error budget in FRD to top-level only and leave trades to design.
- More quantitative assessment of night sky emission line cancellation precision as impact on velocity, spectrophotometric, and other spectroscopic programs.

Can the field flattener optics be left in place (with refocus) for the AO corrected field?

The use of nulling field flattener optics would produce a slight (0.05 - 0.1) gain in Strehl ratio and a slightly more uniform field than would normally be delivered if AO feeds GMOS's usual corrector. Since the image quality degradation without such optics are a) insignificant over the IFU field, and b) still within the pre-slit image quality specs, we concur in removing this optic from our design.

Are absolute encoders more desirable for the ADC prisms? Do the prisms meet the rotation rate requirement, particularly with an air gap?

Rotation rate is designed to move the ADC from any position to any other position within the 50 second reconfiguration time, which we feel should be sufficiently quick for the zenith-crossing case.

Should dome flats be considered as a calibration backup for the calibration unit?

Yes.

The flexure of the dewar window under vacuum must be included in the optical analysis.

This has been done, the vacuum flexure has insignificant impact on image quality.

The Team should be sure that each Project supported group is explicitly aware of the deliverables required from the Project to keep GMOS on schedule.

The draft GMOS Workscope contains the required delivery dates. IGPO remains responsible to communicate this to other workpackages.

The instrument should contain tilt sensors or a comparable system to derive the gravity vector, rather than depending on the TCS.

GMOS has not been able to locate a transducer which continues to work when rotated in a plane normal to the direction it is measuring. Using the identified tansducers, then, would become more complex and require gimbal mounting. We have decided to return to the relative simplicity of depending on the TCS for this information.

The specification for the CCD thermal controller should be revised to address issues of cryostat design for accommodation, power requirement for the heater, and placement of internal thermal sensors.

Noted. This will be part of critical design, and part of the Detctor Controller/GMOS components ICD 1.9.d.1/1.9.3.

If bowing of the slit masks proves to be an issue, stiffening with thin rods at the Mosaic CCD boundaries should be investigated.

Noted.

A commercial vendor for the laser cutter is preferable to in-house development.

Noted.

It is desirable to have more volume for mask or IFU capacity with the HROS fiber installed. Special on-board stowage of the fiber cartridge or a socket disconnect should be studied.

We will keep this in mind if further design work is funded.

The team needs to provide a breakdown of mass and CG for instrument (Stated at review that this was done, but it wasn't provided.)

The latest version of this is available from Peter Hastings.

The electronics block diagram shows SDSU II controller. This has not been decided on. The baseline is ARCON.

We will revise the drawings when a controller is selected.

Note that the telescope slightly vignetts the 5.5 armin GMOS science field. (It was stated that this is unvignetted.) This is a very minor amount (few percent).

Consider building in a set defocus from the IFU input lenses to the slit plane to eliminate the need to refocus when putting in the IFU.

We are investigating this. We don't think at this stage there will be a problem. It may turn out that the degradation in image quality makes this unnecessary for 0.2 arcsec sampling, but it may be desirable for finer sampling options.

Current error budget breakdown counts diffraction twice (pre- and post-slit).

The error budget is being revised to correct this problem.

Consider "lips" machined into each lens cell part. This eliminates the need for the shimming part of the assembly process and gets a good, fast reference for mounting one lens relative to the other. Done properly, this provides some level of self centering (at least gets one very close to start with). This is a standard method used by many commercial suppliers. It is quick, easy, very accurate (typically 50 micron decenter within a cell is relatively straightforward).

If we understand what is being proposed here, we feel that it may remove some of the necessary degrees of freedom needed to easily achieve alignment of the optical groups. The GMOS mechanical designers will discuss this with Jim Oschmann to reach a consensus on the value of this technique before proceeding any further with the cell design.

A quick calculation was done after the review on the oversizing needed for the collimator. For the smallest IFU envisioned, and considering mis-alignments, roughly 12-15% oversizing was found to be desirable (for the collimator optics). Chris was going to try to oversize the optics this amount to the extent practical and give the results to Jeremy to assess the impact (not expected to be large) if they couldn't quite provide all of the oversizing desired.

Noted.

Concern was expressed by the GMOS team after the review about the thermal shock characteristics of calcium fluoride. They should investigate this promptly to understand handling limitation for this material.

They were concerned about rapid changes in ambient temperature, including sudden local temperture differences caused by things such as cold freon sprayed directly on the material, causing it to shatter. They should talk to people who use calcium fluoride frequently for windows on cryogenic instruments (which must go through large temperature swings during cool down and warm up periods).

Noted. The GMOS designers responsible for mounting our optics have visited the DEIMOS group, who are using CaFl extensively, and will continue to contact others with experience with this problem.