Response to Preliminary Design Review Committee Report

Gemini Near Infrared Imager Team
Institute for Astronomy

and

International Gemini Project Office
United States Gemini Program

June 27-28, 1996

REV-I-G0081

This is the response of the NIRI Project Team to the comments received from the review committee following PDR. The document is organized as follows:

The text of the review committee report was sent to the United States Gemini Program Work Package Manager with informal comments, which are summarized at the beginning of the document.

Next, we give the text of the Review Committee report, which consists of a series of comments and suggestions. After each Review Committee comment (given in *italics*), the NIRI Team responds to each concern.

The undersigned agree with the responses to the comments and the proposed actions described therein. We find that the NIRI Team had only a partially successful PDR, and that the NIRI Team must take corrective action to deliver the instrument on schedule in time for commissioning.

For AURA:

Mark Trueblood, Work Package Manager

Doug Simons, Instruments Project Scientist

Rick McGonegal, Instrumentation Manager

For University of Hawaii:

Klaus Hodapp, Principal Investigator

I. Overview

The Preliminary Design Review (PDR) for the Gemini Near Infrared Imager (NIRI) was held June 27-28, 1996 at the Institute for Astronomy (IfA) at the University of Hawaii (UH). The review committee consisted of Mark Shure (chair -- Georgia State University), Eli Atad (ROE), Tim Ellis (NOAO), Phil Puxley (IGPO), Steve Ridgway (NOAO), and Doug Simons (IGPO).

Informally, the committee expressed the following concerns:

1. The NIRI Team is seriously behind schedule.
2. In the rush to recover schedule, that important engineering studies might not be performed and other committee recommendations might be ignored.
3. Mechanical design is most seriously behind schedule, especially as it relates to the optical design.
4. IfA management must commit to providing the staff required to hold the CDR on schedule.
5. IGPO must hold an interim progress review before giving permission to order long-lead items prior to CDR.

II. Final Report to the NIRI and Gemini Teams

The Committee would like to note many positive points about the present NIRI camera design. Overall, we feel that the design shows a good layout and promises good performance. We are impressed by the integration of the wavefront sensor (WFS) and science arrays, the peripheral field gimbal design, judicious use of fold mirrors to minimize instrument size, general accessibility to the instrument components and the choice of off-the-shelf controllers and motors to minimize costs and development time. However, we have numerous reservations about the progress of the instrument's design to date and what we feel are overly optimistic projections for the future. In summary, we feel that the project will not possess enough manpower to meet the needs for a critical design review (CDR) by April 1997 at the planned level of effort. The members of the NIRI team are excellent, talented people; there just don't seem to be enough of them to meet the project goals in a timely manner.

<u>Response</u>: The NIRI team will submit a new management plan showing cost, staffing, and schedule that includes the OIWFS. The original delivery date must be met on this new plan. Any significant difference between this plan and that originally submitted will be explained. The NIRI team will demonstrate that IfA executive management agrees with the revised management plan and agrees to commit whatever IfA resources are budgeted and scheduled in the revised management plan.

Although we discussed many areas which require further attention, we have identified the following as those needing the most immediate effort:

1. *A more complete optomechanical design*

Although the present design concept appears sound, we do not feel that there has been adequate attention paid to a complete analysis of the optomechanical design of either the science or WFS optical paths. Such an analysis should predict the PSF including diffraction effects and optomechanical tolerances, before the optical elements are ordered. A complete thermal finite element analysis (FEA) should be carried out, allowing a prediction of the entire instrument's cooldown history. This will allow an estimate of the cooling time needed before the science array can be tested, the outer jacket temperature and the time before the instrument can commence low-background astronomical observations. The optical mounts (which were not mentioned during the presentations) should be included in this FEA to determine how alignment varies during cooldown. It is our consensus that there has not been enough interaction between the optical and mechanical design efforts, although this may have been due to recent personal circumstances. More dialog between these efforts will be vital to the ultimate success of the design.

<u>Response</u>: This comment has several parts. (1) The NIRI Team will hold an interim optomechanical design review prior to ordering optics and other long-lead items. The following topics and study results will be presented:

a. Predicted PSF including diffraction effects

b. Optomechanical tolerances
c. Predicted thermal effects on optical tolerances
d. Preliminary baffling plan
e. Proposed surface roughness specification and scattering analysis
f. Optical alignment scenario
g. Ray trace of entrance window that includes thermal and pressure effects, including the thermal gradient's changing the refractive index, to the extent permitted by the NIRI Team's analysis software or help is made available from other sources, such as NOAO
h. Stresses on the pupil viewing optics

(2) At a date after the optomechanical design review, the results of a thermal analysis more detailed than that presented at the PDR will be given. This analysis will include a more detailed prediction of the instrument's cooldown history (with a prediction of any cooldown hot spots) and the risk to key optics of maximum cooldown and warmup rates.

These studies and interim reviews will be folded into the revised management plan.

2. *Cryogenic testing of new mechanisms*

The NIRI design incorporates many new mechanisms (including the Geneva mechanism and beamsplitter turret assembly) which have not been tried in previous instruments. Although they all seem appropriate in principle, they must be tested as prototypes at cryogenic temperatures to verify that they will actually work properly in the final instrument. There is no substitute for such careful testing. Design faults must be identified and corrected prior to the point when the instrument is assembled and tested as a single unit. The final fabricated assemblies should also be cold-tested before instrument assembly.

Response: A cold testing plan is already in place and is under way. This includes developing a 3D engineering model of the mechanisms to be tested (filter wheel with Geneva mechanism, gimbal mirror, and OIWFS focus assembly), extracting 2D fabrication drawings from the 3D model and adding dimensions, converting the fabrication drawings to CNC machine language, manufacturing the parts, inspecting and assembling the parts, testing the assemblies at cryogenic temperatures, and turning over the assemblies to the software group for developing the control systems. The NIRI Team hopes use these assemblies in the final instrument instead of regarding them merely as test units.

3. *Detailed baffling plan*

We were concerned by the lack of concern displayed about the thermal baffling. Baffling for scattered and thermal light has not yet been incorporated into the optomechanical design. This should be done as soon as possible (certainly before the optics are ordered), as it may require repeated exchanges between the optical and mechanical designers, resulting in some modifications to the instrument. An important function of the baffling will be the reduction of light reflected from the filters and then scattered into the optical path. Careful attention should be paid to thermal baffling of the light path once the light passes through the filter wheels on its way to the science detector array. We believe that an open configuration is not sufficient beyond the filter wheels.

Response: The NIRI Team will present a preliminary baffling plan at the optical interim review, and the final baffling design at CDR. The baffling plan will rely heavily on a study of stray light to be performed by the Breault Research Organization.

4. *Summary of NIRI observing modes*

Although we do not expect the NIRI team to predict all possible combinations of observing modes at this point, there is a clear need for better specification of the interface between the instrument and the Gemini telescope operating system, both in hardware and software. We believe that one of the best ways to approach this problem is to *summarize the most common operating modes of the instrument. This could be provided by the OCDD. Common modes which should be considered include imaging with and without AO, polarimetry with and without the A&G-mounted polarizer, grism spectroscopy, coronagraphic imaging with AO, and pupil viewing (including focus tests using the Hartmann masks). Since the NIRI team is also going to be responsible for the near-infrared WFS used in GNIRS, the OCDD should include guide star acquisition support with the above modes.*

Response: The NIRI Team will provide Gemini with an updated OCDD by September 6, 1996. Note that Hartmann masks are not planned for the imager.

5. *Overall block diagram of instrument sub-systems*

We see a need for a better integration plan among all of the instrument sub-systems. A complete, but simple, block diagram showing how all these go together would be very helpful in understanding the interaction between these systems. This will be especially important, since the instrument will incorporate electronic systems from outside organizations.

Response: The NIRI Team will provide Gemini with a software block diagram showing the relationships and high-level data flows between the NIRI instrument and the NOAO array controller, the Hawaii OIWFS controllers, and Gemini principal systems by September 6, 1996.

Additional action items:

Listed above are the areas which we think require the highest priority. However, there were other points which are also very important for success of the instrument. These are summarized below. (Editor's note: paragraph numbers were added to the text of the committee report to aid discussion and future reference.)

Optics:

6. *Evaluation of the final optical design must take account of diffraction effects, including performance based upon Strehl ratio and PSF. You should re-examine the trade-off in performance for the 1024^2 array field, when the optics were optimized for the 2048^2 field. For instance, the wings of the PSF will be an important concern for deconvolving adaptive-optics (AO) corrected images.*

Response: A trade of 1024^2 vs. 2048^2 performance with regard to making the f/13 beam telecentric has already been completed, and Gemini directed the NIRI Team to favor telecentricity over 2048^2 upgradeability. The 2048^2 option has been dropped because telecentric optics upgradeable to 2048^2 are significantly more expensive due to their being far larger in diameter or more complex. The diffraction effects will be included in the interim optical review.

7. *A final selection of mirror substrate material must be made and mounts designed as soon as possible. These should be included in the thermal FEA, as they will have strong implications for maintaining optical alignment.*

Response: The mirror substrate material will be fused silica optically polished. The mounts will be analyzed to determine how much of the total optomechanical error budget they use.

8. *We did not see any plan for the evaluation of optics as delivered from the manufacturers. You should not simply rely on elements meeting specifications. Delivery should include interferometric test results or elements be tested at the Institute. Also, some attention should be given to the specification of surface roughness.*

Response: All optics purchase orders will include as a deliverable an interferogram from the vendor, as well as a surface quality specification. The interim optics review will include the results of a scattering analysis that takes into account the proposed surface quality specification.

9. *We saw no plans for the alignment of optics upon assembly in the instrument. The complexity of this instrument will not allow simple trial and error alignment, unless careful attention is paid during the optical design. Work*

through the alignment procedure you will follow and be certain that mounts allow the necessary degrees of freedom for adjustments. This sequence should be described in the instrument documentation.

Response: The interim optics review will include the alignment scenario and a review of each optical mount to ensure the required adjustments are provided.

10. *The ghost image analysis must include the effects of off-axis ghosts. The criteria for neglecting ghosts should be justified for both thermal and non-thermal regimes.*

Response: An analysis of on-axis ghosts was given at the PDR. The interim optics review may include the effects of off-axis ghosts, depending on the cost of Breault to include this analysis in its study.

11. *The coronagraphic mode of operation should be better determined; for instance, what combination of magnification and filters will have to be supported? The masks should be designed before the optics are finalized.*

Response: System level use of the coronographic mode will be given in the next OCDD update. The details of this mode will given at the CDR. The NIRI team will not spend time designing special apodized coronographic masks, but will leave space for them in the pupil wheel.

12. *Before finalizing the sizes of optical elements, attention should be paid to ray footprints on each optical surface.*

Response: This was part of the optical design process performed using the SYNOPSIS package, and is complete. No further NIRI Team action is required.

13. *The grisms should be included in a ray trace analysis. Do they lead to any significant degradation in performance?*

Response: This analysis will be completed by CDR.

14. *The sizable temperature gradient (front to back) in the thick window will lead to a variation in the refractive index. A ray trace should be attempted which includes this effect.*

Response: The effect will be studied and the results reported at the interim optics review. Any results from GNIRS Team studies will be passed on to the NIRI Team.

15. *Is there any performance penalty from requiring telecentricity in the optical design (especially the intermediate plate scale)?*

Response: The NIRI Team already studied this. If the f/13 beam is made telecentric, 2048^2 upgrade performance suffers slightly. Gemini has directed the NIRI Team to make the f/13 beam telecentric at the expense of that beam’s 2048^2 upgradeability.

16. *Make sure that you ask the manufacturer about proper cleaning procedures for all optical surfaces. These should be included in the delivered instrument documentation. Some provision should be made for a "clean room" facility at the IfA during testing and assembly.*

Response: We agree with all of these recommendations. Cleaning procedures will be included in purchase orders and the delivered procedures will be incorporated into the NIRI operations and maintenance manual. The IfA recognizes the need for a clean room, and is far along in procuring such a facility.

Mechanical design:

17. *A cost trade-off study should be done between single-billet and welded-plate construction for the vacuum jacket. This should also address serious concerns about the homogeneity of large billets. Pay close attention to the need for thermal stabilization and stress-relieving treatment of all components.*

Response: The NIRI Team has performed the trade study and has selected a forged tube approach instead of the single-billet approach.

18. *The window cover mechanism should be carefully designed and must operate while NIRI is on the ISS. The instrument emissivity and flat-field uniformity depend critically on the cleanliness of the window.*

Response: We agree. The window cover mechanism design will be presented at CDR. The NIRI Team will provide a clean, dry air flow to prevent dust from accumulating on the window.

19. *The design for the pupil-viewing optics mechanism should be reviewed and changes considered, in order to minimize sudden accelerations.*

Response: This mechanism will be redesigned. The predicted stresses on the optics will be reported at the interim optics review and the mechanism design will be presented at the CDR.

20. *Consider the use of fiberglass for the cryogenic truss structure. What is the justification for titanium, which will be more thermally conductive?*

Response: The NIRI Team was concerned about the high forces at the attach points. Although this problem could be addressed using G-10 and reinforcing plates, other options were explored. The preliminary thermal analysis was performed assuming titanium, and that analysis indicated that titanium will work. The NIRI Team will pursue the titanium option unless more detailed analysis shows a problem.

21. *A pressure relief valve on the vacuum jacket should be considered due to the long time periods at cold temperature.*

Response: The warmup system will be properly instrumented, including pressure sensors, that will permit the system to take corrective action if there is a problem. If a pressure relief valve can be incorporated inexpensively, it will be. We are concerned that such a valve presents yet another opportunity to introduce a leak past the vacuum jacket.

Thermal design:

22. *Although the importance of careful thermal baffling has already been stressed, it bears repeating. It is especially important between the filter wheels and the science array.*

Response: We agree. Please note our response to Comment #3 above.

23. *We could see no need to run the coolers at speeds higher or lower than the manufacturer's standard specification; we recommend that the system be run unregulated. A prediction of the operating temperature should be made and the system performance designed accordingly. The complication of an additional temperature control servo for the first stage of the cryocoolers should not be considered unless absolutely necessary.*

Response: The NIRI Team does not believe this will be either a cost or schedule driver. We agree with the NIRI Team's preliminary analysis showing no need for a precharge can. IGPO will review the requirement for cooldown and warmup times, and will assess the real operations needs against the cooldown history predicted at the thermal interim review. We also agree that running the cooler heads faster than their design speed is very likely to shorten their operating lifetime dramatically, which would signficantly increase Gemini's operating costs for the NIRI. The cooler head control system is a commercial unit purchased to phase the heads as well as to control their speed, so there is no change to the cryocooler hardware design to add or delete this capability.

24. *During the thermal FEA, check for non-isothermal cooling, as well as thermal gradients.*

Response: The interim thermal analysis will include a check for hot spots and a check to assist the risk to key optics of the maximum possible cooldown and warmup rates.

25. *As a minor point; rotate the cooler heads to reduce space needs and increase observatory safety.*

Response: The NIRI Team will study this point and report on it at CDR.

Electronics:

26. *In order to avoid catastrophic failures, some sort of "dead-man" limit switch must be provided for the lead screw mechanisms; these should only be capable of manual reset.*

Response: We do not want a manual reset that requires opening the dewar. The point of the discussion at the PDR was to prevent a software glitch from providing limit switch protection. This can be handled adequately by hard-wired logic that is easy to design and implement.

27. *Accurate temperature sensors must be installed on the 2nd stage of the coolers. These will be important for diagnostic purposes during cooldowns.*

Response: This is quite simple to do, and we see no reason for not doing it. The NIRI Team will implement this recommendation.

28. *An upgrade path should be provided for the Hall sensors (in case problems occur with the less expensive sensors).*

Response: The NIRI Team will provide this upgrade path, as well as including the proposed Hall sensors in the cold test discussed above in response to Comment #2.

Software:

29. *At least a moderate level of error checking should be provided in software for motor-driven assemblies. Careful attention should be paid to the selection of "home" positions (since they will be used repeatedly, make sure they are very safe positions, e.g. for the lead screws).*

Response: Of the various control algorithms presented at the PDR, the NIRI Team recommended the “moderate” algorithm, with which we concur. This is the one that will be implemented, but with a change to the handling of limit switches on linear mechanisms noted above in response to Comment #26. The NIRI Team is working on an absolute encoding scheme using two Hall-effect sensors that has a graceful failure mode back to an incremental encoder that still works with the “moderate” algorithm, as opposed to the primary/backup scheme presented at PDR.

30. *There needs to be a better method of keeping the channels of communication open between the NIRI and Gemini teams. It appeared, for instance, that information about upgrades and new issues about software packages did not make it from Gemini to the IfA. The NIRI team should take advantage of the Gemini email exploder, to keep up with relevant issues regarding the Core Instrument Control System, Observatory Control System, EPICS, etc.*

Response: The NIRI Team will ensure that key members are on the “gemini-instrument” and “gemini-software” email exploders and that they participate in the discussions on this exploder. NIRI Team key members will also contact those working on Gemini key systems by email and possibly by increased travel to introduce themselves and to request that they be notified when interfaces change.

31. *There is also a need to identify and recommend OCS control functions (as a subset of the EPICS engineering control).*

Response: This is similar to Comment #30 above. The NIRI Team will keep in close contact with IGPO programmers working on the OCS.

32. *There was a lack of software and electronics experience in the PDR committee. As these areas become better defined in the future, at least one person from each of these disciplines should be included in future reviews.*

Response: There is no action required of the NIRI Team. USGP and IGPO will ensure that future design committees have more software and electronics design experience, even if it means expanding the size of the review committees.

WFS:

33. *The guide-star sensitivity of the WFS should be estimated and documented before delivery, so observers know what to expect ahead of time. Provision should also be made for the occasional use of very bright stars.*

Response: The OIWFS contains a filter wheel with neutral density filters to handle bright stars. The NIRI Team will predict at CDR the expected performance of the OIWFS and document read noise and quantum efficiency before delivery. IGPO will update the OIWFS model to be consistent with the optomechanical design and to be consistent with IfA detector test results.

34. *If dichroics or mirrors used in the pick-off turret of the WFS are not going to be deposited on large substrates (rather, suspended on thin struts), it should be possible to reduce the mass and complexity of the assembly.*

Response: The NIRI Team will look at redesigning the turrent to lower its cost, weight, and complexity.

35. *If a coronagraph is to be included, the WFS should support imaging close to a bright star.*

Response: The current design supports this capability.

36. *Is there a penalty in wavefront correction using a sensor some distance off-axis (i.e. in the field periphery)?*

Response: Yes. This will be assessed in the updated IGPO performance model. The NIRI Team will include this in its CDR presentation.