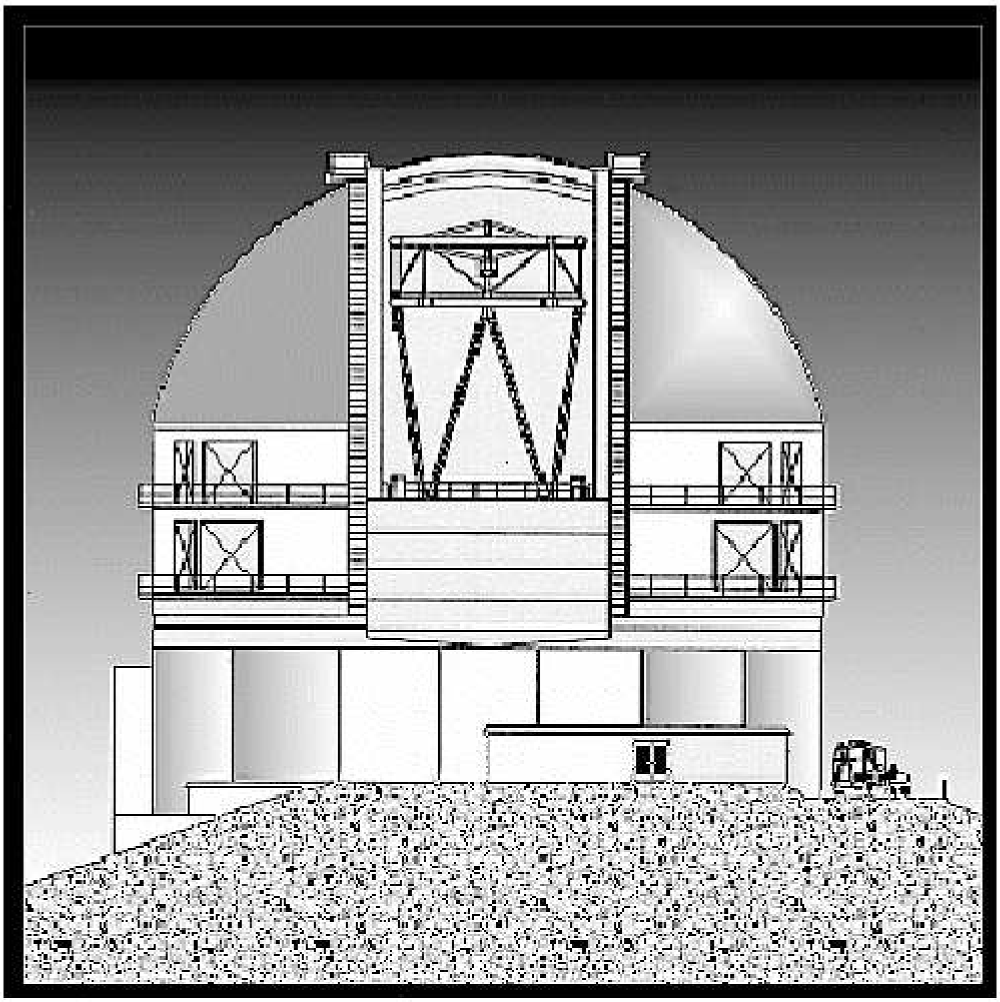
GEMINI
8-M Telescopes
Project

REV-I-G0066

Near-Infrared Imager
Conceptual Design Review Report



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Near IR Imager (NIRI) CoDR Report

Date of NIRI CoDR: 20, 21 March 1995

Place: IFA, Honolulu, HI

Review Panel: F. Gillett (chair), T. Soifer, C. Beichman, P. Puxley, A. Fowler, E. Atad, B. Forrest, E. Tollestrup

Others Present : E. Irwin (IFA), A. Russell (ROE), J. Oschmann (IGP), D. Hall (IFA), D. Robertson (IGP), T. Davidge (DAO), T. Geballe (JAC), M. Trueblood (NOAO), T. Keller (IFA), T. Young(IFA), H. Yamada (IFA), D. Simons (IGP), D. Toomey (IFA), P. Onaka (IRTF), J. Rayne (IFA), K. Hodapp (IFA), A. Tokunaga (IFA)

Overall Summary

The NIRI Functional Requirements are judged to be consistent with the GSC Resolution and IGP requirements for this instrument. The internal instrument background requirements are not adequately specified.

The proposed optical design is endorsed by the review panel as being consistent with the functional requirements. Further recommendations concerning the optical design include;

1) We recommend that the 2nd channel upgrade path not be pursued further.

2) We recommend that the design team further explore the potential for sizing the f/14 and f/32 optical trains for 2048^2 InSb arrays.

3) The optical design for the 1- 2.5um grisms and wollastan prism has to be developed.

We are encouraged by the positive interactions concerning commonality issues between the NIRI and NIRS teams and Gemini. Examples include cyrogenic stepper motors, cryocoolers, arrays and controllers. It is the feeling of this panel that continued and expanded interactions of this sort will be key the successful development of the NIRI. We encourage further cooperation, e.g. in the areas of beam splitters, filters, cryo blacks, and motor and temperature controllers.

As the first of Gemini's facility instruments, the NIRI will play a key role in the definition and development of the Gemini software systems. This will be particularly true in the instrument controller, user interface and data handling areas. We strongly urge the NIRI team become intimately and formally involved in the evolution of the instrument/Gemini system interface. The NIRI team should very quickly develop expertise in and understanding of the Gemini control system hardware and software, and become literate in the Gemini software languages. We suggest that the software/hardware interfaces from the instrument perspective be discussed in depth at the iriswg meeting in the fall.

The following sections of this report include panel comments /suggestions/concerns of a more detailed nature and are organized by subsystem; optical, mechanical thermal, electronic and other.

A. Optical design

The internal instrument background requirements are not adequately specified; We recommend that the IRISWG and GSC adopt specifications of the following form -

a) For lambda > 2.2um; the effective instument emissivity be less than or equal to 1% (TBD)

Note added in Proof: The IRISWG recommended that the effective instrument emissivity be less than 1/2 that of the telescope, in the low emissivity windows between 2.2 and 5.5 um.

b) For lambda < 2.2um; the instrument be capable of sky background limited performance for the highest spatial resolution mode with 1%(TBD) filters in J band.

Note added in proof: the IRISWG recommended an internal instrument background of less than 0.5 e/pix/sec.

1. Tradeoff Summary:

i) <u>Reimaged pupil size</u>. The adopted 36 mm diameter pupil size is consistent with image quality requirements, allows a 0.116 arcsec/pixel spatial scale and utilization of 2 inch diameter filters. A design consistent with use of 1" diameter filters appears to not be feasible, driven largely by the image quality requirements for the f/6 camera.

ii) <u>Camera break at 3μm</u>. The proposed design has no camera break and the image quality and throughput are acceptable. The optical path contains seven active elements including two aspheric surfaces. Throughput is estimated to be 65 to 75% with antireflection coatings, including the dichroic and assuming 1% loss at each Ag reflection.

We recommend that the 2nd channel upgrade path not be pursued further.

- The increase in field size is not considered to be significant scientifically,
- The 2 channel simultaniety, while useful in some cases, e.g. providing guiding info in dark clouds, time variability) is not considered to be worth the cost and complexity
- Including this capability will degrade the performance of the main channel by introducing more reflections and degrading rigidity
- It would result in significantly more cryogenically cooled moving parts (beam splitter wheel and two filter wheels)
- Would require significantly larger (about 1/3) cold work surface
- It would divert attention of design team from issues of the main channel, and

- Significantly increase costs for a severely cost constrained instrument and instrumentation program

iii) <u>Opt/IR dichroic</u> - IR throughput is of prime concern, so this dichroic is IR reflecting and visible transmitting. The FOV transmitted to the external WFS is 3 arcmin in diameter.

iv) <u>Pixel scales</u> - The design incorporates three pixel scales, consistent with the requirements. They are 0".02/pixel (f/32 camera), about 0".05/pixel (f/14 camera) and 0".116/pixel (f/6 camera).

v) <u>Grism capability</u> - an optics wheel in the collimated beam will be available for grisms, and the focal plane mask turret can incorporate appropriate slits. The optical design for the 1-2.5μm grisms and wollastan prism has to be developed. The optics wheel thickness has to be sufficient to accomodate the appropriate devices. The panel judgement is that a 20mm thick wheel is
probably not adequate for these devices.

vi) A hybrid cryogenic system with LN_2 used to speed up cooldown and heaters to provide accelerated warmup.

vii) A pupil viewer lens wheel is included.

viii) <u>Sizing of the optical trains</u> of the finer two pixel scales for utilization of 2048^2 InSb arrays should be considered. There should be adequate clearances for the f/14 camera such that mounting and baffling will not be a driver in the final design. If this appears to be difficult, then a decision re the oversizing of the f/14 camera should be revisited.

ix) <u>Filter wheel number and polarization approach</u> - Two filter wheels are included, and the optics wheel can incorporate wollaston prisms as well as grisms. This combination should provide adequate numbers of filters and significant flexibility in capabilities.

x) A <u>grism capability</u> beyond 3um is a low priority, consistent with the GSC resolution.

xi) <u>Coronagraphic masks</u> - The pupil wheel and focal plane mask turret provide substantial long-term flexibility in this area.

2. Other comments on the optical design

We request information on the % change of plate scale with wavelength, including the effect of refocusing the detector, as well as information on the % distortion. The range of focus movement should be carefully analyzed including effects of filter changes, thermal changes, camera changes, mode changes, etc. There could be a reliability issue if a focus change is required every time something is changed.

The optical design has been developed using geometrical ray tracing programs. The final assessment of performance has to include diffraction effects.

ZnS comes in two forms, one of which is not useable in the 1-2.5µm range because of absorption. The Cleartran version will have to be used for elements of the NIRI optics, and this material is more difficult to diamond turn. The design team has to carefully evaluate the viability of proposed optical elements re availablity, doability and cost.

The dewar window will supercool due to radiation to cold innards. It is very important to prevent moisture condensation on the dewar window and protect the window from thermal shock. This could also be a problem for the optical feed window. It will be very important to keep entrance window clean, both from perspective of maintaining low instrumental emissivity and maintaining a
stable flat field. Cleaning and protection of this key element is essential. A dust cover is probably necessary.

The f/14 and f/32 cameras include four flat mirrors not in the f/6 design, two of which are movable. The next stage of optical design must include these mirrors and the precision of their positioning as part of the performance evaluation.

The surface quality and scattering properties of the optical elements has to be clearly specified. A baseline layout including baffling should be developed asap and evaluated using a diffuse transmission program, like ASAP, in order to allow design evolution and optimization re surface requirements and baffle design for low instrument emissivity and internal background. The scattering properties of the opti/ir dichroic and dewar window are key to the instrument emissivity and need to be thoroughly investigated and evaluated. The scattering properties of diamond turned aspheric optical elements and the need for, and viability of, post-turning polishing also needs to be carefully evaluated.

Cryo blacks are likely to be an issue. We suggest that the NIRI team work with the NIRS team to see if this is another area where commonality could be advantageous. NOAO has an anodized after sand blasting approach with measured ir properties, and also a black anodized Al foam that can be epoxyed to walls as required, if space is reserved for this purpose.

Coordination of 50mm filter definition and purchase between NIRI, NIRS, Subaru, NOAO, KECK, etc, could be benefical to all parties.

One possible assessment of the surface quality requirements for optical elements could be based on rms surface error => degradation of strehl ratio.

A. Mechanical

The mechanical design is essentially a stiff plate cold work surface to which all the optics are mounted. The cold work surface is supported relative to the dewar walls via a truss structure. The panel has some concern re stability/stiffness of the truss support concept, particularly the "2-

dimensional" approach to the internal rigid structure. It seem likely that a 3D support structure will be needed in order to meet the flexure tolerance. This clearly needs further analysis. Flexure assessment should be made on the basis of amplitude of effect over a one hour integration, i.e. 15 deg change in elevation angle.

First order assessment of weight and balance suggests there should be no problems in this area.

Some concern was expressed that the positional repeatability and stability of the filter wheels could be marginal using a detenteless positioning system.

B. Thermal

The conceptual approach of balanced CCC heads together with LN_2 for accelerated cooldown and appropriately placed resistive heaters for accelerated warmup is generally supported. The CoDR felt that a properly designed passive heater system would perform well and be much simplier than a complex multi-element software controlled warmup scheme. The CCC heads will be common with the NIRS.

The panel is concerned that a LN_2 temperature may not be low enough to ensure that dewar background is small compared to the detector dark current. According to A. Fowler calculations, with 5.7μm cutoff wavelength, a hemisphere at 77K will produce a 1 electron/sec/pixel photocurrent. Since many components will generally be somewhat higher temperature than the bath temp, we recommend that the CCC be used for temperature maintainence during operation, in order that the optics/baffles and other surfaces viewed by the detector array can be maintained at well below 77K.

Watch out for H_2O outgassing from dewar walls - H_2O should be trapped so it doesn't deposit on cold optics.

The current level of thermal analyis is very rudimentary, and much more work has to be done in order to properly design and evaluate the thermal system. A significant level of thermal analysis of the NIRI design will be required in order to understand issues like transient cooldown of large optical elements, overall thermal stability and operating temperatures, control of relative temperatures to prevent cryo pumping on critical elements during cooldown and warmup cycles, etc.

C. Electronic

The general approach to electronics design appears to be consistent with Gemini requirements. The general concept for layout within the instrument housing appears to be ok. Commonality between NIRI and NIRS in areas of motor controllers and temperature controllers appears to be attractive.

We are concerned that 16 channels in I/O board may not be sufficent. The number of housekeeping channels may be significanly higher.

Jim Oschmann pointed out that Gemini may want to utilize 2-3 slots in the instrument VME crate for the OBWFS. A decision will be needed soon.

*D.	Other*

A first draft of the Operations Concept Description (OCD) is required. This should include observing modes both with and without the use of the AO system and include sensitivity estimates.

The IRTF instrument group has more experience than the IfA group in building facility class instrumentation and also with InSb arrays. We strongly encourage substantial cooperation between these two capable groups in order that the best NIRI can be obtained for the available resources.