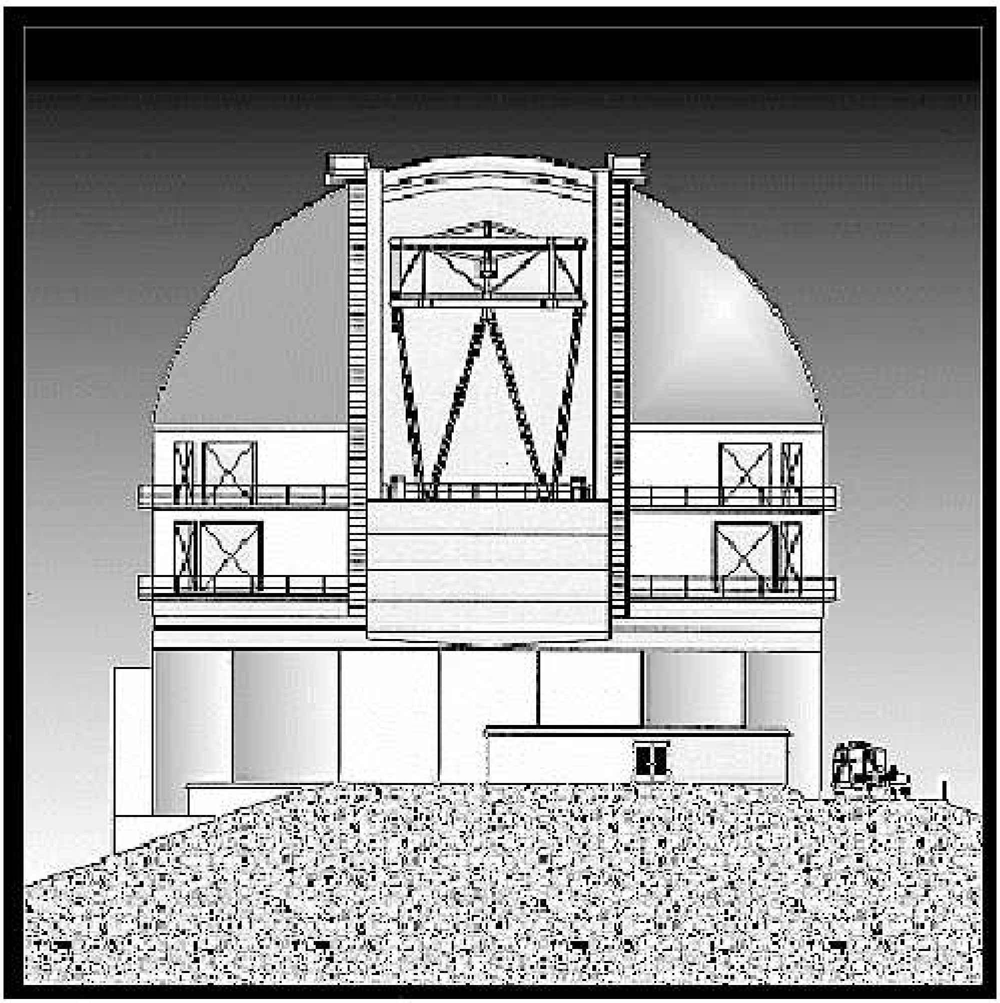
GEMINI
8-M Telescopes Project

SPE-PS-G0050

Gemini Instrumentation Program Plan



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Executive Summary

The development of an instrumentation plan is a complex problem. The original instrumentation plan was based on the implementation plan presented to the Gemini Board at its November 1992 meeting.

Since this original program was developed the Project has become the premiere national facility for six participating countries. Consequently, the 1994 Gemini Instrumentation program has to provide world class scientific capabilities to an expanded and evolving partnership.

The Project Scientists, the Gemini Science Committee and the Gemini Instrumentation Group faced the task of satisfying the conflicting demands of providing premier scientific capabilities, satisfying national aspirations, producing a financially responsible and internationally balanced program responsive to the needs of the 1994 Gemini Partnership. It became clear that the formulation an acceptable instrumentation program was becoming a completely over-constrained problem.

At its meeting in November, 1993, the Gemini Board asked for recommendations for an instrumentation program that continued into the Operational phase of Gemini. As will be seen, the instrument planning for operations is a crucial aspect of the overall Gemini Instrumentation Program now being proposed as this can mitigate many of the deficiencies and constraints of the original program.

The proposed Phase I program aims to bring more balance to the instrument complement across the Gemini Telescopes and the GSC believe that this plan provides the minimum complement of instruments which meets the Gemini Science Requirements, while satisfying many of the aspirations of the partner countries. It is recognized that the first years of the Instrument Development Fund, which is part of the operations budget, will have to be used to augment the construction budget to finance this plan. The distribution between construction and development funds has been done for programmatic reasons and does not imply a priority among instruments.

The Gemini Board is asked to approve:

1. The principle of using the first years of the Instrumentation Development Fund to augment the current instrumentation budget to produce a balanced and acceptable Phase 1 Instrumentation Program

2. The allocation of the 1-5 μm spectrograph work package to the US

3. The allocation the Multi-Object Spectrograph (MOS) work package as a collaboration between Canada and the UK

4. The allocation of the High Resolution Spectrograph workpackage to the UK, contingent on final approval of the Instrument Development Fund as part of the Gemini Operations Plan

5. The allocation of the CCD workpackage as an international collaboration led by the US Project Office, as recommended by the GSC, to encourage:

i. A timely procurement schedule to support the Optical Instrument workpackages.

ii. A wide participation of the Gemini international community in possible foundry runs.

This workpackage includes the provision of acquisition cameras, which will also be used for commissioning, and instrument wavefront sensors, part of which will be done in collaboration with Canada.

6. The allocation of the CCD controller workpackage to Chile, in collaboration with CTIO.

7. The allocation of a mid-infrared camera workpackage to the US contingent on final approval of the Instrument Development Fund as part of the Gemini Operations Plan.

8. The development of a continuing instrumentation program, Phase 2, to ensure a smooth and effective transition of the Gemini Instrument Program into operations. This program will include discussions with the National Observatories on possible mechanisms for sharing instruments between Gemini and other telescopes.

Contents:

1. Introduction

As an introduction to the proposed Instrument plan for the Gemini telescopes we have extracted the following section from the Gemini Science Requirements Document (Version 1. 2)

"The function of the telescope optics and system is to collect the incoming radiation from astronomical sources while preserving the spectral and spatial information according to the science requirements and to provide it in a form that can be used efficiently by the instruments. The instruments, with their associated optics, deliver the radiation to the detectors from which the final signal is obtained. The instruments for Gemini fall in two broad categories, imagers and spectrographs. Imagers emphasize spatial information over spectral information in astronomical sources,- spectrographs have the opposite emphasis. The two-dimensional format of modem detectors often enables instruments to be developed that provide both imaging and spectrographic capabilities simultaneously.

The combination of technology of mirror coatings, detectors, optical materials and atmospheric windows leads to the separation of instruments by wavelength into four broad categories: ultraviolet (UV), 0. 3 to 0. 38 microns; Optical, 0. 38 to 1 micron, Near Infrared, I to 5 microns,- and mid-infrared, 8 to 30 microns. The boundaries among the categories are approximate, and instruments in practice may operate over more than one wavelength region.

Instrument planning for Gemini to date has taken into consideration the key science programs, the properties of the telescopes described in the previous section, the current state of instrumentation and detectors, and projections forfeiture developments, especially in the areas of adaptive optics and detectors.

Common requirements for all instruments provided by the Gemini project are,-

1) The instruments must fully exploit the 8-m aperture and excellent image quality of the Gemini telescopes.

2) They must be easy to use ’facility class " instruments enabling a high degree of productivity from observers.

3) The instruments must be stable throughout at least a one hour integration. Slit losses, flexure and misalignments may contribute to no more than 0. 1 pixel shift throughout this integration period for zenith angles up to 60 degrees.

4) Facility instruments should be reliable and easy to maintain since the requirement of the project is to keep the scheduled telescope time lost to both telescope and instrument failure to below 2 % of the scheduled time; a goal being 1

The goal of the project should be to provide these instruments for both telescopes as part of the Gemini facilities."

2. The Process

Over most of 1993 seven instrument working groups (IWG's) met and actively discussed the individual descriptions and capabilities of the instruments and facilities needed to do science with the Gemini Telescopes, their conclusions are documented in the following IWG Reports;

1. Optical Imaging and CCD's -	Chaired by Gerard Luppino (Univ. of Hawaii)
2. Multi-Object Spectroscopy -	Chaired by Pat Osmer (Ohio State Univ.)
3. High Resolution Spectroscopy -	Chaired by Caty Pilachowski (NOAO)
4. IR Imaging and Array-	Chaired by Jay Frogel, then Chas Biechman (IPAC)
5. IR Spectroscopy-	Chaired by Pat Roche (Univ. of Oxford)
6. Adaptive Optics-	Chaired by Rene Racine (Univ. of Montreal)
7. Acquisition, Guiding and- Wavefront Sensing	Chaired by Charles Jenkins (RGO)

The GSC reviewed the reports of these groups at its October 1993 meeting in Tucson and produced a preliminary set of recommendations.

The task of wrestling with these recommendations to construct a coherent program that could be accommodated within the schedule and budget of the capital phase of Gemini was undertaken by the Project Scientist Team and Gemini Instrumentation Group; principally at meetings at the January 1994 AAS in Washington, in Tucson in early March and again at the SPIE meeting in Kona in mid-March this year.

The preliminary program was presented to the National Science Advisory Committees (SAC's) in late March and early April and final feed back from these meetings brought by the Project Scientist team to the GSC at the II- 13 April meeting this year.

This plan, which we call Phase I is discussed here. The Gemini Board asked for recommendations for a continuing instrumentation program into the Operational phase of Gemini. As will be seen, the instrument planning for operations is a crucial aspect of the overall Gemini Instrumentation Program as it can mitigate many of the deficiencies and constraints of the original program.

3. Development of the Phase I Instrumentation Program

The development of an instrumentation plan is a complex problem. The original instrumentation plan was based on the implementation plan presented to the Gemini Board at its November 1992 meeting. It consisted of the following instruments/capabilities

Mauna Kea -	Optical Acquisition camera
	1-5 micron Camera
	1-5 micron Spectrograph
	Optical Multi-Object Spectrograph (MOS)
	As a facility - a low order natural guide star adaptive optics feed.
Cerro Pachon -	Optical Acquisition Camera
	High Resolution Optical/UV Spectrograph (HROS)
	Borrowed IR instruments from CTIO

Since this original program was developed the Project has become the premiere national facility for six participating countries. The 1994 Gemini Instrumentation program has to provide world class scientific capabilities to an expanded <u>and</u> <u>evolving</u> partnership.

For example in the Canadian case, the recent success of the Hubble refurbishment, and continued success of sub arcsecond imaging and spectroscopy at the CFHT has heightened interest in exploiting the best ten percentile seeing conditions at both Mauna Kea and Cerro Pachon. Argentina, Brazil and Chile are keenly interested in multi-object spectroscopy on Gemini South. With the success of the Keck and its HiRes instrument the UK has maintained its strong scientific interest in a high resolution spectrograph, which will compete with Keck in the southern hemisphere. Within the US there is a continuing desire to have mid-IR instruments on Gemini since this provides a unique and unchallengeable niche for Gemini science. This aspiration has been further heightened by the imminent availability, from US-DOD programs, of large format, new technology mid-infrared arrays. There is no simple solution to finding a set of scientific instruments for the two telescopes which will satisfy the majority of the members of each of the six scientific communities within the constraints of the construction budget.

In addition, because of its high intellectual value the instrumentation construction is to be shared between the partners in proportion to their share of the capital funding. This can only be done approximately as there are only a small number of instruments to be allocated. The Project is attempting to solve this problem using preliminary cost estimates.

Another factor relating to the costing is that the instrument budget of $11.7M has been set assuming costs which include no overhead, contingency or inflation. The Gemini Agreement (Annex G) recognizes that there is insufficient funding to pay for standard [full] overheads, and the UK, US and Canadian Project Offices are trying to find ways of providing the instrumentation within the budget envelope. The contractual arrangements will be different within each of the three countries. In the UK, the instruments will be built within the universities and the Observatories, under the overall coordination of the UK Project **Office.** In Canada, the instrumentation will be built primarily within NRC labs, with the possibility of subcontracts to university collaborators. In the US, one instrument was allocated to the University of Hawaii as part of the site agreement, and other instrumentation will be the subject of competitive bidding. Because this bidding process has not yet started, it is difficult to know whether the US can provide its instrumentation within the amount budgeted. However, the intent is to inform potential bidders up front that some form of cost sharing will be needed and that Guaranteed Time may be provided from the US portion of the observing time in return. In Canada and in the UK the overheads charged will probably be small or zero but, at least in the Canadian case, there is a desire for equitable sharing of the financial pain as well as of the intellectual benefits of Gemini instrumentation.

The South American partners are naturally eager to be involved in their share of instrumentation. They may do this through the provision of electronics for instruments, rather than through the provision of a complete instrument. They have also expressed a strong interest in seconding their staff to the instrumentation labs of the other countries building instruments of common interest to their scientific communities. In this way their staff can participate in modern, relevant instrumentation development even if they do not have overall responsibility for a specific instrument.

The Project Scientists and the Gemini Instrumentation Group faced the task of satisfying these conflicting demands of providing premier scientific capabilities, satisfying national aspirations and producing a financially responsible and internationally balanced program responsive to the needs of the 1994 Gemini Partnership. It became clear that the problem of formulating a globally acceptable instrumentation plan was completely over-constrained.

Consequently, an alternative program is being proposed which can be funded by combining the resources in the construction budget with the funds included in the first few years of the Instrumentation Development Fund, as defined in the DRAFT Operations Plan.

This program aims to bring more balance to the instrument complement across the Gemini Telescopes and to respond more adequately to the aspirations of the evolving and expanded partnership in the following ways;

- Provide a 1-5 micron imager (for science and commissioning) and 1-5 micron Spectrograph to Mauna Kea as originally planned.

- Provide a Multi-fiber feed from the Gemini f/16 Cassegrain focus to the CFHT coudé Spectrograph.

- Duplicate the Optical MOS instrument (with an integral field and imaging mode), the first MOS being commissioned on Gemini North then moved to Gemini South for first light. The second MOS, which will be constrained to cost no more than 70% of the first MOS, can then be delivered to Mauna Kea.

- Use some of the savings inherent in the above approach to fund a simple but capable broad band 10 - 20 micron imaging capability which fully exploits the new "deep well" 256 x 256 blocked-impurity-band mid-IR arrays becoming available. This camera should be commissioned on Mauna Kea and be available for use at first light on Cerro Pachon.

- Provide a fully capable Cassegrain OUV HROS for Gemini South with R 80,000 and/or R-120,000.

- Provide funds to allow the integration and use of CTIO IR instruments on Gemini

The Project Scientists and GSC believe that this plan provides the minimum complement that meets the Gemini Science Requirements, while satisfying the scientific aspirations of all the partner countries. It is recognized that the first years of the Instrument Development Fund will have to be used to finance this plan.

4. Phase 2 Planning.

With this as the Phase 1 program, the following additional capabilities are proposed for Phase 2 as funding within the operations plan permits.

In no particular priority the Phase 2 program should contain:

- A copy of the Gemini North IR imager for Gemini South
- 8K x 8K Optical Imager(s)
- Shared 10-20 micron Spectrograph with UKIRT (Michelle)
- Shared IR instrumentation with CTIO for Gemini-South (Phoenix, SQUID, IRS-2)
- "Second Generation" Laser Guide Star Adaptive Optics system

5. A Summary of the Phase 1 Instruments and Support Activities.

5.1 1-5μm Imager.

The 1-5μm imager will be the first science instrument delivered to the Mauna Kea telescope and will be essential for commissioning the telescope.

5.1.1 Baseline Requirements

Detector Technology - 1024xl024 InSb, 27μm pixels 1-5μm wavelength coverage. Currently being developed by SBRC/NOAO/US Naval Observatory through the Aladdin Project.

Pixel sizes and Fields of View -

	High Resolution		Low Resolution	
Wavelength (μm)	Pixel Size	FOV	Pixel Size	FOV
1 - 2.4	0.02"	20.5"	0.08”	82”
3 - 5	0.042"	43.0"	0.1”	102"

Standard Services - At least two Filter Wheels able to accommodate up to 20 each 2" filters, grisms and polarizers; Coronographic mask; Grism to cover the J-K bands; Pupil Imaging for commissioning use;

Fast Guiding and Adaptive Optics - Provision of an optical feed (0.6μm-0.85μm passband) from a 3' field using a cold dichroic in the instrument.

Operational Requirements - Must be capable of operating in any orientation to allow mounting on either an upward looking or side looking port on the instrument support structure. In order to promote improved reliability, reduced operations cost and ease of implementation the use of Closed Cycle Refrigerator System is a requirement.

5.1.2 Instrument Allocation.

As part of a Memorandum of Understanding between the NSF and the University of Hawaii the IR Imager has been allocated to the Institute for Astronomy, University of Hawaii, which will perform the design, manufacture, test and commissioning of this instrument. This instrument will be subject to the same Gemini procedures (e.g. Design Reviews, Acceptance Testing, etc) that will be applied to all other Gemini instruments.

5.1.3 Proposed Delivery Schedule

The overall Program Schedule is shown in Figure 1. The proposed delivery date for the IR Imager is the first quarter of 1998 (before the official first light date) to assist in the commissioning of the telescope systems.

5.2 8-30μm Imager

5.2.1 Baseline Requirements.

Wavelength range - 5μm to 25μm with extension to 30μm as a goal.

Plate scale - - 0.13 arcsec/pixel (required to sample the telescope diffraction limit at 10 microns).

Field of View - as set by array

Instrument background - contribution should be < 1% effective emissivity

Throughput - Maximized (considered a high priority)

Standard Services - Filter requirements: one cold filter wheel with 20 - 30 slots for filters, etc.

Fast Guiding - Tip-Tilt correction achieved by sensing in the peripheral guide field.

Operational Requirements - Must be capable of operating in any orientation to allow mounting on either an upward looking or side looking port on the instrument support structure. In order to promote improved reliability, reduced operations cost and ease of implementation the use of 3-Stage Closed Cycle Refrigerator System is a requirement.

5.2.2 Instrument Allocation.

It is proposed to allocate this instrument to the US as a Gemini workpackage. The process of allocation within the US will take the form of a competitive bid within the US community. The US Gemini Project Office will be responsible for coordinating the bidding activity as described in section 7.

5.2.3 Proposed Delivery Schedule

The overall Program Schedule is shown in Figure 1. The proposed delivery date for the 8-30@m Imager is the third quarter of 1999 and will facilitate the long wavelength commissioning of the Mauna Kea telescope.

In order to produce a balanced instrument distribution in Phase 1 of the Program it is proposed that this instrument be moved to Cerro Pachon at the time of the commissioning activities on the southern telescope.

A schedule for the competitive bidding process, which is consistent with the overall Program Schedule is shown in Figure 2.

5.3 1-5μm Spectrograph

5.3.1 Baseline Requirements

Detector Technology - 1024xl024 InSb, 27μm pixels 1-5μm wavelength coverage. Currently being developed by SBRC/NOAO/US Naval Observatory through the Aladdin Project.

Pixel Scale - Should be capable of exploiting 0.1 - 0.2 arcsecond slits with sampling - 0.05 arcsec/pixel.

Slit Length - >= 50 arcsec.

Throughput - Maximizing throughput is a critical scientific priority.

Spectral resolutions - The lowest dispersion mode must allow each atmospheric window to be covered across the 1024 array (R - 2000), and an intermediate dispersion mode must be provided which allows the observations of key astrophysical lines between the atmospheric OH lines (R >= 8000).

Fast Guiding and Adaptive Optics - Provision of an optical feed (0.6μm-0.85μm passband) from a 3' field using a cold dichroic in the instrument.

Operational Requirements - Must be capable of operating in any orientation to allow mounting on either an upward-looking or side-looking port on the instrument support structure. In order to promote improved reliability, reduced operations cost and ease of implementation the use of Closed Cycle Refrigerator System is a requirement.

5.3.2 Optional Capabilities.

The following are considered to be desirable options, which will enhance the multiplex advantage of the spectrograph. With the exception of the first of these, they are not listed in any particular order:

Integral Field Mode - highest optional priority.

Cross Dispersion or simultaneous wavelength coverage - covering J, H, & K

Multi-Slit - with particular emphasis on J, H, & K

Slit length of 150 aresec - with a pixel scale of 0.15 arcsec/pixel.

Increased Spectral Resolution - In addition, spectral resolutions in the range 15,000 - 30,000 are considered to be options.

5.3.3 Instrument Allocation.

It is proposed to allocate this instrument to the US as a Gemini workpackage. The process of allocation within the US will take the form of a competitive bid within the US community. The US Gemini Project Office will be responsible for coordinating the bidding activity as described in section 7.

5.3.4 Proposed Delivery Schedule.

The overall Program Schedule is shown in Figure 1. The proposed delivery date for this instrument to the Mauna Kea telescope is the 4th quarter of 1998.

A schedule for the contracting process, which is consistent with the overall Program Schedule is shown in Figure 3. Any significant delay in the competitive process could affect the ability to deliver this instrument within the currently proposed schedule.

5.4 Multi-Object Spectrograph

5.4.1 General

This phase 1 program attempts to bring more balance to the instrument complement across Gemini North and South. One of the main aspects of this approach is identifying a method to fund two MOS instruments. By building two instruments with substantially similar characteristics a saving can be made on the design costs for the second instrument. Current thinking estimates that we can build two substantially similar MOS's for approximately 1.7 times the cost of building the first. This has been factored into the Program budget which now reflects the delivery of two MOS instruments.

5.4.2 Baseline Requirements.

Image Scale - 0.08 - 0.1 arcsecs/pixel

Field - As set by the array size

Wavelength Range - 370nm - 1100nm

Slit Sampling - 2.5 times the image pixel scale

Spectral Resolution - Up to 10,000

Imaging Mode - Sufficient to support the MOS mask production

Slit Production - Capability to manufacture precision slit masks on site

Integral Field Mode - Sub Apertures with diameters of 2.5 times the pixel scale over an 8 arcsec FOV

5.4.3 Optional Capabilities.

Extension of wavelength coverage with the following priorities:

1. Provide a UV capability (to the atmospheric cutoff) for the Southern MOS

2. Extend the wavelength capability of the Northern MOS to 1.6μm

3. Extend IR coverage of the Southern MOS (coatings permitting)

4. Extend UV coverage of the Northern MOS (coatings permitting)

A high spatial resolution integral field mode - to take advantage of the Adaptive Optics capabilities that will become available initially in the North and later in the South.

5.4.4 Instrument Allocation.

Within the UK (University of Durham) and Canada (DAO) there is substantial common scientific and technical interest in the Gemini MOS'S. Consequently, in the current allocation model, the MOS(S) workpackage will be a collaboration between the UK and Canada.

At the present time the UK and Canadian Project Offices in conjunction with the International Project Office are exploring a number of areas in preparation to setting up a collaboration. Areas being discussed are:

Exploration of common features in the design and construction of two MOS'S; Determination if two instruments can be delivered within the current Gemini budgetary constraints;

Identification of a mutually acceptable scientist to head up the instrument design team;

Formulation of a management plan that is both workable and acceptable to all parties.

5.4.5 Proposed Delivery Schedule.

The current proposal is to ship and commission MOS-1 on Mauna Kea and then on completion of MOS-2 to ship MOS-1 to Cerro Pachon for the telescope commission and then commission MOS-2 on Mauna Kea.

This has the advantage of being able to commission the second telescope with a thoroughly shaken down and commissioned instrument and commission MOS-2 with a better under-stood telescope system.

The overall Program Schedule is shown in Figure 1. The proposed delivery date for MOS-1 to the Mauna Kea telescope is the 1st quarter of 1999.

Delivery of MOS-2 is scheduled for the fourth quarter of 2000 allowing MOS-1 to be moved to Cerro Pachon.

5.5 High Resolution Optical Spectrograph.

5.5.1 Baseline Requirements.

Resolution - 120,000 and 50,000

Image Quality - 1.3 pixels in the spectral direction (enclosed energy)
0.1 arcsecs in the spatial direction (enclosed energy)

Slit Width - 0.24" @ R=120,000
0.60" @ R=50,000

Slit Length -1'

Sampling - At least 2.5 pixels at both resolutions

Wavelength Coverage - at least 90% from 3 10 nm to 660 nm at R=50,000; complete coverage as far into the red as possible at R=120,000

Order Separation - at least 6" on the sky at all wavelengths

5.5.2 Operation at Cassegrain.

The Gemini Science Committee recommended that the highest priority for the use of HROS be at the Cassegrain focal station, with the highest scientific priority put on throughput. Resolutions of 30,000 to 80,000 would be acceptable if this is required to achieve the required instrument stability at Cassegrain.

5.5.3 Off Telescope Operation.

The capability will exist for the operation of a HROS, in the high resolution mode (R=120,000), within the telescope pier which provides a highly stable thermal and vibrational environment as well as being free of the flexures normally associated with varying gravity loads.

5.5.4 CFHT Fiber Feed.

The current plan targets the HROS for delivery to the Southern telescope. In order to provide a high resolution spectroscopic capability in the north the project office, in conjunction with the CFHT and the Canadian project office have been investigating the feasibility of connecting Gemini to the CFHT coudé spectrograph via fibers. Funding for this activity has been included in the baseline budget.

5.5.5 Instrument Allocation.

It is proposed to allocate the HROS to the UK as a workpackage. The current UK proposal is to build this instrument as part of a joint collaboration between University College London (UCL) and The Royal Observatories. In this model UCL will be the design authority for the science performance with the Royal Observatories responsible for the day to day workpackage management.

5.5.6 Proposed Delivery Schedule.

The overall Program Schedule is given in section 4. The proposed delivery date for HROS to the southern telescope is the 2nd quarter of 2001.

The proposed date for implementing the connection between Gemini and the CFHT is currently mid- 1999.

5.6 CCD Procurement

5.6.1 General.

The GSC recommended that the proposed model for CCD development, which was for a international consortium from the Gemini partner countries led by the US project Office to produce a program to procure detectors for wavefront sensors (WFS's), the acquisition cameras, the Multi-object Spectroscopy (MOS), and High Resolution Optical Spectrograph (HROS), but not for 8K science imagers, be adopted. The intent of the GSC was to encouraged

i. A broad participation of the international communities in this program through collaborative foundry runs, as this may allow for greater capability of the detectors ultimately delivered to the Gemini Telescopes.

ii. A timely procurement schedule to support the Optical Instrument workpackages

This workpackage includes the provision of acquisition cameras and instrument wavefront sensors a part of which will be done in collaboration with Canada.

5.6.2 CCD Specifications.

The Optical detector workpackage includes a number of systems to satisfy the various requirements within the telescope facilities and instruments. The desired systems are

- Focal Plane Array for the Multi Object Spectrograph (MOS)
- Focal Plane Array for the High Resolution Optical Spectrograph (HROS)
- Acquisition Cameras for each of the telescopes
- 6 Fast Readout/Small Format devices for fast guiding and Active Wavefront Sensing

5.6.2.1 MOS Detector.

The present MOS detector is proposed as a 4K X 4K CCD array with 15μm pixels to be achieved with two 2K X 2K devices (standard building blocks) butted together with the characteristics shown in Table 1.

Gaps (mosaic)	<1.0 mm
Flatness	<10μmP-V
QE	>40% @ 3100 A
	>80% @ 6500 A
	>40% @ 9500 A
Readout Noise	< 4e
Dark Current	< 6 e/pixel/hr
Full Well	> 100, 000 e

Table 1: Characteristics of the Gemini "Standard Building Block" CCD.

The MOS detector will be provided in a dewar which is compatible with the external focal plane of the spectrograph camera.

5.6.2.2 HROS Detector.

The HROS detector can essentially be the same as for the MOS. Some differences may be required such as a non-square format to match the echellogram, an optimized blue and red portion of the focal plane again to match the echellogram. In addition, it is desirable to minimize the readout noise for this instrument and the use of skipper amplifiers, or some other method to ensure low readout noise, may be required.

The HROS detector will be provided in a dewar which is compatible with the external focal plane of the spectrograph camera.

5.6.2.3 Acquisition Cameras.

The purpose of the acquisition camera is to provide for the accurate positioning of "invisible" objects onto narrow (~0.1”) slits. The baseline requirements are:

- Field viewing via a reflection in the Instrument Support Structure Field of View 2' square
- Readout Rate of at least 2 frames/second
- Re-imaged optics with a baffled internal pupil for use when observing in the IR (i.e.. No baffles and high sky brightness)

The detectors would be packaged in a dewar which would also house the required filters, shutter and mechanical mounting arrangements.

5.6.2.4 Wavefront Sensors.

These devices are expected to be fast (up to 1 kHz frame rate) small format (64 X 64) multiple readout CCD'S. They will perform the following functions:

Peripheral WFS - Located in the A&G system, there are two WFS's per system providing Tip-Tilt, Focus and the Higher Order information required for Active Optics Control.

On-Board WFS - Located on the instrument to provide low order, close to on-axis (tip-tilt/focus information) by way of an optical feed from the instrument. Eventually each instrument (operating short of 5 µm) will require such a system. Initially we only have funds to provide 1 or 2 systems which will be shared between instruments.

5.6.2.5 CCD Controllers.

For the science instruments (MOS and HROS) and the Acquisition Cameras a standard detector control system will be used. The CTIO ARCON controller, developed at CTIO, has been identified as satisfying the projects current requirements and they may be built in Chile for Gemini as a Chilean workpackage.

The fast/small format CCD's are very specialized and the controllers for these will differ from the science detector controllers. It is likely that these detectors/controllers will be procured as a single package.

5.7 IR Arrays and Control Electronics

5.7.1 IR Arrays.

The choice of array for the 1-5µm instruments will be the 1024xl024 InSb devices currently being developed by the ALADDIN Program see Table 2. It is fully expected that these devices will be available well within the required timescales for Gemini. A strategy for the procurement of these devices is still under discussion, but it seems likely that Gemini would benefit by joining a consortium which would contract with SBRC for a production run.

In the case of the longer wavelength arrays it is very much the case of watching the developments in this area. There are a number of companies who are interested in providing arrays for this wavelength range. We propose to wait until the selection of the group to build the 8-30μm imager before committing to a particular device or technology.

Number of Pixels	1024(H) x 1024(V)
Architecture	4-Independent 512 x 512 quadrants
Pixel Size	27μm Square
Effective Fill Factor	100%
Number of Outputs	32 (8 per quadrant)
Frame Rate	50 mS
IR Material	Thinned InSb
Full Well	300 x 10^3 electrons at 0.8v bias
Wavelength Range	0.9μm - 5.5μm
Operating Temperature	35 Kelvin
Dark Current	<0.1 e/sec
Noise	<25 e rms
Quantum Efficiency	>80% 0.9μm to 5μm

Table 2: ALADDIN 1024 x 1024 InSb Focal Plane Characteristics.

5.7.2 Array Controllers.

Both IR Working Groups recommended that the 1-5μm Imager and the 1-5μm Spectrograph should have common array and controller technology. In addition it is a desirable goal to examine if this concept of a common controller can be extended to include the operation of the 8-30μm Imager and other future mid-IR instruments. Within the Phase 1 budget there are insufficient funds for the Project to pursue any independent array or controller development. Since there are already a number of groups who have built or are building array controllers that will handle the larger format arrays it is not apparent that any development program will be required.

The Project is recommending that the choice of array procurement strategy and controller technology be delayed until it is decided who, in the US, will be building the 1-5μm Spectrograph and the 8-30μm Imager. The Gemini Instrumentation Group will then work with these groups and with the University of Hawaii to find a common solution that meets the requirements of the near IR instruments and examine what options exist to extend these capabilities to the mid-IR instruments.

6. Instrumentation Program Management.

6.1 Introduction

This section describes the process that the Gemini Project proposes to use to manage the procurement of instruments for the Gemini 8-m telescopes. It also proposes how the National Gemini Project Offices (NGPOs) can assist the International Gemini Project Office (IGPO) in the procurement process and also in the subsequent monitoring of instrument contracts/workpackages.

The instrument procurement, which will be carried out in the Gemini partner countries, will be handled as per the requirements of the individual countries. In the UK and Canada the procurement will be handled as workpackages with the allocation of the individual workpackages being coordinated by the National Gemini Project Offices. In the US all the instrument activities will be competitively bid in the community, with the exception of the IR Imager which has already been allocated to the University of Hawaii as part of a MOU with the NSF. All US instrument procurements will be coordinated by the US Gemini Project Office and shall be treated as contracts.

Each instrument contract or workpackage shall be considered as a discrete project that forms part of the Gemini Instrumentation Program. The Program is managed by the Gemini Instrumentation Manager who reports to the Gemini Project Manager.

It is expected that instrument building groups that are chosen to build instruments for Gemini will have demonstrated the following capabilities during the selection process: strong scientific interest in the proposed instrument, professional engineering and management skills, technical competence, and a proven track record of astronomical instrument building.

It is expected that each project shall have a recognized scientific leader (Principal Investigator, Project Scientist or whatever). This person shall provide the scientific drive and direction for the instrument project. In addition to strong scientific leadership a successful project also requires competent engineering management. Each project shall appoint a professional engineering manager (in the case of workpackages he shall be designated the Workpackage Manager) who will assume responsibility for the technical management of the instrument project. The engineering manager for each contract or workpackage shall report on a regular basis to the Gemini Instrumentation Manager and the relevant National Gemini Project Manager on such matters as schedule, finance, technical issues, etc. as laid down in the various agreements between AURA and the Gemini partners. Figure 6. outlines the program management structure and also indicates where the science working groups appear in the process.

The commencement of acquisition activities for each instrument will be staggered to accommodate a staged delivery schedule, allowing approximately 6 months between the delivery of each instrument. Because the instruments are dependent on other aspects of the telescope development and differ in complexity and technological maturity, the schedules for individual instruments will remain flexible until more accurate schedule estimates are obtained from the contractors and the other Gemini Groups. In addition, critical interfaces with other areas of telescope development must be identified as early as possible and monitored continuously.

What follows, in this document, is a description of the phases and activities associated with the execution of a single instrument contract or workpackage. In this case the term instrument is used to describe a single contract or workpackage objective and can be used to cover Acquisition and Guiding, Adaptive Optics and Detector Procurement as well as individual instruments.

6.2 Role of the National Project Offices.

6.2.1 Instrument Procurement.

The National Project Offices can play a major role in assisting Gemini in the instrument procurement process.

UK Gemini Project Office (UKGPO).
The establishments of the UK Observatories (ROE and RGO) will most likely play a major role in the construction of the instruments allocated to the UK. Because the UKPGO is situated within the UK Observatories it is ideally placed to coordinate procurement activities in the UK community and to provide liaison between the UK University groups and the IGPO.

Canadian Gemini Project Office (CGPO).
As with the UK, the Canadian instrumentation construction activities will be centered at their National Observatory (DAO). The Canadian project office is also based at DAO and therefore they too are ideally placed to coordinate procurement activities for the Canadian workpackages.

US Gemini Project Office (USGPO)
The USGPO may be in a different situation to that of the UK and Canada. It is certain that some of the instrument work will be done by institutions outside the National Observatory (IR Imager in Hawaii) and the capability of the USGPO to manage the coordination will differ from that of the UK and Canada. However, the US are keen to compete the instrument procurement in their community which yields a more involved process than for the UK and Canada. It therefore makes sense for Gemini to have the USGPO assist them in coordinating the procurement activities as per the other partner countries.

As well as coordinating the procurement activities the NGPOs can assist in other areas such as helping to prepare workpackage definition papers, assisting in the preparation of workscopes, etc.

6.2.2 Contract/Workpackage Monitoring.

The Gemini Instrumentation Group has limited manpower resources and as such will not be capable of closely monitoring all of the individual workpackages/contracts in the partner countries. The National Gemini Project Offices can provide the International Gemini Project Office with substantial assistance in this area. In the UK and Canada "on-site" workpackage monitoring by the UKGPO and the CGPO will be invaluable. In the US, it is likely that some of the instrument work will take place at NOAO, and therefore the USGPO can play a role similar to that of its UK and Canadian counterparts. In addition, the USGPO can assist the IGPO in the monitoring of "off-site" activities.

6.2.3 Reporting.

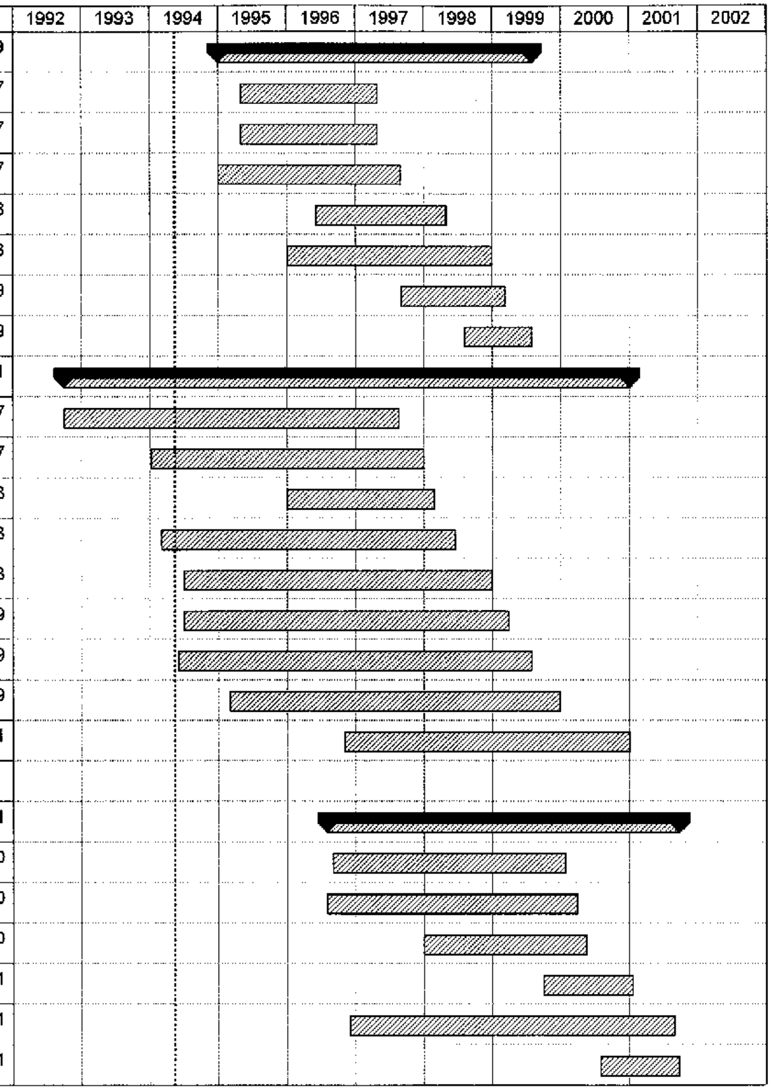
It will be a requirement in all of the instrument contract/workpackage agreements for the instrument builder to provide the IGPO with regular (monthly) progress reports relating to budget, schedule and technical issues. Copies of these reports will be sent to the NGPOs by the instrument builder(s) to facilitate the monitoring process.

6.2.4 Responsibility.

The ultimate responsibility for all financial and technical aspects of the Instrumentation Program remains with the IGPO. From time to time it may be necessary to delegate some of the technical responsibility to the NGPOs to allow a more efficient process. The Gemini Instrumentation Manager shall be responsible for delegating such authority.

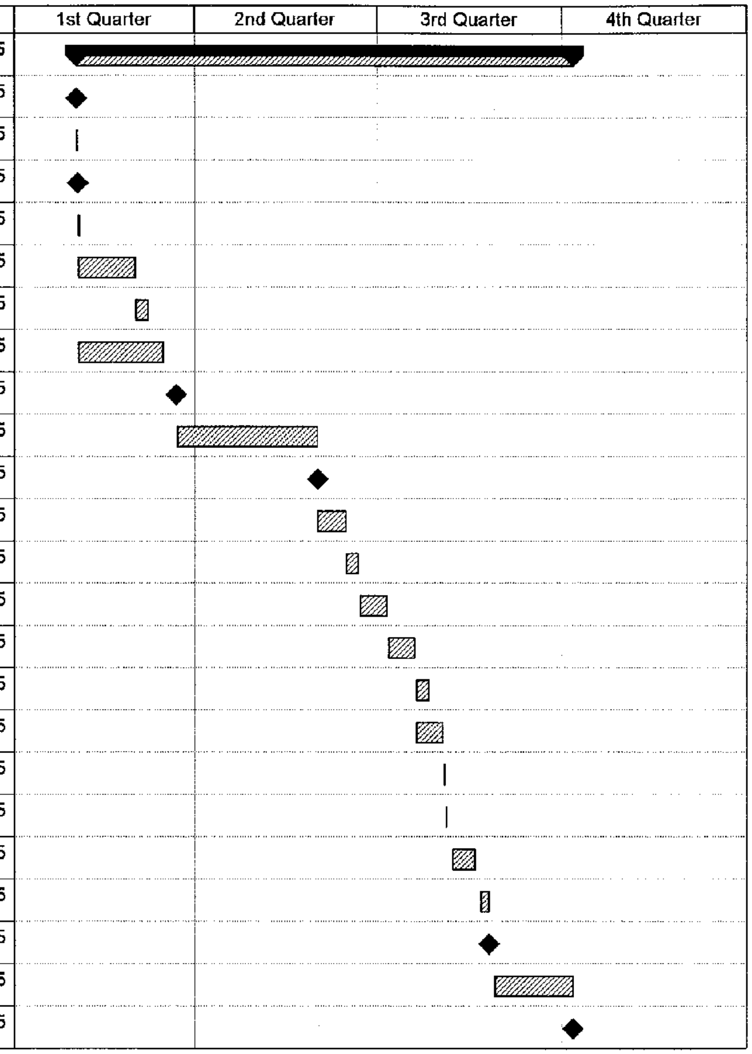
Gemini Instrumentation Program Plan - Phase 1.

ID	Name	Scheduled Start	Scheduled Finish
1	**Support Activities**	**January 2, 1995**	**July 30, 1999**
2	IR Arrays Phase 1	May 1, 1995	April 30, 1997
5	IR Controllers Phase 1	May 1, 1995	April 30, 1997
6	CCD Development & Procurement	January 2, 1995	August 29, 1997
7	CCD Electronics	June 3, 1996	May 1, 1998
3	Wavefront Sensors (X6)	January 1, 1996	December 31, 1998
8	CCD Camera Heads	September 1, 1997	March 12, 1999
4	CFHT Fiber Feed	August 3, 1998	July 30, 1999
9	**Mauna Kea Activities**	**October 1, 1992**	**January 3, 2001**
10	Cassegrain Rotator/ISS	October 1, 1992	August 20, 1997
11	A&G/Wavefront Sensors	January 3, 1994	December 31, 1997
12	Acquisition Camera	January 1, 1996	February 27, 1998
13	1-5 Micron Imager	March 1, 1994	June 16, 1998
14	1-5 Micron Spectrometer	July 1, 1994	December 31, 1998
15	MOS-1	July 1, 1994	March 31, 1999
16	Adaptive Optics	June 1, 1994	July 30, 1999
17	10-20 micron Imager	March 1, 1995	December 28, 1999
18	MOS-2 (Copy of MOS-1))	November 1, 1996	January 3, 2001
19			
20	**Cerro Pachon Activites**	**August 1, 1996**	**September 24, 2001**
21	Cassegrain Rotator/ISS	September 2, 1996	January 26, 2000
22	A&G/Wavefront Sensors	August 1, 1996	March 30, 2000
23	Acquisition Camera	January 1, 1998	May 17, 2000
25	MOS-1 Moved from Mauna Kea	October 1, 1999	January 18, 2001
24	High Resolution Optical Spectrograph	December 2, 1996	September 3, 2001
26	CTIO IR Instrumentation Integration	August 1, 2000	September 24, 2001



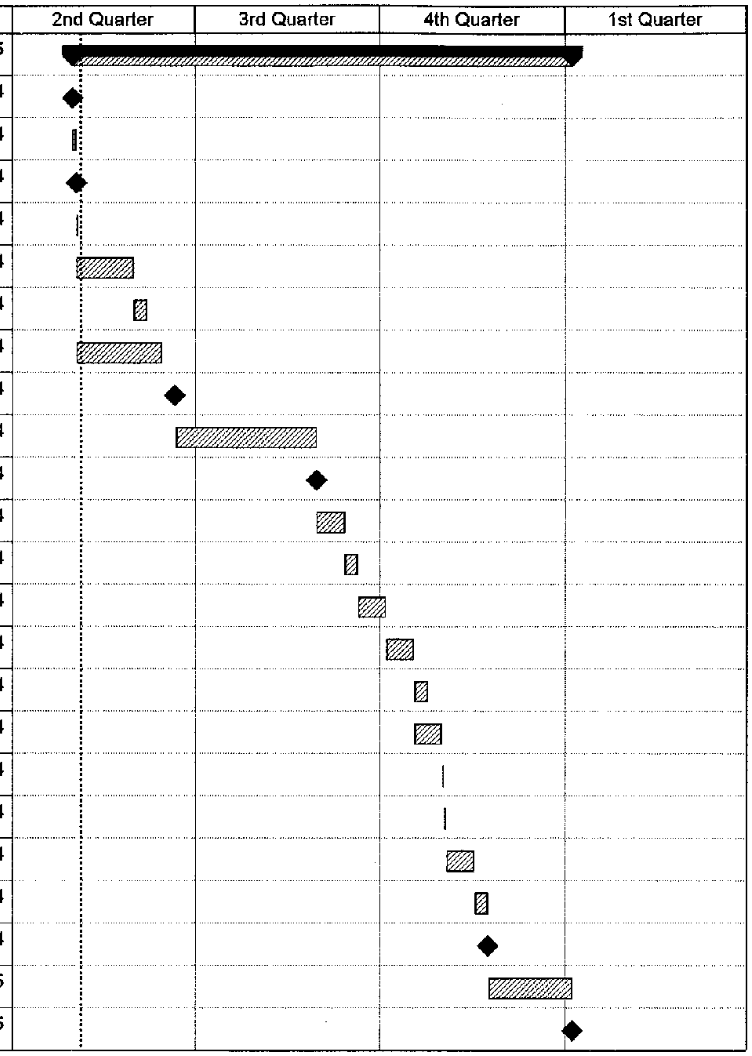
8-30 micron Imager contracting schedule

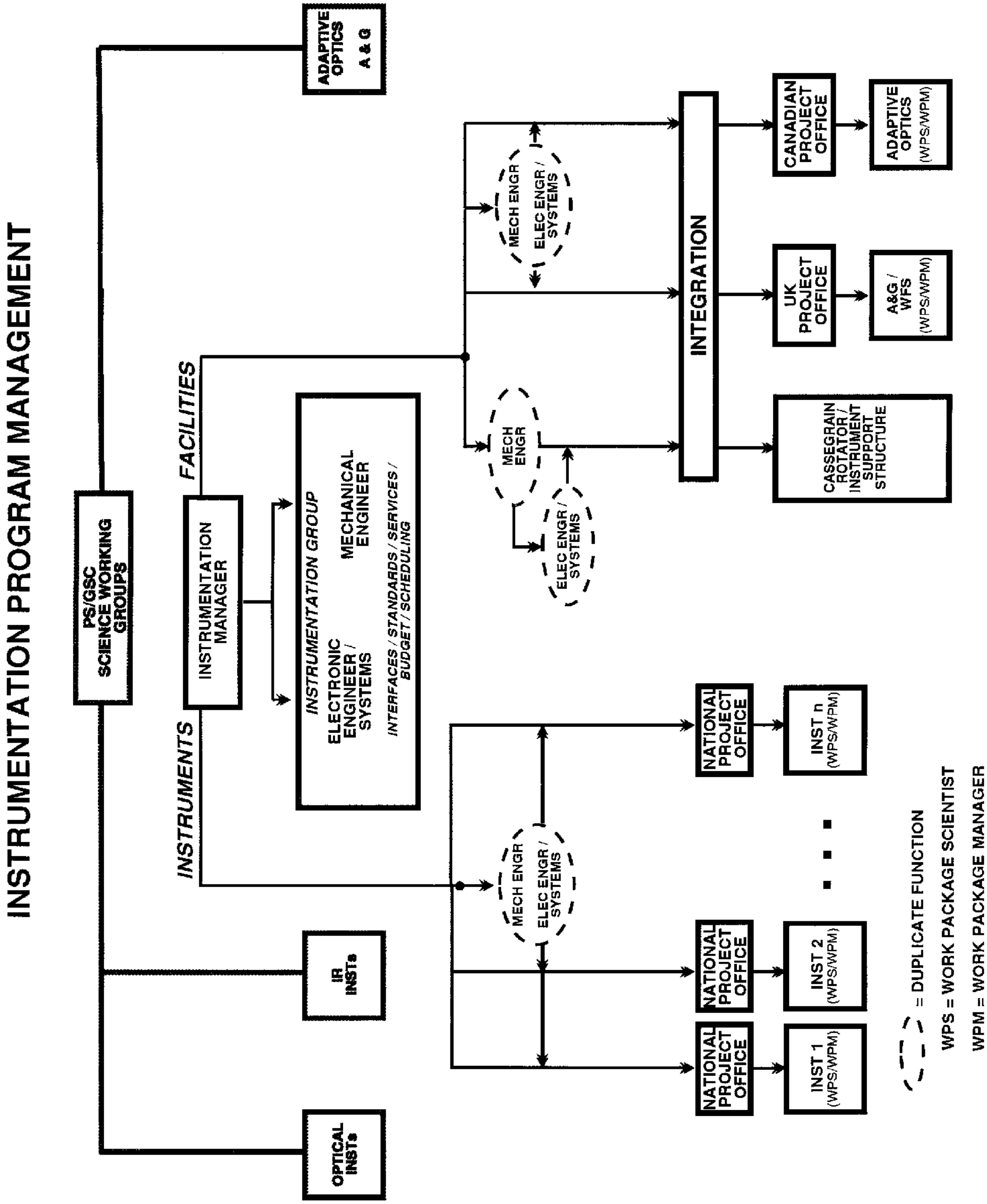
ID	Name	Scheduled Start	Scheduled Finish
1	**8-30 micron Imager Contracting Effort**	**February 1, 1995**	**October 6, 1995**
2	Begin Contract Effort	February 1, 1995	February 1, 1995
3	Provide Selection Plan	February 1, 1995	February 1, 1995
6	Release Announcement of Opportunity	February 1, 1995	February 1, 1995
4	Project Manager Approval	February 2, 1995	February 2, 1995
7	Receive Letters of Interest	February 2, 1995	March 2, 1995
8	Prepare Bidders List	March 2, 1995	March 8, 1995
5	Prepare RFP	February 2, 1995	March 16, 1995
9	Issue RFP	March 22, 1995	March 22, 1995
10	Prepare Proposals	March 23, 1995	June 1, 1995
11	Receipt of Proposals	June 1, 1995	June 1, 1995
12	Evaluation Period	June 1, 1995	June 15, 1995
13	Complete Preliminary Evaluation Report	June 15, 1995	June 21, 1995
14	Negotiations with Respondents	June 22, 1995	July 5, 1995
15	Best and Final Offer	July 6, 1995	July 19, 1995
16	Reevaluate Offers	July 20, 1995	July 26, 1995
17	Complete Final Evaluation Report	July 20, 1995	August 2, 1995
18	Prepare Request for Contract Form	August 3, 1995	August 3, 1995
19	Project Manager Approval	August 4, 1995	August 4, 1995
20	Negotiate Contract	August 7, 1995	August 18, 1995
21	Contract Signatures	August 21, 1995	August 25, 1995
22	Contract to AURA	August 25, 1995	August 25, 1995
23	AURA & NSF & Gemini Board Approval	August 28, 1995	October 6, 1995
24	Begin Work	October 6, 1995	October 6, 1995



1-5 micron spectrograph contracting schedule

ID	Name	Scheduled Start	Scheduled Finish
1	**IR Spectrometer Contract Effort**	**May 1, 1994**	**January 4, 1995**
2	Begin Contract Effort	May 1, 1994	May 1, 1994
3	Provide Selection Plan	May 1, 1994	May 2, 1994
6	Release Announcement of Opportunity	May 3, 1994	May 3, 1994
4	Project Manager Approval	May 3, 1994	May 3, 1994
7	Receive Letters of Interest	May 3, 1994	May 31, 1994
8	Prepare Bidders List	May 31, 1994	June 6, 1994
5	Prepare RFP	May 3, 1994	June 14, 1994
9	Issue RFP	June 20, 1994	June 20, 1994
10	Prepare Proposals	June 21, 1994	August 30, 1994
11	Receipt of Proposals	August 30, 1994	August 30, 1994
12	Evaluation Period	August 30, 1994	September 13, 1994
13	Complete Preliminary Evaluation Report	September 13, 1994	September 19, 1994
14	Negotiations with Respondents	September 20, 1994	October 3, 1994
15	Best and Final Offer	October 4, 1994	October 17, 1994
16	Reevaluate Offers	October 18, 1994	October 24, 1994
17	Complete Final Evaluation Report	October 18, 1994	October 31, 1994
18	Prepare Request for Contract Form	November 1, 1994	November 1, 1994
19	Project Manager Approval	November 2, 1994	November 2, 1994
20	Negotiate Contract	November 3, 1994	November 16, 1994
21	Contract Signatures	November 17, 1994	November 23, 1994
22	Contract to AURA	November 23, 1994	November 23, 1994
23	AURA & NSF & Gemini Board Approval	November 24, 1994	January 4, 1995
24	Begin Work	January 4, 1995	January 4, 1995





INSTRUMENTATION PROGRAM MANAGEMENT
PS/GSC SCIENCE WORKING GROUPS
OPTICAL INSTs
IR INSTs
ADAPTIVE OPTICS A & G
INSTRUMENTS
FACILITIES
INSTRUMENTATION MANAGER
INSTRUMENTATION GROUP
ELECTRONIC ENGINEER / SYSTEMS
MECHANICAL ENGINEER
INTERFACES / STANDARDS / SERVICES / BUDGET / SCHEDULING
MECH ENGR
ELEC ENGR / SYSTEMS
NATIONAL PROJECT OFFICE
INST 1 (WPS/WPM)
INST 2 (WPS/WPM)
INST n (WPS/WPM)
INTEGRATION
CASSEGRAIN ROTATOR / INSTRUMENT SUPPORT STRUCTURE
UK PROJECT OFFICE
A&G / WFS (WPS/WPM)
CANADIAN PROJECT OFFICE
ADAPTIVE OPTICS (WPS/WPM)
= DUPLICATE FUNCTION
WPS = WORK PACKAGE SCIENTIST
WPM = WORK PACKAGE MANAGER