I. MANAGEMENT (D17)

The Gemini Observatory serves the interests of all its member countries, as provided for in the international Gemini Agreement, which governs all aspects of the Observatory and all entities that play roles within the Observatory.

A. Introduction

The preceding Sections have described Gemini achievements and aspirations as a science research effort. At the same time, AURA manages and operates the Observatory as a freestanding science center. Section IV now describes the operational management side of this effort.

B. Partnership Organization and Roles – The Main Players

The management structure and administration of Gemini reflect its intrinsic nature. The Gemini Board communicates policies and directives through the National Science Foundation (NSF), the executive agency, to the Association of Universities for Research in Astronomy (AURA), which serves as the managing organization.

1. Partner Countries and Agencies

Various government agencies of the Gemini Partner countries established the Observatory. These agencies continue to establish broad funding and policy guidelines through the Gemini Board, and empower the NSF to carry out the work of the Observatory. Based on funding support, these are shown below.

<table>
<thead>
<tr>
<th>Country</th>
<th>Share (%)</th>
<th>National Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>50.1</td>
<td>National Science Foundation (NSF)</td>
</tr>
<tr>
<td>UK</td>
<td>23.8</td>
<td>Particle Physics and Astronomy Research Council (PPARC)</td>
</tr>
<tr>
<td>Canada</td>
<td>15.0</td>
<td>National Research Council (NRC)</td>
</tr>
<tr>
<td>Australia</td>
<td>6.2</td>
<td>Australian Research Council (ARC)</td>
</tr>
<tr>
<td>Argentina</td>
<td>2.4</td>
<td>Cosejo Nacional de Investigaciones Científicas y Technicas (CONICET)</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.5</td>
<td>Ministry of Science and Technology (MST)</td>
</tr>
<tr>
<td>Chile¹</td>
<td></td>
<td>Comisión Nacional de Investigación Científica y Tecnológica (CONICYT)</td>
</tr>
</tbody>
</table>

2. Gemini Board

The Gemini Board sets budgetary policy for the Observatory and carries out broad oversight functions, as defined in the international Gemini Agreement. The Gemini Board has reserved the right to approve the appointments of the Gemini Director and Associate Directors for Gemini North and South.

¹ Initially, Chile was both a regular partner and a site host. Today, Chile remains as a site host only.
a. **Designated Members**

The Partnership has identified certain Board members as Designated Members. These are selected by the Partner agencies from the US, UK, and Canada to represent their respective interests. Each Designated Member has separate veto power over any Board decision that he/she deems to be not in the Partner’s interest. Thus, the NSF’s Designated Member must concur with all decisions made by the Board, including budgets, staffing, and program plans.

3. **Executive Agency – NSF**

Under the Gemini Agreement, as the executive agency the NSF acts as the sole conduit for funding and policy guidelines for the Observatory. NSF also selects and contracts with a managing entity for Gemini.

   a. **Gemini Observatory Visiting Committee – NSF Oversight**

On behalf of the Gemini Board, the NSF established the Gemini Observatory Visiting Committee (GOVC) as an independent oversight panel that performs site visits and reviews every two years. The NSF selects the Committee members, which includes members from the international Gemini community. Nominees may not have any formal relationship with AURA.

The GOVC reviews the Observatory’s overall health, the Director’s performance in operating the Observatory in a user-oriented manner, the Observatory’s effectiveness in providing an excellent environment for research and maximizing scientific productivity through technical and operational improvements, and other facets of Observatory operations and AURA management that affect user service.

4. **Managing Organization – AURA**

The NSF selected the Association of Universities for Research in Astronomy, Inc., a non-profit US corporation of 36 universities and research institutions, as the managing organization for the Observatory. AURA’s primary mission is to establish, operate and maintain outstanding astronomical research centers for use by all qualified US astronomers and, in Gemini’s case, non-US astronomers as well.

In addition to the Gemini Observatory, under cooperative agreements with the NSF, AURA manages the National Solar Observatory and the National Optical Astronomy Observatory (with telescope facilities in Arizona and Chile). It also manages the operation of the Hubble Space Telescope and will manage the James Webb Space Telescope through the Space Telescope Science Institute, under contracts with NASA. AURA manages the Gemini Observatory as a distinct operational unit.

C. **AURA’s Management of Gemini – Focused on Excellence**

AURA is accountable to the Gemini Board, through the NSF, for operating the Observatory within specified parameters of performance, schedule, scope, and budget. The NSF provides the necessary authority to enable effective execution. In turn, AURA delegates authority to the Gemini Director and provides oversight in accordance with AURA policy.
1. AURA Structure

The AURA Board of Directors establishes policies, approves its budget, elects members to its internal management councils, appoints the President, Center Directors, and other principal officers, and otherwise manages the affairs of the corporation according to its charter.

AURA strives to compose its Board of the most knowledgeable and best-qualified professionals available. Thus constructed, it is impossible to exclude the potential for conflicts of interest from time to time. AURA’s internal policies aim to avoid such conflicts, wherever possible, and to mitigate and manage them if they are not readily avoidable.

The AURA President is the corporation’s chief executive officer and responsible for overall management, within policies and guidelines established by AURA’s Board. The Center Directors are the chief operating officers for their respective Centers.

![Diagram of AURA Structure]

Figure 4-1. The Gemini Observatory integrates the Partner agencies, their astronomy communities, and the Observatory itself into a single working unit. The national science groups at the bottom form a closed loop through their agencies at the top by the Gemini Board.

2. Established Policies

With NSF approval, AURA has established a set of overall policies that define general boundaries for the conduct of business by the Centers. In addition, with NSF approval, AURA
has worked with Gemini in certain areas to develop Gemini-specific policies essential to its unique program and circumstances.

3. **AURA’s Operational Oversight of Gemini**

The AURA Board provides oversight for all activities of the corporation, within the limits of responsibility set by its NSF cooperative agreements. The AURA Oversight Committee-Gemini (AOC-G) provides information, recommendations, and findings to the Gemini Board and responds to specific oversight requests from the Board. The AOC-G reports through the AURA President to the AURA Board. The AOC-G includes a minimum of seven members, at least three of which are elected from a slate of candidates nominated by non-US Gemini Partner countries.

The AOC-G fulfills two major functions. First, in providing external oversight over the operational aspects of the Gemini Observatory, the AOC-G reviews productivity, the adequacy of observing procedures, the efficiency of user services, and AURA’s performance as the managing entity. Second, it assists AURA in carrying out essential management duties such as those pertaining to personnel matters and administrative policy development.

4. **The AURA Tenure Program – Maintaining Scientific Excellence**

Gemini’s considerable reliance on queue-scheduled service observing requires:

- A science staff that uses the Gemini telescopes as well or better than visiting astronomers, and whom the Gemini communities accept as credible observers.
- A substantial commitment to the Observatory and mission by the staff, particularly the science staff.

Thus, a principal element in operating the Gemini telescopes is the ability to hire, motivate, and retain a cadre of high-quality scientists. This cadre also represents a significant operational investment, since it is the repository of the detailed operational knowledge that makes the Observatory run. The AURA tenure program is a key tool in science-staff recruitment, management, and career development.

Gemini’s implementation of the tenure system incorporates both multi-faceted tenure criteria and an effective post-tenure review process. Using the tenure system, Gemini achieves these key objectives with:

- Tenure decisions based on institutional and strategic priorities that emphasize scientific excellence, Gemini community service, and commitment to the Observatory and its mission.
- A regular process of periodic evaluation of all tenured staff that enhances the value of tenure to the Observatory and AURA.
- Post-tenure reviews aimed at facilitating professional growth by providing positive, constructive feedback.

D. **Internal Performance Oversight**

In addition to independent oversight by the NSF/Gemini Board and the AURA Board, the Observatory’s organizational structure provides internal checks and balances to monitor and improve performance.
Sustaining excellence in the Observatory’s performance of its mission requires relevant objective data. Various aspects of Gemini science operations lend themselves naturally to quantitative measurements of Observatory and National Office performance:

1. **Science Productivity**

   a. *Science Impact Measured by Publications and Citations*

   The Observatory keeps a very detailed publications database that is updated on a weekly basis. The research productivity based on the number of papers and citations is one of the criteria for deciding whether or not to maintain an instrument on the telescope. For the full statistics on citation, Gemini works with the Herzberg Institute of Astrophysics that has experience in managing publication and citation statistics. HIA also provides useful historical comparisons between observatories/telescopes that help us to assess ourselves in a critical way.

   b. *Science Productivity for Each Telescope*

   Using the Gemini publications database, the number of publications is tracked as a function of instrument, original program ranking, and several other criteria. It provides a robust basis for analysis of indicators of the popularity and productivity of all Gemini capabilities and observing modes.

   c. *Average Cost of an Available Science*

   Having a reliable database of publications and a good knowledge of budget, one can establish the cost of the science products. This can be done in various ways such as cost per paper or per citation. One can then make comparisons with other ground-based or space observatories, which can be a usually very revealing exercise.

   d. *Number of Programs Executed and Users Served*

   Gemini keeps statistics by country and demands for each instrument. These are indicators of the effectiveness and competitiveness of the instruments, spectral windows explored, and observing modes (e.g. AO versus non-AO, queue versus classical).

   e. *Quality of Services Provided Through the Distributed Model*

   Oversubscription rates and their histories are tracked on a semester-to-semester basis. They are a measure of demand and can be compared to similar information from other observatories. Feedback from observers is also a useful tool, although astronomers are traditionally poor at filing feedback forms on their data. Focused questionnaires sent regularly to users are good probes. Semi-annual meetings of the Operations Working Group provide a very effective forum where NGO representatives and Gemini North and South Associate Directors review their concerns and user issues.

2. **Time Charged According to Partner Share**

   The principal investigator for each observing program is charged the time spent executing that program. These aggregated charges comprise the overall Partner usage. However, a finer level of measurement is available from the Observatory Control System, since it timestamps each step of the observation. Thus, the time required to slew the telescope, reconfigure it, acquire the target, carry out the observing sequence, perform calibrations, and assess data quality are all
recorded. Similarly, time lost due to weather or failure of either a telescope or instrument, or time spent on scheduled engineering activities, also is recorded.

The metrics available to measure the observing system performance are:

- The efficiency of execution of an observation program, as either a classical or queued observation.
- Within the queued program, the percentage of highly ranked proposals completed within a given semester, tagged by nationality and instrument technique.

These quantitative measures are used to provide feedback to further improve the observing systems (e.g., calibration systems, instrument efficiencies and observation sequencing) and to further optimize the queue system and observing performance.

3. Gemini’s Distributed User Support System

This system also time-stamps its activities via its “help desk” function, whereby each requestor assigns their query to a subject category that is used to route it to the appropriate National Office or to Gemini. The system’s built-in reporting tools allow for quantifying:

- Load and balance (e.g. the number of requests received per NGO, instrument or subject, and country of origin).
- Performance (e.g. number and timeliness of user-request responses).
- Fairness (e.g. distribution of response times by country of origin, instrument or subject).

When ranked by subject or instrument, these performance data on the support system provide feedback for improving user-support tools and information, such as manuals and web pages. When organized by NGO, this information allows the Partnership to assess the effectiveness of the distributed-user support model.

4. Program Reviews

In close communication with AURA, the NSF, and the Gemini Board, the Director organizes periodic reviews of the Observatory’s overall performance that summarize performance metrics, financial data, scientific accomplishments and other information relevant to management goals.

To minimize the burden of the review process on Observatory staff, the AOC-G and GOVC make themselves available for scheduled reviews, and the Gemini Board and the NSF are invited to do likewise. The reviews also are open to the AURA Board, and individuals invited by the Gemini Director.

5. Gemini Reports

The Gemini Director submits the following Observatory reports through AURA to the NSF to be coordinated with established formal reviews, such as the Gemini Board meetings. While these might reasonably be considered NSF oversight tools, they originate from the Observatory and also provide Gemini with the opportunity to evaluate itself, since the Observatory is reporting on its own performance along a variety of axes. These reports include, but are not limited to:
a. **Annual Progress Report and Program Plan**

This covers Observatory accomplishments, the status of scheduled observing during the most recent twelve months, and scheduled projects and issues to be resolved during the following twelve months.

b. **Annual Financial Report**

This document summarizes expenditures to date, outstanding financial commitments, and a comparison of costs incurred with budgeted funds.

c. **Master Site Plan**

This annual report provides the NSF with a comprehensive update on all buildings and land holdings (owned or leased) controlled by the Observatory. It includes maps, site plans, and textual descriptions of each asset, its purposes and current and expected future needs.

d. **NSF Facilities Project Reports**

This actually consists of two annual reports. The first is a pre-year estimate of performance based on objective criteria, such as the number of hours available for scheduled observing programs. The second report is a post-year report on the actual performance based on the defined metric criteria during the performance period.

6. **Impact of PIO Program**

The Gemini Public Information and Educational Outreach program is very active in both the host communities and throughout the Partnership (see Section IV.J.6). Gemini monitors the number of school and public events, teacher trainings, and other programs, and the number of people reached. Gemini tracks the effectiveness press releases and the media that respond by publishing them. Gemini also tracks the details and number of hits on the Observatory’s web pages.

**E. An Integrated Observatory – A Collaboration of Communities**

Gemini must effectively and efficiently meet the diverse science objectives of the Partner science communities. During the construction of the Observatory, AURA and the Gemini Partners collaborated to develop an integrated working structure. The AURA-operated Observatory is joined with the Partners, firstly through their agencies on the Board, and secondly by direct links to their national astronomy communities. The community links operate through committees and offices that actively shape the science program and participate in science operations.

The Observatory’s “customers” are the Partner agencies, acting on behalf of their respective science communities. Gemini’s integrated approach makes the agencies and their communities intimate participants in the Observatory’s science and instrumentation programs; they are a part of the Observatory itself. At the same time, the science communities are connected through their normal working channels to their respective policy and funding agencies. This serves to ensure that science operations proceed expeditiously, and in the longer term, that the communities close the loop on needs, performance, and policy with their agencies and the Gemini Board.
Another impact of this approach manifests at the organizational level, where a high degree of “matrixing” occurs between functional units within and between each area of responsibility. Thus, for example, in many instances addressing issues of science operations requires a discussion of management elements that support those operations.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FUNCTION</th>
<th>COMPOSITION</th>
<th>REPORTS TO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gemini Finance Committee (GFC)</td>
<td>Reviews all aspects of finances, including proposed and actual budgets, expenditures and contracts</td>
<td>Designated members (US, UK, and Canada), senior agency financial staff, other Board appointees</td>
<td>Gemini Board</td>
</tr>
<tr>
<td>Visiting Committee (GOVC)</td>
<td>Reviews all aspects of Observatory operations and AURA management, makes site visits every two years</td>
<td>NSF appoints</td>
<td>Gemini Board Via NSF</td>
</tr>
<tr>
<td>AURA Oversight Committee-Gemini (AOC-G)</td>
<td>Exercises oversight of Gemini operations on behalf of AURA</td>
<td>AURA appoints 7 members or more, at least 3 are nominated by non-US Partners</td>
<td>AURA President</td>
</tr>
<tr>
<td>Gemini Science Committee (GSC)</td>
<td>Advises on science issues and instrument requirements, assesses Gemini response to national communities, evaluates Observatory performance</td>
<td>Partner agencies appoint 15 active astronomers: 6 US, 3 UK, 2 Canada, and 1 each from other partners</td>
<td>Gemini Director</td>
</tr>
<tr>
<td>National Gemini Offices (NGO's)</td>
<td>Coordinate national activities, manage Partner's observing requests and provide support</td>
<td>Partner agency determines selection of representatives and other staff</td>
<td>Determined by Partner agencies</td>
</tr>
<tr>
<td>Operations Working Group (OWG)</td>
<td>Advises on the development program, manages and coordinates observer support</td>
<td>NGO representative, Gemini Assoc. Dirs. of North, South, Development, and Engineering</td>
<td>Gemini Director</td>
</tr>
<tr>
<td>National Time Allocation Committees (NTAC)</td>
<td>Prioritize national observing time requests</td>
<td>Partner agency determines selection, NGO manages</td>
<td>Determined by partner agency</td>
</tr>
<tr>
<td>International Time Allocation Committee (ITAC)</td>
<td>Advises on conflicts in draft telescope schedule and queue, reports on historical time use</td>
<td>One representative from each national TAC, Gemini Assoc. Directors of North and South</td>
<td>Gemini Director</td>
</tr>
</tbody>
</table>

Figure 4-2. The Gemini Board, NSF, AURA, and Partner-community groups monitor, coordinate, advise, and otherwise interact with the Observatory to ensure optimum performance.

In summary, AURA and its partners utilize an organizational structure whereby the Gemini Board provides overall direction through the NSF, as executive agency, and AURA, as managing organization, with advice from their respective oversight committees. The national astronomy communities interact with the Observatory in an operational sense through the Gemini Science Committee (GSC), the International Time Allocation Committee (ITAC), the Operations
Working Group (OWG), and the individual National Gemini Offices (NGOs). These relationships are illustrated in Figure 4-1 and further clarified in Figure 4-2.

The resulting tight coupling of the Observatory and the science communities ensures a constant exchange of information and support on science planning, instrumentation, observing operations, user support, and diverse priorities. Further, it allows the user-scientists to be directly involved in vital aspects of the program on a regular basis, and to provide feedback and guidance to the Partner agencies.

**F. Observatory Organization – The Working Model**

The two Gemini telescopes operate as a single observatory, maximizing scientific return and saving costs through an integrated structure that allows for a common telescope allocation process, common management practices, uniform approaches to software and observing support and a single program for instrumentation and upgrades.

Observatory functions are organized around teams, with the intent of minimizing hierarchy and maximizing communications throughout the organization. Using communications technologies such as video conferencing, Gemini creates "virtual" teams that span oceans and continents, and hence reduce the need to duplicate skills in Chile and Hawaii. The Deputy and Associate Directors lead these staff teams, under the guidance of the Director. Figure 4-3 shows these relationships.

The ultimate goal of the Gemini science system is the largest possible volume of high-quality, meaningful science research results flowing out from the Gemini Partner research communities. Beyond the “internal” staff teams, the Observatory joins with its communities through the NGOs, ITAC, GSC, and so forth, to complete the science system under Gemini’s Distributed Model. Within the Observatory, as Head of Science, the Deputy Director is constantly monitoring the efficacy of the global system.

Although coordinated, the user observing programs at the two telescopes each proceed along their own paths, in part determined by the extent to which views of the celestial sphere and instruments suites differ from each other. Notwithstanding these differences, the two telescopes share a common set of science observing processes and procedures coordinated by the Associate Director for Science Operations.

A single Engineering team and a single Operations team, headed by their respective associate directors, provide common services to the Hawaii and Chile observing sites. Similarly, both sites have a common instrument development program, led by the Associate Director for Development. All three of these efforts are highly coordinated and employ extensive use of cutting-edge digital communications systems to provide remote diagnostics, video conferencing, and cross-site training and exchanges to knit the Gemini Observatory together in a highly cost-effective manner.

**1. Gemini Director – The Directorate**

The Gemini Observatory Director is responsible to the Gemini Board, through the NSF and AURA, for the overall conduct of the Observatory. The Director defines and carries out the overall scientific mission of the Observatory, as approved by the Gemini Board and provides scientific and management leadership. The Director also ensures the Observatory is in
compliance with federal and other regulatory requirements, including the maintenance and development of the Observatory Safety Program.

The Director’s office is the reporting point for the International Time Allocation Committee (ITAC), which serves both observing sites. The Gemini Science Committee advises the Director on defining and executing the Observatory’s scientific mission. Twice a year the Director meets with the Operations Working Group (OWG), which is comprised of representatives of the National Gemini Offices and the Associate Directors of Gemini North and South, Development and Engineering. This serves to ensure effective coordination of Observatory operations support across the international Partnership and it offers a forum for providing advice on the management of the Gemini Development program.

2. Deputy Director, Head of Science – The Global Science System

The Deputy Director reports to the Director and assists the Director in a wide range of matters affecting the Observatory and it user communities. The Deputy Director also acts on the Director’s behalf on many occasions, as directed.

The Deputy Director is overall Head of Science. In this role, the Deputy Director is responsible for monitoring and responding to the productivity of the overall science mission. The Deputy Director also manages interactions with the National Gemini Offices, tracks key research performance metrics, and engages the NGOs, ITAC, GSC, and other appropriate groups in necessary efforts to optimize the Distributed Model to reach the highest achievable levels of science throughput. The Deputy Director is the principal science interface to the Public Information and Educational Outreach program. Together, the Director and Deputy Director conduct the research appraisals of the Gemini scientific staff.

3. Associate Director, Science Operations – The Observing Program

The Associate Director for Science Operations is the single point of contact for science operations at both telescopes. Reporting to the Gemini Director, the Associate Director is responsible for the ensuring that both telescopes develop and continuously improve a common set of efficient and effective procedures and practices for observing operations. Together, the Director and the Associate Director conduct the operations performance appraisals of the science operations heads for both sites.

In view of the distance in time and space between the Gemini Director’s office in Hawaii and Gemini South, this associate director also acts as the Head of Gemini South, empowered to act with the Director’s authority when circumstances require swift action but preclude consultation.

a. Heads of Science Operations, North and South

The Heads of Science Operations North and South are primarily responsible for the day-to-day management of the science programs at their respective sites. They are responsible for scheduling science programs on the telescope their ensuring their execution, as well as the scientific quality, services, and capabilities of their respective telescopes. This includes balancing telescope scheduling and use to meet the needs of all the Partners, while maintaining high quality scientific performance.

The Heads of Science Operations supervise the Staff Astronomers, Gemini Fellows, and Science Support Associates (SSAs) at their respective telescopes. They coordinate with the Associate
Director for Science Operations and each other to ensure the highest level of science productivity within the Observatory. They interact with the Director on all matters relating to the quality and effectiveness of science operations and the resources needed to sustain high science throughput. Together with the Associate Director, they conduct the operations performance appraisals of the Staff Astronomers, Gemini Fellows, and SSAs.

4. **Associate Director, Development – The Unified Instrumentation Program**

The Associate Director for Development formulates and manages the scientific aspects of the instrumentation program. Within given constraints, the program must:

Deliver instruments in compliance with the fixed budgetary and schedule limits of the instrument and facilities development funds.

Fulfill the overall scientific mission of the Observatory and the specific Gemini science requirements established by the Director on behalf of the Partnership.

Carry out responsibilities for development with sensitivity to an equitable sharing of responsibilities and benefits between the Partners, in accordance with the Gemini Agreement.

Acting under Board approval, the Associate Director makes all reasonable efforts to ensure that instruments meet established science requirements. With the concurrence of the Associate Director for Engineering and in consultation with the Gemini Science Committee, the Associate Director for Development has the authority to change the cost and scope of instrument agreements on behalf of Gemini. The associate directors for engineering and development also have the discretion to leverage developments in new technologies.

5. **Associate Director, Engineering – The Unified Engineering Team**

The Associate Director of Engineering leads the core engineering team, which serves both sites in supporting the maintenance and upgrade of facilities, instruments, hardware, software, and instrument development. In addition, this office supports the development program by providing project management services, on a peer basis with the Associate Director for Development, and works with all other associate directors to ensure that the Observatory continues to realize its goal of highest quality.
Figure 4-3. The key relationships between the management team and the various scientific, operational, and business functions of the Observatory depend on both direct and matrix connections among the various functional groups and connections to the Gemini communities.
6. Associate Director, Operations – The Unified Infrastructure Team

The Associate Director for Operations is responsible for the provision, allocation, and overall management of the services supporting the Observatory’s administrative, technical, logistical, and infrastructure needs in conjunction with fulfilling its scientific mission. Duties of this office include the management of financial and human resources affairs, safety, information systems, and public information and outreach.

G. Senior Management Staff – The People

The Gemini Project assembled a first-rate management team to serve on the Directorate during its initial years of operation. Most of these professionals are expected to continue providing their skills and experience at all levels of the Gemini organization during the coming years.

Dr. Matt Mountain has held the position of Gemini Director since late 1994. Matt served as International Project Scientist from 1992 through 1994, providing scientific leadership. Matt received his B.Sc. in physics in 1978 and his Ph.D. in astronomy in 1983, from the Imperial College of Science and Technology, London University. He then held a research fellowship at the Imperial College before joining the staff at the Royal Observatory, Edinburgh. During his seven years there, he studied star formation and infrared instrumentation, culminating in his participation and collaboration in the commissioning of a new infrared spectrometer for the United Kingdom Infrared Telescope (UKIRT) in Hawaii. Matt also headed a program for implementing active and adaptive optics on the UKIRT at the Joint Astronomy Center in Hawaii.

Dr. Jean-René Roy is the Deputy Director for Gemini North and Head of Science, obtained his Ph.D. in astronomy from the University of Western Ontario, London, Canada. After postdoctoral work at Caltech (USA), the University of Utrecht (The Netherlands) and the Herzberg Institute of Astrophysics (Canada), he was on the staff of the Department of Physics of Laval University (Quebec, Canada) from 1977 until 2000, when he joined the Gemini Observatory. Before joining the Observatory, Roy was closely involved with the Gemini Science Committee and the Gemini Board as a Canadian representative. He chaired the Board in 1998 and 1999. While at Laval University, he took extended research leaves at the Anglo-Australian Observatory, the Canada-France-Hawaii Telescope, the Observatoire de Paris-Meudon and the European Southern Observatory – Garching. His research areas are the chemical and morphological evolution of disk galaxies and the evolution of massive star forming regions.

Dr. Phil Puxley is Associate Director for Gemini South. Previously he spent four years as the Associate Project Scientist, during which time he was responsible for developing and implementing the plan for science operations. Prior to joining Gemini he was a Senior Scientist at the Royal Observatory, Edinburgh, where he served as Project Scientist for two infrared instruments. His experience as a support astronomer includes work at the UKIRT, and as an active researcher, he has carried out spectroscopic observations and infrared imaging of massive star formation in galaxies.

Dr. Doug Simons currently serves as Associate Director for Development. He received his B.S. in astronomy at the California Institute of Technology in 1985 and a Ph.D. in astronomy at the University of Hawaii in 1990. Subsequently, he worked as a staff astronomer at the Canada-France-Hawaii Telescope for four years, joining the Gemini Project in May 1994. His principal
areas of interest include infrared instrumentation and infrared studies of the galactic center, low-mass stars, and star formation regions.

**Mr. Peter Gray** is Associate Director for Engineering for the entire observatory, a position he has occupied for the past two years. Prior to joining Gemini, Peter held a similar position in Chile with the ESO Paranal Observatory in Chile, and was the engineering manager responsible for the construction, integration and testing of the four VLT eight-meter telescopes over a period of five years. He career as a senior engineer spans over 20 years of service at many of the world's major observatories, including the University of Arizona, UK La Palma Observatory, and the Anglo-Australia Observatory. His background is as an opto-mechanical engineer and hold degrees in engineering and physics.

**Dr. Jim Kennedy** is Associate Director for Operations for the entire observatory, a role he has played for seven years. He led the effort to establish the in-house administrative and operational systems for long-term operations activities for both Gemini telescopes. Jim has been a senior manager for AURA for more than 18 years. Trained in radio astronomy and physics, Jim is a former academic Engineering Technology chair, and high-level manager in industry. He has a strong, balanced background in science, engineering, and educational program management.

**Dr. Francois Rigaut** is the Adaptive Optics Program Scientist. He received a Ph.D. in astronomy at the Observatoire de Paris in 1992. At the European Southern Observatory (ESO), Dr. Rigaut was the lead scientist for the COME-ON adaptive optics system on the La Silla 3.6m telescope from 1989 to 1992. He then moved to the Canada-France-Hawaii Telescope as the project scientist for the Adaptive Optics Bonnette (PUEO) until 1997. Before coming to Gemini in February 1999, Dr Rigaut spent two years heading the adaptive optics group at ESO, headquarter in Garching, Germany. In addition to adaptive optics and instrumentation, his principal areas of interest include studies of the galactic center, star-forming regions and gravitational lenses.

**Polly Roth** has served as Gemini Controller for more than six years. She has a B.S. in accounting from the University of Minnesota and nearly 30 years of experience in accounting and administration for non-profit organizations. This has included service as accounting manager for the California Association for Research in Astronomy (CARA) during the construction of the Keck I telescope. She was also the CEO of a $10 million non-profit corporation that provides employment and training services.

**Melissa Welborn** is the Human Resources Manager and the Safety Manager for the Observatory. She has a B.S. in education and is certified as a mediator and a Senior Professional in Human Resources. Melissa’s extensive experience in human resources and safety includes having served as a vice-president of the American Society for Training and Development. She has been with Gemini for seven years, managing human resources functions that encompass significant immigration issues. She also has served as a Regional Director of the Society for Human Resources (SHRM).

**Peter Michaud** has acted as Gemini’s Manager of Public Information and Outreach since June 1998. Peter holds a B.S. in atmospheric physics, certification in physical science education. Prior to joining Gemini, Peter spent almost a decade managing the Bishop Museum Planetarium in Honolulu. A highly effective outreach specialist, Peter has played a central role in developing
the Gemini Outreach Program, which is active in the site communities of the Big Island and La Serena, Chile, as well as globally.

H. Key Personnel – The Director
Dr. Matt Mountain has been the Director since 1994, having served the two previous years as the Project Scientist. AURA has recently renewed his five-year contract. With impressive credentials as an infrared astronomer and instrumentalist (see above), his leadership has been crucial to the success of the program over the last five years as the project proceeded through construction and integration, test, and commissioning stages. Matt has been a key architect of the Gemini operations philosophy and plan, and his leadership in the next phase will be essential.

I. Instrument Development Management
This section describes how Gemini Observatory will build upon lessons learned over the first decade in the program and manage the instrument development program in the future. It is divided into three sections.

The first includes a top-level description of the instrument development “life cycle” within Gemini, explaining how the Observatory shepherds the development of instruments through a multi-year process.

The second describes recent changes in the instrument program that will be used to streamline the procurement of future instrumentation, reduce the risk of schedule and cost overruns that plagued many previously acquired Gemini instruments, and through a competitive bid process, allocate future instruments to the most qualified teams in the world, all while balancing this enormous long-term reinvestment in the Partnership.

The third section is a summary discussion of instrument development risk management. In reality, proper risk management is an intimate, continuous component of every step of the development process. It requires providing for the early recognition of deviations, and providing planned alternatives that are aggressively pursued when critical factors threaten to exceed limits. Given this reality, risk management topics are woven into the discussions below that describe the lifecycle elements, as they occur.

1. Instrument Development Life Cycle
The process used to take instruments from basic concepts to completed systems can be broken down into four broad components, as shown in Figure 4-4.

This multi-year process begins with Gemini community-based strategic planning to define future science directions for the Observatory and roughly estimate the resources needed to reach these goals.

Gemini’s diverse and worldwide groups of instrument builders then are invited to participate in competitive design studies for new instruments.

After a down-select phase, assignments for instrument are awarded to qualified teams who build them under contract to Gemini.
Each of these steps is discussed in more detail below and together they describe a science driven process for defining and developing future instruments.

It is a challenge to accurately forecast scientific trends, given the rate of discovery within astronomy today, but the Gemini process ensures an instrument set that is well reasoned with requirements tempered by a vision of the Observatory’s science direction in the context of other ground- and space-based facilities.

Currently Gemini is in the first phase (Science Definition and Long Term Budget Planning) of the development program for its next round of instruments. It is also in the last phase (Completion Phase) for a number of instruments being delivered now at Gemini-North and Gemini-South. Maintaining continuity between these beginning and ending steps in the program is crucial to providing a steady stream of state-of-the-art instruments for the Gemini community to future use.

It is important to note that while many instruments are being delivered currently, it takes years to complete the “lifecycle” illustrated in Figure 4-4. Furthermore, astronomy has always been a technology-limited scientific enterprise, and the instruments being delivered now were designed, on average, about five years ago. Given that it will take at least 5-7 years from now to build the Gemini’s next generation of instruments, the current round of instruments will be over a decade old from a technology perspective, making them obsolete in many ways by the time the next generation of instruments arrive. The time to start building the next generation of instruments for Gemini is clearly at hand, if Gemini is to retain its preeminent role as a leader among ground-based observatories.

a. **Step 1 – Science Definition and Budget Planning**

Determining which instruments are developed through the design-study level requires input from a variety of sources. Broad community involvement is needed to determine an optimal set of scientific drivers, from which an initial instrumentation suite can be derived. This initial science-definition phase is led by Gemini, working in close cooperation with Gemini’s National Offices, which act as conduits for astronomers within each Partner country. In essence, the National Offices are Gemini’s portal to its end “customers”, the astronomers who will use future instruments at Gemini.

The science definition phase is centered about a series of topic-oriented scientific workshops that organize participation along lines of expertise in astronomy. Topics range widely from planetary science and star formation to nearby galaxies and cosmology. The product of these scientific workshops is a series of legacy-caliber science missions worthy of being pursued at Gemini.

The broadly defined set of new instrument requirements needed to fulfill these aspirations is derived from these potential science missions. Beyond providing overall organization, one of the
Gemini’s primary process roles is to provide technical support for astronomers who need guidance on telescope and instrument capabilities (e.g., sensitivities, image quality, spectral coverage, etc.). This type of interaction is crucial to ensure that the science objectives defined by the community are technically feasible.

The whole process of mapping science goals into instrument requirements is inherently non-linear and circuitous, with design trades being weighted by various reality factors, including technical feasibility, risk, cost, etc. Though complex, within a year of the culminating international science workshop, Gemini develops a program outlining science missions and the corresponding next-generation instruments, with clear traceability to the science goals identified by its community.

Beyond leading the definition of new instrumentation, Gemini will also explore modifications to existing instrumentation, if cost-effective approaches for augmenting capabilities exist. A phased approach to deployment also may be used to maximize the scientific return on instruments. For example, it may not be possible to design instruments in the initial phase with sufficient detector coverage to meet all of the science goals. However, sub-populating the focal plane with detectors at the outset, while designing the optical train, array read-out controller, data handling system, and other elements to handle an upgraded and fully populated focal plane in the future is a cost-effective approach to providing instruments with staged capabilities.

Finally, during this stage preliminary cost estimates are generated to support broad trades between and within competing instruments, as different modes are considered for inclusion or deferral. Performance models also are developed in order to guide and constrain the process of refining the science possibilities identified in this early stage of the project. Such early cost and performance containment is intended to guide (but not overwhelm) the process of defining scientific capabilities in an early stage where scientific creativity and originality are especially valuable.

b. **Step 2 – Announcements of Opportunity**

The product of the science definition phase is a set of design guidelines and rough cost estimates for a set of instruments that can be used to launch frontier science with Gemini. In some cases it may be necessary to fund technology development, at modest levels, to establish the viability of particularly challenging new instruments, reduce the risk of developing them, and define cost estimates with much better accuracy for budget planning purposes.

A balanced approach, that takes advantage of varying site conditions, spectral/spatial resolution, and wavelength range with at least some instruments having relatively simple designs, allows the community varied capabilities for pursuing predicted and unforeseen research pathways alike. Other factors considered in developing the next suite of instruments include the long-term balance of instruments at both site, the need to phase in new capabilities with older ones likely to be decommissioned, and in some cases constraint of finite resources which precludes developing some instruments immediately, although potentially they could be built in the future round of development.

A good example of many of these issues is GIRMOS. Several years ago, when the Phase 2 instrument set was devised, Gemini and the National Offices determined that the technology needed to make a deployable cryogenic integral-field infrared spectrograph was highly uncertain,
which made deriving cost estimates difficult. As a result, Gemini funded several technology studies to look into both cryogenic fiber-based and image-slicer concepts for this instrument.

One idea that emerged from this effort was the novel GIRMOS concept, from the UK/ATC. The technology studies defined in detail the design approach to build such an IRMOS, but also revealed, the cost to be prohibitively high and its applicability with MCAO marginal at typical target sky densities and apparent magnitudes.

Now, some three years later, an instrument with roots in the GIRMOS concept has emerged on the proposed instrument list from the Aspen Workshop. The envisioned instrument would work behind a Ground Layer Adaptive Optics System, to boost the sky coverage of the instrument. While these events have resulted in delays in developing the world’s first cryogenic deployable integral field spectrograph, they also have led to careful assessments of cost, risk, and science capability that will, in the end, produce an instrument with enormous research potential.

With design guidelines and rough order of magnitude (ROM) cost estimates developed for instruments and key areas of technology development, Gemini will release Announcements of Opportunity (AO’s) to solicit proposals for design studies and/or development programs. These AO’s will be distributed via web pages, advertisements, the Commerce Business Daily, and other venues to stimulate interest in a broad range of potential bidders, ranging from the private sector to universities and national laboratories and facilities.

The product of the AOs will be a series of proposals, submitted to Gemini for review by Source Selection Boards (SSBs). Gemini will chair these boards but they will also include specialists, consultants, and experts from around the world. Comprised of five to six members, the SSBs will use common selection guidelines and criteria successfully used by Gemini in the past.

Selection criteria include the quality of the proposal submitted, cost, facilities available, past experience, merits of the technical approach proposed, etc. When possible, more than one team will be selected to conduct design studies for an instrument to stimulate competition and reduce cost.

### c. Step 3 – Conceptual Design Phase

After Gemini selects a proposal for a new instrument the design-study phase commences. The core product of this step is sufficient information to decide whether to proceed with building it.

During this phase detailed and complex trades are made between scientific capability, cost, schedule and various risks. The scientists and engineers on the instrument team, with regular input from the Observatory, make assessments of exact plate scales, optical throughput, spectral resolution, stability and so forth to ensure that the trades comply with high-level scientific goals and technical/programmatic constraints.

The design-study teams work within cost ranges, derived by Gemini in consultation with experts in various fields, so that teams do not produce designs beyond the fixed budgets available to design and build instruments. Design- study deliverables typically include:

- **Overall Instrument Design Description** – Illustrates all aspects of the design at a level needed to develop a reliable cost estimate for completing the instrument, including
mechanical 3-D renderings, electronics schematics, optical designs, sensitivity estimates based upon performance models, etc.

- **Functional Performance Requirements Document (FPRD)** – A document that describes all the technical requirements the instrument must fulfill and serves as the guide for the engineering team to continue with detailed design and fabrication of the instrument.

- **Observational Concepts Definition Document (OCDD)** – A document drafted by the instrument science team to describes how the instrument will be used at the telescope. The OCDD and FPRD are cross-linked, as requirements for scientific performance map directly into engineering technical requirements. The documents undergo further refinement before finalization at the CDR level of the instrument design phase.

- **Unique Interface Control Documents (ICDs)** – While Gemini will issue ICDs to define key electrical, mechanical, optical, and software interfaces to the telescope, some interfaces will be unique to an instrument and must be sourced by the instrument team.

- **Management Plan** – Describes for the remainder of the project the management approach intended to complete the instrument, including how it will be designed, fabricated, integrated, tested and commissioned at Gemini. This also contains a detailed Work Breakdown Structure (WBS) for the entire project, with costs, manpower requirements and durations associated within each WBS component. A detailed schedule for completing the design, fabricating, testing and commissioning the instrument is also submitted. A procurement list that describes the needed components and materials and tallies the total cost to complete the instrument is also submitted to Gemini.

- **Science and Technical Trade Studies** – These describe the derived science applications for the proposed design and the results of technical trade studies conducted during the instrument design phase (e.g., trades between mechanical layout and cooling efficiency, total mass and rigidity of the optical train in a varying gravity load environment, etc.)

- **Error Budgets** – Detailed error budgets applied to the opto-mechanical design of the instrument, which indicate allowed positional errors of optical components, wavefront errors and throughput allocations. These budgets also demonstrate how errors stack up to meet required image and/or slit-throughput requirements, factoring in telescope and atmosphere errors provided by Gemini.

As mentioned before, if the budget permits, design studies are issued on a competitive basis between at least two teams. This naturally promotes competition in what will undoubtedly be an expensive arena and leads to greater technical diversity. Also, since Gemini owns all aspects of the designs (except for those agreed on as proprietary), the Observatory may choose the strongest aspects of different designs and merge them into more optimized designs, and/or merge individuals or entire teams into collaborative efforts. Design-study teams are given cost envelopes to work within through the Requests for Proposals, and without competition teams will lack motivation to develop designs costing less than the indicated budget available. Thus despite the higher initial costs of competing design studies, using them at this early stage in the process has repeatedly proven to be a net cost reducer in the overall Gemini development program.
d. **Step 4 – Completion Phase**

At this stage, detailed cost estimates have been derived for instruments and various forms of key or enabling technology identified and, if possible, developed in parallel. Historically, the most risk-prone period in this phase, when unforeseen problems emerge and additional work is required, is occurs upon completion of the first tests, early in the instrument’s integration phase. The instrument developer also faces risk as slips [errors??] accumulate, as running costs become dominated by the ongoing manpower needed to keep the project going beyond its planned duration. Management structures and development strategies must address these issues during Phase 2 to minimize such risks.

In general terms, this can be achieved by “freezing out” decisions early in the process and recognizing that, while such decisions may impact performance at some level, they ultimately bring forward the key initial tests of the project and expose issues before resolving them becomes time-critical.

The use of existing or previously proven designs and technology also reduces risk and is reflected in the types of technology development that would be funded early in the project through the Conceptual Design Phase.

Following the authorization for instrument construction, using a detailed project plan to identify items whose purchase requires a long lead time and then aggressively pursuing procurement has worked in the past to “buy” schedule contingency early in the Completion Phase and reduce the impact of technical problems that emerge during the test phase.

The Completion Phase includes a key project milestone on the path toward delivering the instrument. This part of the design work substantially culminates in the Critical Design Review (CDR), which includes deliverables such as:

- **Final FPRD and OCDD** – Final changes are made to these fundamental design and operational documents up to the CDR, upon consultation with Gemini. Note that the FPRD serves as the basis for the Acceptance Test Plan, while the OCDD serves as the basis for the User’s Manual; i.e., though frozen at CDR, they are drawn from heavily in subsequent delivered documentation.

- **Compliance matrix** – A detailed summary table, indicating whether the design proposed meets or fails each design requirement listed in the FPRD.

- **Final derived error budgets** – Made in consultation with Gemini, these include changes made in error budgets submitted during the conceptual design phase.

- **Final system design** – This typically includes a complete 3-D, opto-mechanical model, sufficiently well developed to permit fabrication drawings to be immediately extracted. Also included are the predicted cooling performances of cryogenic instruments, mass budgets, finite-element analyses indicating predicted flexure or thermal performance under varying environmental conditions, etc.

- **Software** – Detailed software designs, including all ICDs, flow charts, etc. needed to begin coding the actual software immediately.
• **Electronics** – Final design documentation for all electronic systems, including cabling descriptions, layouts for wiring throughout the instrument and grounding schemes, all sufficiently detailed for immediate manufacture of the electronics.

• **Acceptance Test Plan** – In draft form, a plan that describes the procedures needed to verify that the instrument meets all requirements listed in the FPRD, using a variety of tests before the instrument is shipped and after it is connected to the telescope.

• **Verification and Commissioning Plan** – In draft form, a plan that describes how to systematically characterize the instrument’s performance in all modes on the telescope. Such tests provide astronomers performance data used in formulating observing proposals.

• **A revised budget and schedule to complete the instrument** – Including a WBS showing all the tasks needed to fabricate, integrate, test and commission the instrument.

• **Draft manuals** – These include a user manual, software manual and service and calibration manual.

• **Safety Review** – As part of CDR, a safety review is conducted to determine whether the design meets safety requirements, particularly in the area of installation, maintenance, repair and operation of cryogenic systems, high-voltage drivers, large and potentially dangerous mechanisms, etc.

Some aspects of the design are frozen well before CDR. For example, the optical design often is frozen at the Preliminary Design Phase (PDR), because optics frequently are long-lead items and the instrument design flows substantially from the optical design; thus, to delay procuring optics until a later stage is of limited value.

Actual fabrication of instrument components proceeds at this point, with the noted exceptions of key long-lead items. The project-building phase no longer involves detailed or complex design trades with the science team, as all key decisions impacting performance should have been made previously. Tasks during this phase focus on parts procurement, issuance of subcontracts to machine shops or specialty vendors, careful tracking of components as they arrive, etc.

This phase tends to have relatively few risks, and it leads to an integrated instrument that requires extensive testing in a lab environment to verify functionality and performance. As mentioned previously, this critical period of initial laboratory testing substantially defines the likelihood of the instrument being delivered on schedule, so earlier steps taken to advance this milestone generally reduce the risks of schedule and cost increases.

Though subsystem testing certainly helps reduce complications downstream with full-up system tests, full integration of the instrument is necessary to allow the recognition and resolution of complex system-level interactions, whether optical (focus or light leaks), mechanical (flexure), electronic (unexpected noise), or software (unforeseen control system interactions).

This is particularly the case for large cryogenic instruments, which have long thermal cycle times. For Gemini-class instruments, each episode of rework can take weeks just to thermally
cycle the instrument, and this entails enormous costs over a protracted troubleshooting period.

Following the completion of the integration and testing steps, Gemini conducts on-site acceptance testing by. Typically this involves a Gemini-selected team with expertise in a broad range of engineering disciplines, as well as science and management representatives. They use an acceptance test plan, agreed upon well in advance and derived from the FPRD, to formally work through all aspects of instrument performance and functionality to verify that contractual obligations have been met.

In cases where the instrument fails to meet performance specifications, it is necessary to evaluate the consequences from a science perspective before making a final pragmatic assessment of the real impacts of the identified problems. All interfaces that can be checked should be verified on-site before the instrument is shipped to either Gemini-North or Gemini-South.

In general, up to 95% of the acceptance test plan can be executed before the instrument is shipped, with final verification occurring after the instrument is mated to the telescope and final checks on key interfaces are verified and on-sky performance is measured.

At the end of this multi-year process commissioning can begin. The purpose of this step is to characterize in detail the instrument’s actual performance, in conjunction with the Gemini science staff, so that future astronomer-users understand the installed instrument’s performance sufficiently to design research programs based on its capabilities.

2. Changes Over a Decade in Gemini’s Instrument Program

Thus far, basic questions on instrument procurement and approximate costs have been addressed. A natural follow-up question is, “How will Gemini improve the track record of its instrument program to ensure new instruments meet program-wide goals?”

Gemini’s instrument program has evolved considerably during its ten-year lifetime. In many ways the changes made in the instrument program have been reflections of the nature of the Gemini Partnership, which also has changed as the Gemini 8-m Telescope Project has metamorphosed into the Gemini Observatory.

To date Gemini’s instrument program has produced five facility-class instruments; five telescope facilities (including ALTAIR, GPOL, and GCAL) and six instruments or facilities are still under development (including MCAO). Clearly, Gemini’s instrument program is one of the largest in ground-based astronomy. Unlike any other program, it calls upon an international resource base, and in many respects it has been a leader in key technology development beneficial to all of astronomy.

Given the experience of all the instruments delivered to date, Gemini is well poised to carry out the design and fabrication of a modern, new suite of instruments to serve as the platforms for future observations at Gemini. While this is true today, the early Gemini program suffered from fairly staggering losses, including enormous cost overruns, multi-year schedule slips and, perhaps most importantly, lost scientific opportunity. The lessons learned from these episodes have served to reshape the program into its present form.
It should be noted that Gemini is not alone in this situation. Figure 7 illustrates how poor the cost and schedule track record has been for 8 – 10 m instrument programs. While the track record of Gemini’s instrument program is arguably improving, the past problems cannot be ignored. However, it is important to recognize the variety of changes made that will lead to improved program performance as the next set of instruments is built.

**Competition:** The initial round of Phase 1 instruments built for Gemini was allocated to organizations within the consortium, according to Partner shares. This was for a range of reasons, including expertise in a particular technical field, interest in a particular scientific field, etc. This approach to assigning instruments to teams was substantially competition-free, and while it was effective in ensuring that project funds were distributed uniformly back to the Partners, it failed to award projects based upon broadly competitive merit.

Gemini has abandoned this approach in the current instrument allocation process, which is based upon a fairly conventional competitive bid system. The only restrictions are that only Gemini Partner countries can bid on Gemini instruments and that, over time, the instrument development budget should go back into the Partnership according to Partner shares.

![Graph showing budget and schedule performance](image)

**Figure 4-5** – Data compiled by Adrian Russell at the UK/ATC depicts schedule (left) and cost (right) overruns that have occurred with 8-10 m class instruments built at a variety of institutions including Gemini. Instrument names have been withheld in this plot. The track record of managing the development of this class of instrumentation is demonstrably poor, with cost overruns often exceeding 2-3x the original approved budget and deliveries often being years behind schedule.

Given the size of the Gemini consortium in the worldwide arena of astronomical instruments (arguably larger than any other comparable program), this reinvestment in the Partners is not a fundamental problem. Nonetheless, Gemini must maintain a program that is attractive to a wide range of bidders, while recognizing that many observatories compete for the same instrumentation resources. Changes designed to attract participants to the program are discussed below.

**Project Management:** In the first round of Gemini instruments, the selected teams had essentially no experience with building instruments of the size and complexity of a Gemini facility-class instrument. This new breed of instruments represented a quantum leap for most teams, and familiar approaches to managing PI-class instruments no longer applied. Consequently, early Gemini instruments experienced inadequate project management techniques that significantly contributed to such problems as cost overruns, schedule slips and feature/scope creep.
In many cases oversight was inadequate, for gauging progress against a project plan. Exacerbating this situation was Gemini’s early hands-off approach of not requiring a formal project management structure to build instruments or deal directly with overruns, since the instruments were all on fixed-price contracts and overruns were therefore not a primary Gemini project concern.

The whole area of project management has been overhauled in recent years, out of recognition by Gemini’s instrument teams that their survival depended on it. While most institutions could absorb a 20% overrun in a past $500,000 project without major implications, a 20% overrun in a $5–10M Gemini instrument could financially cripple these same institutions.

Today, Gemini requires formal project management for all teams awarded instrument contracts. The full-up cost of an instrument is reevaluated at all major design reviews, and cost metrics are forwarded on a monthly basis to allow Gemini to detect potential disasters long before they might occur and protect the interests of both the contractors and Gemini.

**Full Costs:** In the past Gemini paid only for direct costs (parts and salaries for all instruments, and, as part of the contracting process, instrument teams had to either forego overhead payments or seek compensation through an independent arrangement with their national funding agency.

This led to a range of complications. First, failure to pay full prices for instruments proved to be a disincentive in a competitive arena where better opportunities for compensation existed, either financially or through scientific opportunity, than Gemini offered to its instrument teams during this era.

Second, seeking overhead payments through a separate funding track inevitably led to delays in starting projects, as bids are not tied to federal fiscal cycles.

To bypass these problems, Gemini now pays the full costs of instruments through increased contributions from Partner funding agencies. This practice, combined with guaranteed telescope time (described below), makes Gemini’s instrument program unique. As demonstrated through its initial application in the GSAOI proposal process, it has proven to attract a range of potential teams for Gemini’s program.

**Direct Contracting:** Concurrent with the above-mentioned changes in costing structure, Gemini also initiated the option of directly contracting with any organization selected to build an instrument. In the past, the National Gemini Offices have been the de facto source of contracts for new instruments a parallel workscope between Gemini and the NGO established a formal link to the builder. This had several downsides, including the creation of delays as unnecessarily complicated Gemini/NGO workscope negotiations were conducted in parallel with NGO/vendor negotiations. While this complex structure was rooted in the fixed-cost nature of Gemini contracts and the National Offices’ role to minimize, if not eliminate, cost overruns on behalf of their respective funding agencies the net advantage was dubious. This structure ensured a role for the National Offices in helping to manage Gemini’s instrument program, but it proved ineffective, given that overruns occurred anyway.

Today, Gemini has the option of direct contracting with any instrument team. This not only reduces contract negotiation periods (a key stumbling block in starting new instruments), but also better defines Gemini’s roles as the actual end customer and budget holder in contracts with
instrument builders. The policy regarding contract pricing also has changed. While Gemini continues to use only fixed-price contracts, it reserves contingency within its budgets and works closely with instrument teams to hold any overruns within the total budget envelope, which includes contingency.

This streamlined, more realistic approach to defining the working relationship between Gemini and its instrument builders is revolutionary compared to the original approach and will surely pay dividends in the future. It was first applied with GSAOI, and no startup delays occurred after selection of the team – a first in the instrument program.

**Redefining a Vendor/Customer Relationship:** One of the largest and earliest challenges in building a more viable instrument program was to revise the working relationship between Gemini and its instrument teams. Initially instruments were built under a partnership model, but this resulted in a fuzzy distinction between Gemini’s role as a customer and the instrument builder’s as vendor. The previously described contracting model was a manifestation of this problem.

In Gemini’s current project management the customer/vendor relationship is more explicit. Contracts define the deliverables and Gemini-controlled payments up front to avoid confusion and potential problems later. This more conventional approach benefits both parties to the agreements.

**Guaranteed Telescope Time:** A key new component of Gemini’s instrument program is the use of guaranteed telescope (GT) time in exchange for providing an instrument. This has several benefits. First, the policy acts as an incentive to institutions that stand to receive up to 20 nights of telescope time in exchange for building an instrument.

Second, the actual amount of time awarded is performance-driven, so that teams lose GT as instrument delivery slips. This provision motivates instrument teams to complete projects on time. The project scientist drives closure on instruments from within the team, which otherwise would suffer very little impact from late instrument deliveries. The GT arrangement rewards (and penalizes) a team based on actual delivery performance without using actual cash, based on the expectation that most teams’ institutions would resist financial penalties for late deliveries.

These and other changes in Gemini’s instrument program have overhauled the program at multiple levels over the past decade. Managing such a large program will always be a dynamic process, and further changes are likely in the years ahead. In summary, the changes described above have achieved an instrument program that is:

- More attractive, as Gemini pays full costs and awards telescope time to builders;
- Much more efficient, given the option of direct contracting, with no need for separate overhead payment negotiations;
- Less institutionally threatening, given that formal project management and contingency are built into budgets as standard procedure;
- Structured around fair competition, so that over time all Partners have opportunities to benefit from Gemini’s program, and its astronomical community benefits from instruments built by teams selected through a conscientious and judicious process.
Although the instrument program is still imperfect, the Gemini Partnership clearly has learned important lessons during the program’s first decade, and it will continue to make changes in the future to ensure its long-term success.

3. Development Risk Management

Risk management is a key need in managing a development program like Gemini’s. Risk management must be emphasized even more in the future, as the costs and technical challenges associated with the Aspen instruments will vastly exceed those of instruments built in the past for Gemini.

The risks to the builder and the Observatory need to be understood, quantified, monitored, and controlled throughout the development of these unique instruments. While aggressive risk management is commonplace in the commercial sector, past instrument development teams have not given it serious attention. Since Gemini deals exclusively in fixed-price contracts, even a 10% cost overrun with an Aspen instrument represents a major problem for most institutions to absorb.

Various steps to reduce risk in development management are incorporated in the delivery and assessment of the documents, reviews, and milestones described above in the conceptual design and completion phases. Having made technical, schedule, and cost risk adjustments at the outset, at each subsequent step the remaining uncertainties are reassessed and addressed as required.

One of the principal items in schedule and cost risk is simply getting the program started on time. A corollary, for all project stages, is the need to identify components with long lead-times for acquisition from outside sources and to aggressively pursue early procurement of those items.

An important strategy for mitigating technical risk is the reuse, when practical, of proven components, such as the NIRI components in that have been usable in three instruments so far, and components of ALTAIR that are in two other instruments.

Other standard tools in risk management rely on the thoughtful use of cost and scope contingencies. For example, for instruments relying on unproven technology but predicated on fixed schedules and budgets, Gemini contingency is defined in a variety of forms up front.

For example, functional contingency (margin for graceful design descopes) is discussed during the conceptual design study phase, when acceptable descopes must be defined for high-risk scenarios.

A 30% budget contingency is assigned to each instrument as its the conceptual design phase is completed. The manufacturer directly controls half the contingency and Gemini holds the other half in reserve. If problems occur during the development, previously agreed-upon milestones or other contractual provisions trigger the release of contingency according to a defined plan. These practices offer considerable latitude in managing risks over the course of developing what is inevitably a one-of-a-kind instrument.

Another common approach to unproven technologies is to require separate, up-front technology development efforts for uncertain critical elements. For example, if an instrument relies on a key
but unproven deformable mirror technology, a separate technology development effort might be launched with a defined range of products due before the Critical Design Review.

If the desired product is not developed in time to support its integration in the instrument, then the previously defined fallback options are imposed to fulfill the reduced capabilities previously agreed upon. On the other hand, if the new mirror can be made, but outside the cost envelope, Gemini can release contingency funding once the development effort is completed, risks are understood, and an agreed-upon approach is defined.

Of course, monitoring risk is integral to controlling it, so the Observatory builds a reporting structure into each contract that typically includes the following over the duration of the activity:

- Information about the current technical and financial status of the work, detailing expenditures in money and manpower compared to originally projected levels
- An updated schedule outlining the most current project plan to completion. This plan is generally maintained in Microsoft Project or an equivalent program
- A list of the major milestones with the original, previous, and current dates by which they will be attained, as well as explanations for any significant changes from the previous dates, with each subsequent list including all explanations from previous lists
- Problem areas related to the work, including potentials for delays
- Action items for AURA and the builder (both open and closed), and their status
- Proposed changes in key personnel.

Risk tables are generally used (see Figure 4-6) to track specific risk items over the course of regular submissions of monthly reports or major reviews. These reports, in combination with pre-planned major reviews and intermittent site visits, allow the direct monitoring of progress on all fronts, with the aim of controlling risk at all stages. In addition, the submission of these written monthly reports triggers a teleconference with builders to discuss technical, financial, or schedule issues in detail. The intent in this series of steps is to detect major problems during the instrument development and long before they can pose serious risks (e.g., failure to complete the instrument).

### System Risks

<table>
<thead>
<tr>
<th>Item</th>
<th>Area of Concern</th>
<th>Science Impact</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Detector Delivery</td>
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<td>MEDIUM</td>
</tr>
<tr>
<td>2</td>
<td>Detector Damage</td>
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<td>LOW?</td>
</tr>
<tr>
<td>3</td>
<td>Lack of Focal Plane Motherboard</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>4</td>
<td>ODGW Performance</td>
<td>LOW</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>5</td>
<td>ODGW Read Out</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>6</td>
<td>Focal Plane Assembly Delivery</td>
<td>LOW</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>7</td>
<td>SDSU-3 Induced Bias Drift</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>8</td>
<td>Test Cryostat Development</td>
<td>LOW</td>
<td>LOW</td>
</tr>
</tbody>
</table>

Figure 4-6. A representative risk table from the GSAOI CDR is shown.

**J. Business Operations – Keeping the Wheels Turning**

The approach to the business management of the Observatory recognizes the nature of an international project. The NSF and AURA are US institutions that work closely with counterparts in other Gemini partner countries. Accordingly, the Observatory is administered in accord with the principles of the Gemini Agreement in an open, transparent way that is fair and equitable to each partner country.
In the event that the Observatory’s adherence to all applicable US laws and regulations raises issues of fairness with respect to non-US partner countries, AURA will help the NSF find appropriate ways to resolve such issues. AURA and NSF previously have exercised this critical function on a number of occasions, e.g. resolving a conflict between US import duties and Chilean laws pertaining to astronomy.

The NSF reviews and approves AURA’s policies and procedures. All matters requiring NSF approval are first submitted to the AURA President for review and concurrence. All such communications and approvals are in writing from AURA to the NSF.

The Associate Director for Operations holds responsibility for Observatory business management. That office directs the Gemini administrative unit, whose mission it is to provide/ensure:

- Sound controls, for government contracts and corporate governance;
- Excellent data reporting, for management's analysis and government oversight;
- Accurate data with "clean" audits in both the government and private arena;
- A safe and healthful working environment for all Observatory personnel and visitors;
- Sharing of the Gemini scientific legacy with the outside world.

In formulating the administrative systems, the primary goal was to establish the most cost-effective systems possible, consistent with the scientific objectives of the Observatory. Therefore, the Observatory utilizes existing resources through sharing infrastructure with other Mauna Kea observatories at Gemini North, and with Cerro Tololo Inter-American Observatory (CTIO) and the SOAR Observatory near Gemini South in Chile. The Observatory will continue to utilize the ever-increasing levels of communications technology to operate the telescopes as a single observatory, using common management and administrative systems to the extent feasible.

There are several types of administrative systems required for proper operation of the Observatory. For purposes of the management plan, they are generally grouped as follows:

- Accounting and Finance
- Human Resources
- Contracts and Procurement
- Safety
- Network and Computer Support
- Facilities Operations
- Intellectual Property

Each system is briefly summarized below. Following the summaries is a description of the general methodology utilized to implement each system.
1. **Accounting and Finance**

The Observatory has a computer-based accounting system to track and compile information regarding funds received and expenses incurred in operations. The accounting system includes standard accounts payable, accounts receivable, payroll, purchasing and general ledger functions. In addition, it manages all the property-tracking functions. These systems interconnect the Observatory's work sites in Hilo, La Serena, and Tucson to provide rapid information transfer to and from the central records.

The format for accounts and reporting is structured to provide Observatory management (including the Gemini Board) with required operational data, while providing a compatible interface with the standard form of AURA financial statements. The financial systems encompass activities related to banking, investment of funds, monitoring/auditing, and budgeting. Finally, the Observatory has internal control systems to monitor accounting and financial functions, as well as the standard external audits that are a part of the audit of the AURA corporate structure.

The Controller is responsible to the Associate Director for Operations for managing all Gemini financial accounting and related Federal, State, AURA, and Gemini compliance matters. This includes supporting budget preparation, accounting, financial reporting, payroll, banking, purchasing, paying, property control, audit support, import/export, and other duties as assigned.

2. **Procurement and Contracts Administration**

The Observatory has procurement-related systems for both Gemini North and Gemini South. These systems include acquisition contracting, purchasing, shipping/receiving, import/export control, and contracts/grants. They also include appropriate systems for awarding work packages to Gemini Partners, as well as to share staff and facilities with Gemini partners. The Controller is responsible for contracts and procurement management. However, major budget authority rests with the Director and the Associate Directors.

3. **Human Resources**

The HR services encompass standard functions, including recruiting, employee relations, immigration, and the administration of personnel policy, compensation, and benefit plans. Recruiting functions are conducted according to hiring policies formulated by the Observatory in consideration of AURA policy and the requirements of applicable national and local laws. Given the Observatory’s international nature, the management of visas and other immigration issues requires significant effort.

The Human Resources Manager reports to the Associate Director for Operations regarding all HR activities and related Federal, State, AURA, and Gemini compliance matters. This includes recruiting, salary surveys, performance evaluations, fringe benefits management, EEO and other Federal- and State-mandated programs, voluntary employment and training programs, and other duties as assigned.

4. **Safety**

The goal of the Gemini safety program is to provide a safe and healthful environment for Gemini’s employees and visitors. Meeting this goal requires training for, and ensuring
compliance with, all locally and nationally mandated safety requirements, as well as other appropriate safety standards. Essential elements for achieving compliance include:

Maintaining awareness of regulations and best practices in the US and Chile (and applying the “higher standard” (typically US standards) in Chile).

Developing and implementing policies to support compliance, for example:
  - Identification and application of proper safety equipment,
  - Mandatory periodic high-altitude medical examinations,
  - Mandatory physician's permission for return to work after accident or illness, and
  - Internal and external comprehensive safety inspections.

Sustaining a prevention program that includes:
  - Frequent site monitoring and training,
  - Appropriately trained safety officers for its various sites,
  - Regular safety meetings for staff,
  - New employee orientations and recurrent employee training, and
  - Strict enforcement of safety rules and procedures.

Pursuing a response program that reacts to accidents and safety incidents and aims to understand their causes and effects. This encompasses:
  - Formal procedures for event reporting and appropriate responses,
  - Thorough investigations of each event to identify corrective actions, and
  - Assurance that identified safety corrections to procedures and activities are promptly and correctly applied. This involves:
    - Documentation of all safety-related activities,
    - Regular reviews of compliance status with the Director and senior managers, and
    - Sanctions for failure to cooperate.

The Safety Manager is responsible to the Associate Director for Operations for ensuring that the Observatory complies with Federal, State, Chilean, AURA, and other regulatory and policy requirements, including the maintenance and development of the Observatory’s safety program.

5. Information Systems

High-bandwidth digital communications systems tied to state-of-the-art computing systems are essential to the Gemini program. The IS group develops and maintains policies, procedures, and support for the internal and external network infrastructure, including secure access and virtual private networks, and computer systems administration. The group provides this support for nearly 1,000 distinct network-connected devices at five sites across two hemispheres and three continents.

Gemini has high-performance connections from each of its sites to the US Internet2, with further connections to the rest of the world. These current capabilities and future requirements are discussed further in Sections II.E.4 and III.C.4, respectively.

6. Public Information and Outreach

Gemini is building a considerable legacy of scientific and technical knowledge and experience on the part of the Partner nations and their science communities. In the largest sense, Gemini has
an obligation to share this knowledge within the Partnership and with the world at large. The role of the PIO group is to facilitate the broad dissemination of this knowledge.

The PIO group performs its functions by being an information resource for the education and information offices of the various Partner agencies and their communities, providing a forum for communication among those information offices, providing newsletters and press releases, and establishing and maintaining media relationships with the international popular science media as well as national and local press.

The PIO group actively supports various educational initiatives on all scales, in including many that foster science education in local communities around the observing sites in Hawaii and Chile. PIO personnel also work to raise public awareness of the value of Gemini science, as well as the importance of local cooperation in minimizing light pollution and other local issues significant to the Observatory.

The work of the PIO group is further discussed in Sections II.J and III.H.

7. Facilities Operations

The day-to-day operations of Observatory facilities are directly coordinated by their respective site managers. The observing facilities are the responsibility of the Associate Director for Engineering. All other facilities are the responsibility of the Associate Director for Operations. The support staffs are matrixed combinations of the operations, engineering and observing staffs. The site managers ensure the appropriate coordination between the guest observers, other visitors, scientific staff and other Gemini staff members.

8. Intellectual Property

The treatment of intellectual property by the Gemini Observatory falls under two broad categories: technology and scientific data. AURA enforces policies that have addressed both.

a. Technology

The ongoing development and use of technology is essential to Gemini's success. Within the Gemini organization, awareness of the intellectual property policy is an element of responsibility for each group manager. Negotiation and issuance of any licenses is a function assigned to the procurement officer, under the policy direction of the Associate Director for Operations, and ultimately the Gemini Director, who assures adherence to the intellectual property policy established by the Gemini Board. The Associate Director for Engineering is responsible for the technology aspects of the intellectual property program.

b. Data Rights

Assuring public access to data generated by the Gemini telescopes on fair and equitable terms is key to the success of Gemini. The Gemini Board has determined that there is an initial 18-month period during which the investigator(s) allocated time for a particular observing program have exclusive access to those observing data. Following the end of that period, access is free for any non-commercial research or educational purpose.
K. Operational Risk Management – Being Prepared

Gemini Observatory’s Operational Risk Management Plan provides for a multifaceted approach to the minimization of ill effects from unfavorable, but possible, future events. First and foremost, Gemini works to identify and prevent unfavorable events, preparation of contingency plans which provide alternative approaches for unknown factors in the future, financial and temporal allowances for unknown future factors and, finally, the Observatory procures insurance that will compensate the Observatory for those occasions when the worst happens. In addition to the operational risk management plan outlined below, please refer to Section I.H.3 of this proposal that talks about risk management in the instrument development program.

1. Managing Expenditure Risk

The keystone to the Observatory’s management of expenditure risk is a comprehensive budgeting process and continuous budget monitoring. Elements of expenditure risk are listed below along with the Observatory’s approach to managing these risks.

   a. Inflationary Risk

The Observatory monitors current rates and projections for the future in their bases of operation in Hawaii and Chile on at least a monthly basis using the websites of the Federal Banking systems in the United States and Chile. Inflationary assumptions are included in all budget models and are reviewed biannually.

   b. Exchange Rate Risk

Approximately 10% of the Observatory’s annual expenditures are transacted in Chilean pesos. Thus the exchange rate for the US dollar into the Chilean peso represents a significant risk factor requiring consideration during budget preparation. Gemini monitors the exchange rate daily and reviews assumptions periodically throughout the year, making budget revisions as necessary. Future projections from expert sources are researched, weighed and taken into account for budgetary assumptions. A conservative exchange rate is used during budget preparation in order to increase the likelihood that surprises in the exchange rate will be good ones rather than unpleasant ones. Another tool the Observatory uses to mitigate the effect of the exchange rate on expenditures is forward currency agreements on many contracts with foreign subcontractors. In most cases, the Observatory is successful in writing fixed price contracts in US dollars.

   c. Operational Risk

The Observatory manages operational risk through the application of strict internal control procedures and mature and tested operational practices.

- All financial dealings are governed by a formal and strictly adhered to internal control policy and related procedures.
- The Observatory has engaged in the consistent application of mature and time-tested policies and procedures and follows all applicable rules and regulations.
- There is a strict requirement for managerial approval of purchases.
- Budget management is much enhanced by the fact that managers receive monthly financial reports that show the status of expenditures as compared to the budget and have access to financial information at any time by request.
There are strict restrictions on the number of individuals who can commit funds to subcontractors and vendors.

The Observatory engages in competitive procurement practices, oftentimes exceeding Federal requirements for competition when it is cost effective to do so, requiring formal bids and doing research on subcontractor and vendor reliability and stability.

The Observatory follows strict contracting practices utilizing fixed price contracts versus cost reimbursement contracts, obtaining bank guarantees where necessary and executing thorough contracts.

The Observatory supports budget management practices that provide enough flexibility so that a manager can respond to unforeseen circumstances.

2. Risk Sharing

Whenever possible, the Observatory will share risk with others. For example, the expenses of the risk reduction studies for the Adaptive Optics program were sometimes shared with other interested parties.

3. Insurable Risk

AURA provides insurance for all allowable coverage (general liability, automobile, and workers compensation).

4. Geopolitical Risk

As technology advances and the economy becomes increasingly global, organizations face risk from factors that previously have had little impact on them. Factors such as the price of oil, other commodities, and manufactured goods are vulnerable to geopolitical events that no single institution can control, and which have far-reaching effects on all. Global factors are clearly outside of an organization’s ability to manage, but the wisdom and ability to create contingency funds often are within an organization’s scope. The Observatory budget includes operational contingencies to meet unexpected events, including geopolitical ones, and while the Observatory cannot create a working relationship with every national government and, AURA has developed a mature and solid relationship with Chilean governmental entities that have jurisdiction over Gemini operations in their land.

5. Operation Interruption Due to Network and Communications Systems Failure

The Observatory has a sophisticated network and communications system that is protected by firewalls, UPS (uninterruptible power source) systems, and data back-ups. In addition, Gemini’s capability for remote operations permits several options for operating the telescopes on both summits. Each telescope can operate independently, or operate the other observatory, or can be operated remotely from either base facility. This built-in control redundancy allows options should parts of the system fail.

In the larger picture, deliberate intrusions into the systems from unauthorized outside entities represent a potential threat to network operations. To address information systems risk management, Gemini’s top managers enforce standards recommended by the National Institute of Standards and Technology (NIST). Until 2003, Gemini followed an informal policy of eliminating risk by implementing the best security practices. However, the climate has changed dramatically, particularly in the non-Microsoft Windows arena, and an audit of Gemini’s
practices has begun, in accordance with the NIST Self-Assessment Guide for Information Technology Systems. After establishing the management of risk analysis and ensuring the follow through of the assessment, detailed investigations into the following areas are being performed:

- **Personnel Security** – How do Gemini users, designers, engineers, software programmers, office staff and managers access computer systems? Investigate the three fundamentals of access, authentication and authorization.
- **Physical and environmental protection** – How does Gemini protect its telescopes, base facilities, mobile equipment and communication links against threats and unauthorized access?
- **Production and Input/Output Controls** – How does Gemini control the flow of observational data from Telescope instrument through to its archive? How are corporate records managed to ensure they are correctly stored, handled and ultimately destroyed?
- **Contingency Planning** – How does Gemini plan to cope with a potential relocation of a base facility or recover from a damaging fire? How would it cope with large disruptions following severe earthquake or volcanic activity?
- **Hardware and System Software Maintenance** – How does the Gemini IS Group monitor the installed base of Solaris, Linux, Mac OS X and Windows servers, workstations and laptops? How does it monitor all routers, hubs, switches, communication links, telephone systems, videoconferencing systems? How does it ensure systems are correctly patched and updated to the latest software releases?
- **Data Integrity** – How does Gemini monitor the accidental or malicious alteration or destruction of data? Is it monitored for change and how is the original restored? How does Gemini manage this process for all operating systems, applications and custom software?
- **Documentation** – Does Gemini have procedures for ensuring the documentation for every computer system and application is obtained, maintained and distributed?
- **Security Awareness, Training and Education** – Do Gemini staff understand the role of the IS Group in providing the above services? Are they aware of their role in ensuring the security of computer systems, observational data and telescope control systems?
- **Incident Response Capability** – These vents are becoming far more common and their impact reaches deep into the infrastructure. Does Gemini have a crisis handbook for managing the handling of a new virus outbreak or server compromise? What are the diagnosis, damage limitation and recovery procedures?
- **Identification and Authentication** – How are user accounts, passwords and privileges maintained on Gemini systems? Are there different mechanisms for Solaris, Linux, Windows, Dial-up users, VPN users, FTP users, Help Desk users, Sitescape users and Jira users, how are these disparate systems uniquely controlled?
- **Logical access controls** – Do the security mechanisms accurately detect unauthorized access? Once logged into a system, what additional controls are there to protect telescopes, instruments, departments, managers, accounting and Human Resources?
• **Audit trails** – How can events be reconstructed or intrusions detected and problems identified? What automated systems perform this analysis and flag system administrators?

As these step are completed the NIST document “Recommend Security Controls for Federal Information Systems” will be introduced to Gemini as a template for Information System policy. This program has been developed by NIST in furtherance of its statutory responsibilities under the Federal Information Security Management Act (FISMA) of 2002, Public Law 107-347. This charter will be the springboard for many service changes in Gemini that will start reviews of fundamental designs of the information systems infrastructure. Although this plan has not been completed yet, its topics could well be:

1. The physical isolation of the telescope-observing network from the external networks.
2. The simplification of multiple user authentication systems to a single RADIUS or Lightweight Directory Access Protocol (LDPA) server.
3. The centralizing of all data storage to a centrally managed secure redundant and distributed storage area network, to include all observational data, home accounts, engineering drawings, management and accounting information.

6. ** Interruption of Operations Due to Weather:**

For most observatories, weather is the biggest factor in the loss of time on the sky, and yet at first glance, this risk seems impossible to manage or control. However, Gemini took a giant step toward mitigating weather effects on observations when it undertook to operate the observatory with a mixture of classical observation scheduling and queue scheduling. In classical scheduling, when the time assigned for an observation arrives that observation may occur under optimal conditions, or less than ideal conditions, or not at all, due to inhibiting weather or mechanical conditions. With queue scheduling, observations are placed in a queue and ranked in order of importance, to be conducted when observing conditions are ideal or nearly ideal. When weather precludes the opening of the dome at all, closed-dome calibrations or engineering tasks can be undertaken.

7. **Reputational Risk**

A January 2004 article in *The Economist* magazine made the statement that “The biggest risk any company faces is the loss of its good name, and you cannot insure against that.” Gemini Observatory’s reputation relies on factors ranging from accounting practices to telescope reliability. To preserve its reputation, Gemini Observatory:

- Places top priority on telescope reliability and quality science, and makes all decisions with those priorities in mind.
- Enforces strict internal controls and adherence to policies, rules and regulations.
- Welcomes extensive oversight by various bodies outside of Gemini operations (Gemini Board of Directors, AURA Oversight Committee, Science Steering Committee, National Science Foundation officials, National Science Foundation Office of the Inspector General, auditors from an independent auditing firm, etc.)
- Engages in local community efforts enhanced by the Public Information Office, participates on the Mauna Kea Management Board, engages in dark sky efforts in Chile and practices good environmental citizenship (for example, proper disposal of hazardous waste).
**L. Summary**

The Gemini Partnership has established a tiered governance structure for the Observatory. Under the authority of the Gemini Board, the NSF acts as the executive agency for the Partnership. Over nearly two decades, the NSF has entered into a series of Cooperative Agreements with AURA to manage the design, development, construction, and operation of the Observatory.

The Gemini Board, the NSF, and AURA all provide programmatic, fiscal, performance, and management oversight of the Observatory through regular peer reviews at several levels, Federal and corporate audits, and various periodic reports.

The Observatory has developed an effective approach to managing its operations as a single entity, despite the wide separation of its various work sites. It has an excellent staff of seasoned personnel led by respected professionals with long experience in managing world-class astronomical facilities.

Gemini has an effective program for developing Partner-community consensus on science directions and implementation. It has also developed and tested an effective program for the management of the production, testing, acceptance, and commissioning of the sophisticated instruments these science programs demand. This program pays careful attention to key risk-management issues using techniques that have evolved and proven themselves over the previous generations of instruments.

Building on AURA’s decades of experience managing observatories with major components in the US and Chile, the business systems of the Observatory are modern and effective in meeting these challenges. These incorporate thoughtful risk-management approaches across a number of important areas requiring ongoing monitoring and action.