Gemini in the Era of Multi-Messenger Astronomy

GEMMA

Gemini in the Era of Multi Messenger Astronomy
Program Execution Plan
Cooperative Support Agreement 1839225
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GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

GEMMA

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Program Execution Plan

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Table of Contents

List of Acronyms

Acronym	Definition
AEON	Astronomical Event Observatory Network
A&G	Acquisition and Guider unit
AIS	Advanced Image Slicer
ANTARES	Arizona-NOAO Temporal Analysis and Response to Events System
Altair	ALTtitude conjugate Adaptive optics for the InfraRed
ALeRCE	Automatic Learning for the Rapid Classification of Events
AO	Adaptive Optics
AOB	Adaptive Optics Bench
AURA	Association of Universities for Research in Astronomy
BTO	Beam Transfer Optics
CAS	Central Administrative Services
CCD	Charge Coupled Device (detector)
CDR	Critical Design Review
CoDR	Conceptual Design Review
CP	Cerro Pachón (the site of the Gemini South telescope)
CPU	Central Processing Unit
CSA	Cooperative Support Agreement
DM	Deformable Mirror
DM0	Deformable Mirror conjugated to the ground-later at 0m.
DR	Data Reduction
DRS	Data Reduction Software
DSP	Digital Signal Processor
ELT	Extremely Large Telescope
EM	Electromagnetic
EMCCD	Electron Multiplying Charge Coupled Device
ESO	European Southern Observatory
FoV	Field of View
FTE	Full-Time Equivalent
FWHM	Full-Width Half Maximum
GeMS	Gemini Multi-Conjugate Adaptive Optics System
GHOST	Gemini High-resolution Optical SpecTrograph
GIRMOS	Gemini InfraRed Multi-Object Spectrograph
GLAO	Ground Layer Adaptive Optics
GMOS	Gemini Multi-Object Spectrograph (-S located at Gemini South, -N at Gemini North)
GMT	Giant Magellan Telescope
GN	Gemini North
GNAO	Gemini North Adaptive Optics (a generic name for new AO system)
GNAOI	Gemini North Adaptive Optics Imager
GNIRS	Gemini Near InfraRed Spectrograph
GPI	Gemini Planet Imager
GW	Gravitational-wave

GS	Gemini South
GSAOI	Gemini South Adaptive Optics Imager
Hubble	Hubble Space Telescope
IRAF	Image Reduction and Analysis Facility
INTEGRAL	INTErnational Gamma-Ray Astrophysics Laboratory
ICD	Interface Control Document
IDF	Instrument Development Fund
IQ	Image Quality
IR	InfraRed
ISS	Instrument Support Structure
JWST	James Webb Space Telescope
KPP	Key Performance Parameter
KSR	Key Science Requirement
LCO	Las Campanas Observatory or Las Cumbres Observatory
LCGTN	Las Cumbres Global Telescope Network
LGS	Laser Guide Star
LGSF	Laser Guide Star Facility
LGSWFS	Laser Guide Star WaveFront Sensor
LIGO	Laser Interferometer Gravitational-Wave Observatory
LLT	Laser Launch Telescope
LPC	Laser Pointing Camera
LQG	Linear Quadratic Gaussian
LSST	Large Synoptic Survey Telescope
LTAO	Laser Tomographic Adaptive Optics
MCAO	Multi-conjugate Adaptive Optics
MMA	Multi-Messenger Astronomy
MOAO	Multi-Object Adaptive Optics
MTCS	MMA-TDA Communications Summit
MTMW	MMA-TDA Media Workshop
MUX	A readout multiplexer; can be used for testing controllers without the more expensive components of a complete detector
NASA	National Aeronautics and Space Administration
NCOA	National Center for Optical-Infrared Astronomy
NCPA	Non-Common Path Aberration
NFIRAOS	Narrow FIeld Infrared Adaptive Optics System TMT
NIFS	Near-Infrared Integral Field Spectrometer
NGS	Natural Guide Star
NGS2	Next Generation Sensor for Natural Guide Star
NGSWFS	Natural Guide Star WaveFront Sensor
NOAO	National Optical Astronomy Observatory
NIRCAM	Near Infrared Camera
NIR	Near InfraRed
NSF	National Science Foundation
NUMA	Non-Uniform Memory Access
O&M	Operations and Maintenance
OAP	Off-Axis Parabola

OCS	Observing Control System (Gemini operations software)
ODGW	On-Detector Guide Window
OIWFS	On-Instrument WaveFront Sensor
OIR	Optical and Infrared
PC	Personal Computer
PI	Principal Investigator
PM	Program Manager
PMB	Performance Measurement Baseline
PMKB	Program Management Knowledge Base (Gemini's Program Management Database)
PMO	Portfolio Management Office
PEP	Project Execution Plan
POLC	Pseudo Open Loop Control
PSF	Point Spread Function
PWFS	Peripheral WaveFront Sensor (two located in the A&G system)
QAP	Quality Assurance Pipeline
RfP	Request for Proposals
RTC	Real-Time Computer
rToO	Rapid Target of Opportunity
SEMP	Systems Engineering Management Plan
SFS	Slow Focus Sensor
SH	Shack-Hartmann
SHWFS	Shack-Hartmann WaveFront Sensor
SCAO	Single Conjugate Adaptive Optics
SIMD	Single Instruction Multiple Data
SOAR	Southern Astrophysical Research Telescope
SF	Science Fold
SR	Strehl Ratio
SwRI	Southwest Research Institute
TDA	Time Domain Astronomy
TMT	Thirty Meter Telescope
TOM	Target Observation Manager
ToO	Target of Opportunity
TT	Tip-Tilt
TTM	Tip-Tilt Mirror
TFS	Transient follow-up system
VIS	Visible wavelength region
VLT	Very Large Telescope
WBS	Work Breakdown Structure
WFS	WaveFront Sensor
XAO	eXtreme Adaptive Optics
ZTF	Zwicky Transient Facility

Executive Summary

In October 2018, in response to the proposal *Gemini Observatory in the Era of Multi-Messenger Astronomy: High Image Quality and Rapid Response to Cosmic Events* (in the following referred to as GEMMA), the National Science Foundation (NSF) awarded a cooperative support agreement (CSA) to the Association of Universities in Astronomy (AURA) to fund the following projects at Gemini Observatory:

1. The Gemini North Adaptive Optics (GNAO) facility, a state-of-the-art multi-conjugate adaptive optics (MCAO) system will be deployed at the Gemini North on Maunakea, Hawaii. GNAO will build on the Observatory's previous investment in the Gemini Multi-conjugate System (GeMS) at Gemini South (GS), and it will employ the latest technology for improved performance in support of the next generation of AO-assisted instruments at GN. As the first MCAO system in the northern hemisphere, GNAO will further enhance Gemini's leadership position in the area of wide-field AO.
2. The Real Time Computer (RTC) project will develop a powerful new RTC design that can be adapted for current and future AO systems at Gemini. The scope of this project includes replacing the existing RTC of GeMS with a new design, as well as providing the RTC for the new GNAO system.
3. The Time-Domain Astronomy (TDA) project, will develop and implement the software improvements required to optimize Gemini's capability for rapid follow-up of the most compelling transient sources identified by the Large Synoptic Survey Telescope (LSST) and multi-messenger astronomy (MMA) facilities. This project will also develop efficient pipelines for real-time delivery of science-quality data products to Gemini users.
4. Multi-Messenger Astronomy Public Information and Outreach (PIO), includes a multimedia planetarium program illustrating the concepts of MMA, classroom materials to promote careers in the science and technology fields involved in MMA research, training workshops for science writers and observatory staff, and an ambitious "summit" to establish a charter for public communication of MMA concepts and discoveries.

The Gemini Directorate determined the GEMMA award will be managed as a program. The day-to-day operation of the component projects are the responsibility of project managers leading project teams with appropriate scientific and technical expertise. The role of the program management office will be one of oversight, coordination, support for project management processes, reporting, and fiscal and contract management. The GEMMA Program Execution Plan (PEP), is developed following the guidelines from the 2017 Large Facilities Office at NSF for the management of MREFC project and describes how Gemini plans to manage and execute the four projects.

This version of the PEP incorporates the initial project execution plans and will be modified annually. The methodology behind the PEP is to incorporate a number of existing (or planned) supporting documents by reference included as appendices. This allows the supporting documents to be updated as the program and projects progress through their life cycles with minimal impact on the high-level elements of the PEP. A list of supporting plans for this PEP is found in Appendix A: Support Documents. Gemini will conduct design reviews at appropriate times within each project's schedule of activities where appropriate. The GEMMA Program Baseline (in section 4) has been established and incorporates the baselines for each project.

1 Introduction

The GEMMA program will provide coordinated management of the projects funded through NSF Award AST-1839225. The GEMMA program and its constituent projects are an outgrowth of scientific planning efforts by the various community workshops and Observatory governance committee recommendations over the past 10 years (looking back at the Aspen program where GNAO was first discussed) and is motivated in part by rapidly expanding development of computational, robotic, communications, and adaptive optics capabilities.

This version of the document represents the approach planned at program initiation to execute the program and projects. Subsequent versions will be issued as the program and projects reach critical milestones or when external factors, such as final decisions on each year's federal budget materialize. Substantive changes to the PEP, following major reviews or significant project changes, will be sent to the National Science Foundation (NSF) cognizant program officer for written approval.

1.1 Scientific Objectives

The Gemini Observatory mission is to advance knowledge and understanding of the Universe by providing its international user community with forefront access to the entire sky. Gemini's twin telescopes in Hawaii and Chile are among the most versatile in the world and are the only 8-meter class telescopes accessible by the entire U.S. astronomical community. It is essential for Gemini to continue to maintain and upgrade its instrumentation, operations, and user support to meet the evolving demands of modern astronomical research.

Two groundbreaking new facilities for optical-infrared astronomy will begin operations near the start of the coming decade: the Large Synoptic Survey Telescope (LSST) and James Webb Space Telescope (JWST). In order to best serve our user community, Gemini will adapt its capabilities to maximize synergies with these two forthcoming facilities. The multi-faceted GEMMA program is designed to upgrade Gemini's instrumentation and operations in order to deliver essential capabilities for forefront astronomical research in the 2020s when both LSST and JWST will be in routine operations.

The major hardware deliverable to be provided by GEMMA will be a state-of-the-art multi-conjugate adaptive optics (MCAO) facility, a key technology for the era of extremely large telescopes (ELT) to be deployed at Gemini North; referred to as GNAO. The ALTAIR system currently in operation at GN was the first facility AO laser guide star system in routine operation. This was a major innovation for its time, but it was commissioned more than 11 years ago, and ALTAIR has become outdated. Its single-conjugate design provides only a narrow-corrected field and does not take full advantage of Maunakea's outstanding conditions for AO performance. In contrast, the planned GNAO facility will provide a corrected field of view of 2 arcminutes with a spatial resolution < 0.1", both comparable to JWST performance. This will establish Gemini North as the premier ground-based facility for wide-field AO studies.

The other AO-related project within the GEMMA program will deliver an advanced, flexible Real Time Computer (RTC) facility for use with the AO systems at both Gemini North and South. The RTC is the brains behind the complex MCAO correction, and the current one in use for GeMS has become unreliable and severely limits the efficiency of GeMS observations. Moreover, its design makes it extremely difficult to adapt for other AO systems. This project will deliver an

upgraded RTC for GeMS that will greatly improve the system reliability and enable GeMS to interface with the next generation of AO-fed instruments. The same flexible design will be used to provide the RTC for the GNAO system and will be adaptable for future AO systems operating at either telescope.

The major operations upgrade within the GEMMA program is the development of new software systems to maximize Gemini's discovery capability in the era of Time Domain Astronomy (TDA). The GEMMA TDA project involves developing all the infrastructure needed to incorporate the Gemini telescopes into an efficient transient follow-up system known as the Astronomical Event Observatory Network (AEON), based on the Las Cumbres Global Telescope Network (LCGTN). Scientific programs that have been awarded time on the AEON system will automatically trigger observations of the most interesting targets identified by "alert brokers" that monitor public alert streams from LSST and other time-domain surveys, including multi-messenger facilities such as LIGO. Gemini's telescopes will provide the largest apertures within the network, and thus will be responsible for characterizing the faintest, highest priority targets. The TDA project includes the development of robust automated data reduction pipelines for rapid delivery of science-quality data products so the user can assess the outcome in real time.

1.2 Scientific Requirements

The GNAO, RTC, and TDA projects within the GEMMA program each have their own set of key scientific requirements for the deliverables that they will provide. See the individual Project Execution Plans for detailed lists of deliverables, threshold and objective science requirements, and parameter specifications relevant to each project.

1.3 Facility/Infrastructure

The Gemini Observatory consists of two 8.1-meter telescopes, located on prime observing sites in Hawaii and Chile, thus providing access to astronomical targets over the entire sky. The Association of Universities for Research in Astronomy, Inc. (AURA) is the managing organization of the Gemini Observatory under a cooperative agreement with the National Science Foundation (NSF). The Gemini Observatory Participant nations are the United States of America, Canada, Brazil, Republic of Korea, Argentina, and Chile.

Gemini South is situated on Cerro Pachon in central Chile at an altitude of 2722m and latitude −30.2 deg, while Gemini North is located on Maunakea, on the island of Hawaii, at an altitude of 4213m and latitude +19.8 deg. The two sites are separated by 85 deg in longitude. Capabilities are not identical at the two sites, but both telescopes are equipped with workhorse imagers and spectrometers as well as more specialized instruments. In addition, Gemini's Visiting Instrument Program provides opportunities for teams to mount their own instruments on the telescopes and provides additional capabilities to the user community.

Gemini features facility AO systems at each site; at present, this includes the single-conjugate, narrow-field ALTAIR system in the North and multi-conjugate wide-field GeMS in the South. The aging ALTAIR system will be replaced by a new, more advanced MCAO system developed by the GNAO project of the GEMMA program. Gemini's ability to switch rapidly among the instruments mounted on the telescope (in less time than required for a typical telescope slew to

change object) enables quick adaptation to changing observing conditions and efficient, multi-instrument follow-up observations, an input requirement for the GEMMA TDA project.

1.4 Scientific & Broader Societal impacts

Scientific Impacts

As discussed in the Scientific Objectives section above, GEMMA is predicated on enhancing the scientific impact of Gemini Observatory by maximizing synergies with other major facilities that will be operational during the coming decade. Two primary science areas are addressed by the projects in this program: high spatial resolution imaging using MCAO, and rapid follow-up of transient sources. The first of these areas is addressed by the GNAO and RTC projects, while the second is addressed by the TDA project.

For instance, the most compelling transient phenomena such as the multi-messenger source GW170817 and the interstellar asteroid ‘Oumuamua have until now been rare enough that they could be pursued with manual triggering and little overall coordination. However, Advanced LIGO will produce many more GW triggers with EM counterparts requiring rapid follow-up study. Early next decade, LSST operations will result in millions of transient alerts each night, ranging from small Solar System bodies to the most distant objects from the epoch of reionization. In order to maximize the discoveries in the vast new time domain opened by the new facilities, there must be an automated system in place to select, prioritize, and observe the most scientifically compelling of the transient alerts using an optimized strategy and deliver the reduced data. The GEMMA TDA project will provide this system for Gemini, streamlining the process of discovery.

Similarly, in addition to enabling a variety of self-contained science such as crowded field near-IR photometry and morphological studies, the new GNAO system will enable wide-ranging investigations involving other facilities that explore the spatial domain with high resolution, including JWST, HST, and ALMA. For example, because of pointing constraints, for any given target within ±40 deg of the ecliptic plane (65% of the sky), JWST can only observe the target during 40% (5 months) of the year. Moreover, current plans are to limit the number of rapid target of opportunity (ToO) observations for JWST to just six per year, with a minimum turnaround time of 48 hours.

This provides an excellent opportunity for synergy: GNAO will be the only facility able to study and monitor high-priority northern targets with a similar spatial resolution and field of view as NIRCAM on JWST. A prime example of this are time-domain targets requiring high spatial resolution, such as multiply lensed supernovae and quasars, for which the predicted times of transient phenomena will depend on the structure of the lensing mass distribution. Operating regularly in Gemini’s queue, GNAO will be able to monitor such targets when they cannot be observed by JWST and when Hubble itself may no longer be operational.

Broader Impacts

Gemini has a very active Public Information and Outreach (PIO) office that has effectively broadened the impact of the Gemini’s scientific research for nearly two decades. The PIO group leads the Observatory’s community outreach activities and electronic communications, including press releases on major results and web features to showcase other interesting topics or

communicate noteworthy items. This highly experienced team will lead all of the public communications, outreach, and educational aspects of the GEMMA program.

The PIO-related effort within the GEMMA program will expand on Gemini's legacy of broader societal impacts with ambitious initiatives inspired by the scientific and technical developments supported by this program. The focus is on multi-messenger and time-domain astronomy and the role of Gemini and other ground-based facilities in this new discovery space. Ultimately, the story told through this work is of a new era in scientific exploration, enabled by cutting-edge technologies and instrumentation supported by focused NSF funding.

As instrumentation enabling multi-messenger astronomy discoveries emerge, a framework for telling a compelling story about these discoveries becomes necessary. To this end, a "summit" of leaders in science education and communications will be convened with the task of converging on a charter to guide the public education and outreach efforts for presenting multi-messenger astronomy to various audiences. This summit, tentatively entitled, "Education, Outreach and Communications in the Era of Multi-messenger Astronomy" is envisioned to include about 25 participants and to be held at NSF's headquarters or an NSF-supported facility involved in multi-messenger astronomy.

Science writers are the conduit through which astronomers communicate scientific ideas and discoveries to the public. Therefore, as part of the GEMMA program, we will organize a one-day workshop for science journalists in conjunction with the American Astronomical Society meeting in Honolulu in January 2020. At this event, a small faculty of professional scientists involved in MMA research will provide perspectives on the present and future of MMA-related topics for up to 30 journalists. Break-out groups consisting of scientists, journalists, and observatory outreach specialists will brainstorm on possible story ideas. Observatory technical staff will also receive training in how to communicate ideas to the media and broader public.

Finally, the PIO funding within GEMMA will also support formal and informal educational activities. The informal education will be in the form of a new multimedia planetarium production to convey the concepts of multi-messenger and time-domain astronomy to students and the general public using an accessible, engaging, and visually stunning storyline. The more formal education will involve the development of STEM classroom educational materials and activities, focusing on topics related to the science and technology supported by the GEMMA funding. The classroom activities will build on Gemini's successful *Journey Through the Universe* program in Hawaii, but will be readily scalable and transferrable to other locations and cultures. The goal of all these educational initiatives is to inspire the next generation of scientists and innovators from across all backgrounds in their pursuit of STEM-related careers.

2 Organization

2.1 Internal Governance & Organization and Communication

The GEMMA program consists of four projects corresponding to the submitted proposal description of work packages. Each of the projects has a separate PEP covering details of that project. For the purposes of project management and resource allocation, the Gemini North Adaptive Optics (GNAO) and the Real Time Computer upgrade are two separate projects. The Gemini Board and STAC have recommended that an Adaptive Secondary Mirror be

incorporated into the long-term plan for the adaptive optics program at Gemini-N. Although the construction of an ASM is outside of the scope of the GEMMA program, the GNAO project will be designed to accommodate an ASM design element.

The high-level structure of Gemini's Observatory project management includes portfolio, program, and project management.

- Portfolio management is to ensure effective use of resources across all active projects and within the observatory, and that programs and projects are prioritized to align with strategic goals.
- Program management is the management of a group of related projects that bring more value to the organization if managed together, GEMMA is one such program.
- Project management is the management of all activities needed to meet a project's objectives. All new project requests go through a portfolio intake process and are evaluated against the observatory's strategic goals. Projects approved for the portfolio are added to the current year portfolio or a future year portfolio.

Each project creates a team whose members may belong to different departments and provide expertise to the project related to their functional area within the observatory. Minimally, the teams consist of a project manager, project scientist, and system engineer. Their role in the project is defined by the framework described below and by the project manager in consultation with the program manager and project sponsor. Decisions regarding resources, project trade-offs, risk management etc. are a collaborative effort between the team, sponsor and program manager. Ultimately the project manager is responsible and accountable for implementing decisions, for the functioning of the team and for delivering the product to the customer, ie. stakeholders, operations and the science users.

This framework incorporates standards from the Project Management Institute (PMI). These standards provide a foundation for project management knowledge and represent the four areas of the profession: project, program, portfolio and the organizational approach to project management. The projects in the GEMMA program will follow the project management methodology built into the Gemini project management database. Following the categorization used by Gemini, GNAO, RTC and TDA projects are considered large tracked projects and the PIO project is considered a medium tracked project.

Large projects with Directorate oversight follow a project management methodology using phases and gates. The first phase, Start-Up, requires a Directorate approved project request to move to the second phase, the Initiation phase.

Project LifeCycle (PLC)

The first phase of GEMMA was approved in the first quarter of fiscal year 2019. The Initiation phase requires project planning be completed. This includes detailed planning documents and the Program and Project Execution Plans.

All projects at Gemini follow a Project Life Cycle (PLC). This life cycle may be further refined in a System Development Life Cycle (SDLC). Both are described in the Portfolio Management

Office (PMO) Methodology. The model used at Gemini is based on a combination of the Project Management Institute (PMI) and PRINCE2 methodologies. In this document, the various roles and responsibilities with respect to the PLC are addressed.

2.2 Project Management Structure

A project manager is confirmed by the Directorate during the startup phase of a project. The project manager manages the day to day activities that guide the project through its life cycle. The project manager is accountable for all activities concerning the project. In order to bear this responsibility, the project manager is given the authority to make decisions with respect to the project's (among other things):

- Scope
- Requirements
- Risks
- Budget
- Resources
- Planning

Without authority, the project manager cannot perform their duties. The tolerance - or limit - of this authority is defined at the start of the initiation phase and depends on the nature of the project. The amount of tolerance may also depend on the project manager's experience level. The project authority is independent of the project manager's accountability to line management and supervisors. Conflicts of interest between the line manager of a project manager should be avoided

2.3 Work Package Management

Some projects are defined to include several activities that can be initiated and executed in parallel. In this case, the project manager may divide the project into work packages according to a Work Breakdown Structure (WBS) - a work package manager may be appointed. There is one notable difference between a project and a work package - the project manager is accountable for the deliverables of the work packages in their project, whereas the tasks in the work package are delegated to the work package manager by the project manager. The work package manager reports to the project manager and is responsible for the initiation and execution of the work package. The project manager and the work package manager can agree on the freedom a work package manager has (tolerances). The project manager then coordinates and monitors the work packages.

2.4 Program management

When one or more projects with distinctive scope support a common interest or are interdependent in terms of deliverables, they may be gathered under a program. This program is managed by a program manager who coordinates the projects in the program and ensures that the program goals are met. The program is managed according to the PMO Methodology. It is the project managers who remain accountable for the deliverables of their projects within the program. The program manager is accountable for the project deliverables of the program.

The Chief Scientist, who serves as the program scientist for GEMMA, works closely with the program manager and sponsor, as well as the project scientists, to ensure that the science goals of the program can be met. The Chief Scientist plays an advisory role in the requirements definition, risk management, design reviews, and implementation of the projects in the GEMMA program. He also acts as a spokesperson for the program (along with others involved in

GEMMA) at scientific meetings and promotes post-project utilization of the deliverables by the community.

3 Governance structure

In the previous section, we discussed the accountability of the project manager and the program manager. The body or person to whom they are accountable depends on the governance structure that has been established. Currently the GEMMA Program Manager reports to the Portfolio Manager, and individual GEMMA project managers report to the GEMMA Program Manager and their line managers for other functional duties.

3.1 Project governance

The project manager is accountable to the stakeholders and is supported by the project sponsor. One of the tasks of the project manager is to gather the input from the stakeholders in order to define the scope of and the requirements for the project. The project deliverables go to the stakeholders. The stakeholders can be represented by the Directorate or a department head, depending on the nature of the project.

The project sponsor is responsible for supporting the project manager, advocates for the project to ensure resources and manage roadblocks to ensure project success. The project sponsor functions as a link between the Directorate and the project manager and in collaboration with the program manager, manages the escalation process outside of the tolerances of the project manager. The program manager, project manager and sponsor relationship are described in the program plan and outlines the process to identify:

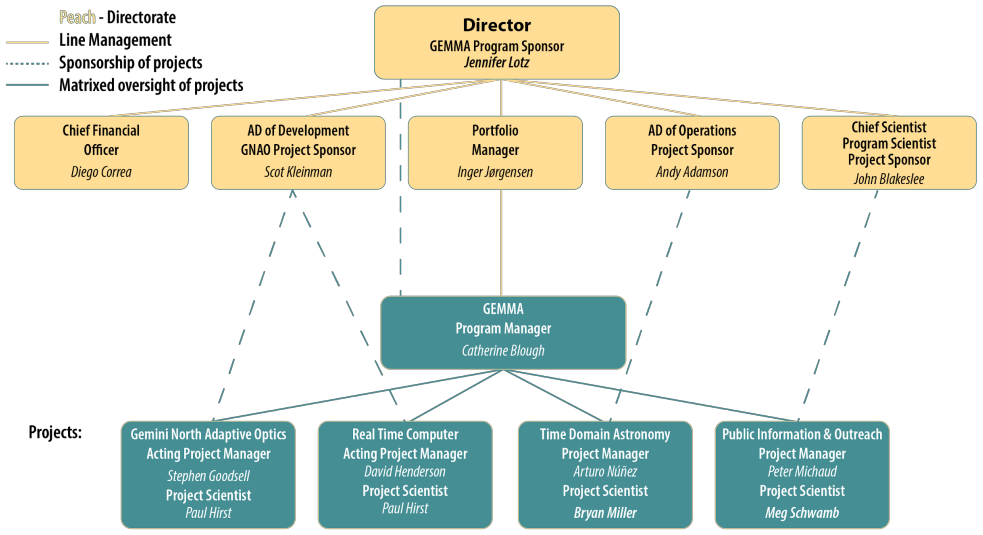
- Defining the Project Manager tolerances.
- The time commitment each can expect from the other.
- The frequency and nature of reports from the project manager.
- Frequency and expectations of meetings.
- How the sponsor expects the project manager to deal with problems AND when and what kind of problems will be brought to the sponsor and program manager.
- How the program manager and sponsor will deal with problems and when and where they will be escalated.

Principle Investigator: The PI has overall responsibility for the scientific success of the project and is the lead scientist for the project. In consultation with the Program Scientist, the PI provides the bridge between the science, technical, and management teams to ensure their vision for accomplishing GNAO and RTC is realized.

3.2 Program governance

The GEMMA program governs four projects, and the program manager is accountable to the directorate. The Gemini Director is the sponsor of the GEMMA program.

When a project is under a program, the project manager is accountable to the project sponsor for the management of the project and is accountable to the program manager for the project deliverables and adherence to the program goals and the deliverables. Within the tolerances agreed upon with the program manager and in consultation with the project sponsor, the project manager has the authority to make decisions on all aspects of the project. Decisions outside the tolerances must be approved by the program manager in consultation with the project sponsor.



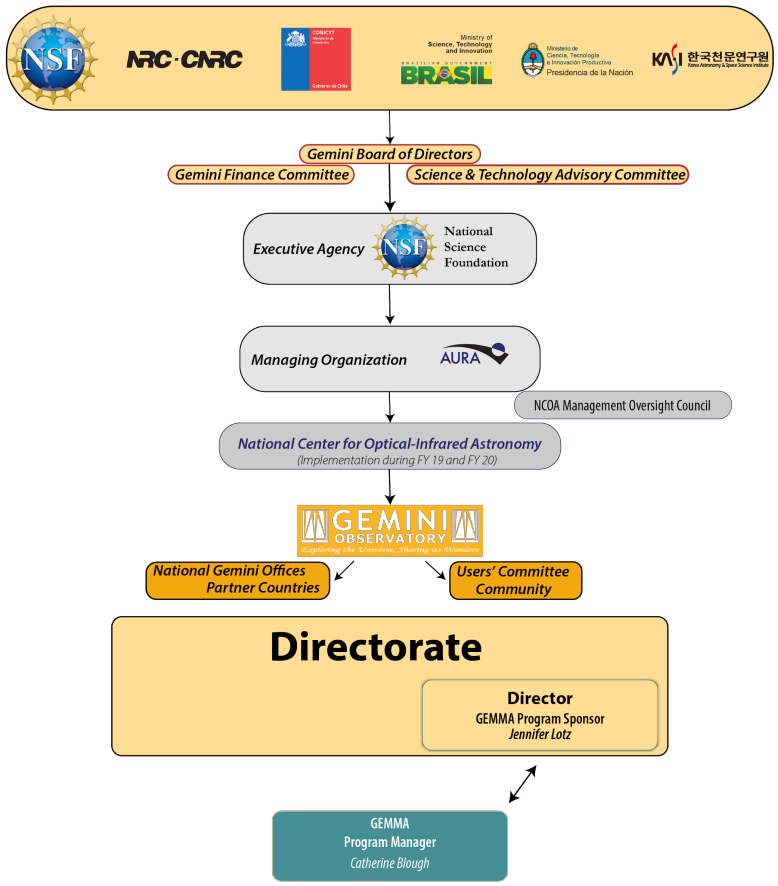
GEMMA program matrix showing the relationship between the Directorate, program, sponsors and projects.

Communication

The Internal Communication Plan listed in Appendix A describes how the status of the GEMMA program will be communicated across the Observatory. In addition to high-level objectives, this plan includes types of communication, method of communication, frequency of communication, who is responsible for distribution, and who will receive what communication.

3.3 External Organization and Communication

Current Gemini Governance, showing the relationships among the Gemini Board and its Science and Technology Advisory Committee (STAC), the Executive Agency NSF, the Managing Organization AURA, the Gemini Observatory and groups with community interactions such as the NCOA Management Oversight Council and the Users' Committee. Below is a graphic representation of the governance structure.



Gemini organization governance diagram

The External Communication Plan describes how the status of the GEMMA program will be communicated to external organizations. In addition to high level objectives, this plan includes types of communication, method of communication, frequency of communication, who is responsible for distribution, and who will receive what communication. The objective of the plan is to maintain open communication between the observatory and the community regarding the program's progress and actively engage the stakeholders.

Please refer to the GEMMA Program External Communication Plan listed in Appendix A.

3.4 Partnerships

Gemini serves a broad and diverse international partnership. For many users, the Gemini telescopes are the only large-aperture telescopes to which they have access. We therefore have to balance this need for diverse and broad capabilities at the Gemini telescopes against the rewards of doing intensive campaigns in specific scientific areas.

The current participants (see diagram above) bring to Gemini diversity in their communities' needs for access to large aperture telescopes and in contributing ideas to improve Gemini's capabilities. Gemini's Strategic Vision directs Gemini to both maintain broad capabilities for its diverse community and specialize in areas that expand upon Gemini's strengths where we can

lead the community and become the observatory of choice. With the proposed projects, we will have a strong foundation for delivering on this vision: a Gemini South equipped with broadly capable instruments, the world's first (and only until GNAO) laser-assisted multi-conjugate AO system operating seamlessly, and observing strategies and systems that enhance the observatory's core strength in event-based follow-up; Gemini North with a state of the art, next-generation AO facility providing superb image quality for all instruments and an equal partner in a multi-messenger astronomy discovery network.

The projects in the GEMMA program require a number of feasibility and trade studies. We will incorporate the stakeholder feedback along with the results of these studies to better tailor our work to the needs of our users. In all cases, we will be guided by our top-level project requirements. While we can alter these requirements through our change-management process, when necessary, we will endeavor to work within our initial scope and address any new demands arising from additional stakeholder or technical concerns.

3.5 Roles and Responsibilities

The Gemini Board is comprised of international participants with the United States, Canada, Chile, Brazil, Argentina, and Korea. The board sets budgetary policy for the Observatory and carries out broad oversight functions as defined in the International Gemini Agreement.

The Gemini Finance Committee (GFC) is comprised of financial authorities from the participant countries. The GFC advises the Gemini Board on financial, budget and long-range planning issues for the Gemini Observatory.

The Science and Technology Advisory Committee advises the Gemini Board on policy matters of long-range scientific and technical importance.

The Executive Agency (NSF) serves in two capacities in the Gemini Partnership. It acts as Executive Agency according to the terms of the International Gemini Agreement, and as such is empowered to act on behalf of the Partnership to execute necessary administrative actions. In addition, the NSF serves as the U.S. funding agency, having programmatic responsibility for oversight of U.S. interests in the Partnership.

The National Center for Optical-Infrared Astronomy (NCOA) will be the foundational hub of the U.S. optical-infrared (OIR) System. NCOA will bring LSST operations, Gemini Observatory, and NOAO under a single organizational framework, with autonomy and accountability to the Gemini international participants.

The NCOA Management Oversight Council (NMOC) provides stewardship and management oversight and advocacy of Gemini operations as well as oversight of LSST operations, NOAO operations and the NCOA Transition project.

The Users' Committee for Gemini (UCG) provides feedback to the Gemini Observatory on all areas of operations that affect current users of the facility, based on the experience of the committee members as well as input collected from the larger community of Gemini users. The Observatory uses this information to improve the service it provides to users.

Each of the Gemini participants and the University of Hawaii, which has regular access to

Gemini, maintain a “National Gemini Office” to support their local users.

The Directorate is responsible for the overall operation of the Observatory. Under the leadership of the Gemini Director, the Directorate defines and carries out the overall scientific mission of the Observatory as approved by the Gemini Board, and provides scientific and management leadership.

3.6 Community Relations and Outreach

During the execution of the GEMMA program, Gemini will maintain a public web page[1] to provide information on program status and updates. The GEMMA program page will be clearly accessible from Gemini’s public home page and science operations web page, and it will contain links for more detailed status information on each of the component projects. We will use the same channels for general information to our user base and the general, as used for other Gemini work: Gemini Focus, e-Newscasts, and social media postings.

Community relations and public outreach are central to the PIO project within the GEMMA program. In brief, the project contains components aimed at public outreach, education, and media training. NSF funding for multi-messenger astronomy will be spotlighted by the planned “MMA summit” that will develop a charter for public communication of the concepts and discoveries related to MMA and other science enabled by the GEMMA funding. The public outreach and educational aspects will include the production and distribution of a multimedia planetarium program telling the story of multi-messenger astronomy, and the development of inquiry-based classroom educational materials and activities to inspire students to pursue STEM-related careers.

4 Design and Development

4.1 Program Development Plan

Please refer to the Program Plan in Appendix A.

4.2 Development Budget and Funding Source

The NSF has awarded AURA funds to support the GEMMA program through Cooperative Support Agreement 1839225. Expenditure limits are determined twice a year in accordance with the yearly budget estimates for the period October 1, 2018 - September 30, 2024 and are subject to adjustment. The initial funding profile is below and the spend plan is addressed in section 4.8.

Year	Start date	End date	NSF Committed Allocation
Year 1	10/1/2018	9/30/2019	$2,932,767

[1] www.gemini.edu/gemma

Year 2	10/1/2019	9/30/2020	$2,813,824
Year 3	10/1/2020	9/30/2021	$3,489,434
Year 4	10/1/2021	9/30/2022	$12,913,705
Year 5	10/1/2022	9/30/2023	$2,335,415
Year 6	10/1/2023	9/30/2024	$1,488,973
		Total	**$25,973,938**

The GEMMA program will require labor effort supplied by Gemini O&M labor resources. The cost of any significant effort is required to be funded from the GEMMA award. We have identified the need to move funds to the labor line item from the contracts line item within the awarded budget. We currently estimate that we will need to move approximately $4.7 million. A revised budget will be submitted to the NSF for approval with the next quarterly report.

4.3 Development Schedule

The high level milestones marked with an asterisk, and schedules for the four GEMMA projects are listed below.

Milestones* and Deliverables

GNAO WBS 1.2	Finish
Project Planning *	12/31/18
Design Phase	9/30/21
Conceptual Design Review *	9/1/19
Completion of Preliminary Design Stage	9/30/20
Completion of Critical Design Stage *	9/30/21
Build Phase	6/30/23

Completion of the Assembly, Integration and Verification Stage	6/30/23
Telescope Integration Phase	9/30/24
Telescope Integration Stage	1/1/24
Telescope Integration and Commissioning Phase	9/30/24
RTC WBS 1.3	Time Frame
Initial lab prototyping and familiarization with software; Demonstrate closed loop operation on a simple lab AO bench (thorlabs AO kit at HBF)	FY2019-Q2 - FY2019-Q4
Develop and Document Conceptual Design*	FY2019-Q4 - FY2020-Q1
CoDR after the GNAO CoDR to incorporate GNAO needs into the design	FY2019-Q4 - FY2020-Q1
Preliminary Design Stage Review*	FY2021-Q2
Critical Design Stage Review* All major software components developed at least to the working prototype level All major hardware components in-house operating at least the working prototype level	FY2022-Q2
Build and commission new GeMS RTC*	FY2023-Q2
Build and deliver GNAO RTC*	FY2023-Q4
Please refer to the detailed schedule in the RTC Program Plan section 6.4	
TDA WBS 1.4	Time Frame
Time Domain Astronomy Software*	12/31/21

Operational Concept Definition*	2/15/19
Scheduler*	1/15/21
TDA APIs*	2/5/20
Gemini Plugin for TOM Toolkit	9/5/20
Real Time Pipelines	11/19/21
Product Distribution Manager	12/18/20
Integration and Commissioning*	7/30/21
Documentation, Training and Operations Handover	12/17/21
Please refer to the detailed schedule in the TDA Program Plan section 6.4	
PIO WBS 1.5	Time Frame
MMA-TDA Communications Summit (MTCS)	
Development of MTCS key objectives, outcomes and venue options*	1/15/19
Program development completed*	6/30/19
Promotion to media/AAS mailing, social media, sign-up created	8/31/19
Summit executed	10/30/19
Development MTCS final report, results/recommendations*	11/30/19
MMA-TDA Media Workshop (MTMW)	

Draft MTMW key obj, outcome and venue, AAS 2020 pre/post	5/10/19
Program finalized*	10/30/19
Develop presentation on results of MTCS for MTMW	11/30/19
Workshop executed*	1/10/19
Staff, Media Training	
Development of objectives, outcomes, scope and venue*	2/28/20
Selection of staff participants (Gemini/AURA centers)	9/30/20
Target execution of training*	11/30/20
MMA/TDA Planetarium Program	
Research production/distribution partners and contractors	11/30/19
Issue call for proposals/bids to potential production contractors	4/1/20
Select production contractor(s)	4/30/20
Program production and script finalization*	1/31/21
Promotion and digital distribution*	9/30/21
Relevant animations and visuals available digitally to media	9/30/21
MMA/TDA Interns	
Create MMA-TDA intern job description	1/30/19
Begin first internship*	5/31/19

Repeat every six months for total of 4 iterations*	7/1/21
Please refer to the detailed schedule in the PIO Program Plan section 6.4	

5 Construction Program Definition

5.1 Summary of Total Program Definition

The GEMMA program consists of managing the overall costs and the risks of the four component projects, as well as the coordination and prioritization of resources across these projects. The four projects within GEMMA are:

1. The Gemini North Adaptive Optics (GNAO) system;
2. Real Time Computer (RTC);
3. Time-Domain Astronomy (TDA);
4. Multi-Messenger Astronomy Public Information and Outreach (PIO) effort.

5.2 Work Breakdown Structure (WBS)

WBS #	WBS Title	Deliverable	Responsible Organization
1.1	Program Management	Increasing Gemini's Capabilities in the era of time-domain and multi-messenger astronomy	Gemini
1.1.1	Project Management	WBS 1.2 through 1.5	
1.2	Gemini North Adaptive Optics Facility (GNAO)	Multi-Conjugate Adaptive Optics System for Gemini North	Gemini
1.2.1	See GNAO Project Execution Plan section 5.3		
1.3	Adaptive Optics Real Time Computer (RTC)		Gemini
1.3.1	See RTC Project Execution Plan section 5.3		

1.4	Time Domain Astronomy (TDA)		Gemini
1.4.1	See TDA Project Execution Plan section 5.3		
1.5	Public Information & Outreach (PIO)		Gemini
1.5.1	See PIO Project Execution Plan section 5.3		

5.3 WBS Dictionary

WBS #	WBS Title	WBS Description
1.1	Program Management	Provide coordination and management for the projects.
1.2	Gemini North Adaptive Optics Facility (GNAO)	Build an improved multi-conjugate AO system
1.3	Adaptive Optics Real Time Computer (RTC)	Implement a common Adaptive Optics Real Time
1.4	Time Domain Astronomy (TDA)	TDA software products
1.5	Public Information & Outreach	Student education, Media training and general public information

5.4 Scope Management Plan and Scope Contingency

Please refer to the program Scope Management Plan listed in Appendix A.

Any changes to objectives or scope (deliverables) as described in the Cooperative Support Agreement require NSF approval, irrespective of any changes to budget/costs. Specific procedures for change requests can be found in the NSF PAPPG.[2]

5.5 Cost Estimating Plan, Cost Reports and Baseline Budget

This Cost Estimating Plan defines the guidelines and methodology used to prepare the cost estimate for Gemini Operations and Instrumentation Development. This document is applicable to NSF funded operations subject to the Office of Management and Budget's (OMB) Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards. The plan covers the following topics and can be found under Reference Documents.

[2] https://www.nsf.gov/pubs/policydocs/pappg18_1/pappg_7.jsp#VIIB1

- Program Planning Process
- Methods and Tools
- Software
- Project Cost Planning
- Project Cost Management
- Labor Costs
- Non-Labor Costs
- Travel
- Contracts
- Other Direct costs
- Economic Assumptions
- Complexity Factor Analysis
- Indirect Costs

5.6 Complexity Factor

Gemini utilizes an analysis of project complexity factors to help determine the appropriate budget allowance. Table 1 shows the 11 complexity factors currently used to evaluate the 4 projects, with slight variations to accommodate the diversity of the projects. Specific factors generated are based on past experience with construction of Gemini instruments.

A percentage of the total cost of the projects is used as a baseline adjustment for the average project. For a relatively non-complex project, the total budget adjustment will be less than this amount; for a more complex project than average, more.

Factor	Title
C1	Basis of Estimate
C2	Technical Complexity
C3	Schedule Complexity
C4	Past Performance
C5	Team Experience
C6	Project Structure Complexity
C7	Management Control Systems

C8	**Underestimation Bias**
C9	**Gemini Strategic Environment**
C10	**Interface and Requirement Complexity**
C11	**Gemini Staff Complexity**

Please refer to the Cost Estimating Plan listed in Appendix A for further explanation of the method for calculating the complexity factor and application to the 4 projects.

5.7 Cost Book, Cost Model Data Set and Basis of Estimate

The Cost Book refers to a document specific to a facility construction project and is not applicable to the GEMMA program and projects in an existing large facility.

5.8 Funding Profile

	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	-Total Fiscal Years
GEMMA External Fees (AURA IDC)	195,288	206,519	267,043	236,203	165,433	116,737	1,187,223
GEMMA Program Mng.	386,772	457,328	457,857	471,593	485,741	500,313	2,759,604
GNAO	1,057,843	1,029,256	1,851,347	11,122,393	1,462,944	685,268	17,209,051
RTC	245,929	280,044	237,356	1,083,515	221,297	186,655	2,254,795
TDA	601,880	622,029	675,831	0	0	0	1,899,739
PIO	445,056	218,648	0	0	0	0	663,703
Total	**2,932,767**	**2,813,824**	**3,489,434**	**12,913,705**	**2,335,415**	**1,488,973**	**25,974,117**

NSF approved budget

Gemini O&M labor resources will contribute to the GEMMA program and projects with funding from the GEMMA award. We have established the following guidelines for when managers, Directorate members, and staff will charge their time against the GEMMA award:

Managers and Directorate members will charge against the GEMMA award for time spent on

- Concrete deliverables, including writing sections for the PEP and any future reports
- Extensive review of documents and reports

Managers and Directorate members will not charge against the GEMMA award for time spent on

- General supervision of staff or projects
- Program and Project sponsor activities

Staff will charge against the GEMMA award for time spent on project and program management, concrete deliverables and documents, but will not charge against the award for participation in general update meetings, or the occasional request for information. Support staff from ITS and Facilities providing routine support for staff working on the GEMMA award will not charge such labor effort against the GEMMA award.

5.9 Baseline Schedule

WBS#	Description	Schedule
1.1	Program Management	Oct 2018 - Sept 2024
1.2	Gemini North Adaptive Optics Facility (GNAO	Oct 2018 - Sept 2024
1.3	Adaptive Optics Real Time Computer (RTC)	Oct 2018 - Sept 2024
1.4	Time Domain Astronomy	Nov 2018 - Nov 2021
1.5	PIO MTCS, MTMW, Media Training, MMA/TDA Planetarium, Interns	Jan 2019 - July 2021

Please refer to the Program Plan listed in Appendix A.

5.10 Schedule Contingency

Gemini requires contractors to maintain a baseline schedule and include schedule contingency beyond the baseline of a reasonable amount (at least 15% beyond the critical path). The schedule, including contingency, shall not exceed the required project completion date. For internal work, we will update our baseline schedule with appropriate contingency at each stage end.

The formal change control process is used to address schedule contingency via change requests and the impact on their related scope and activities. A contingency management plan is currently under development.

6 Staffing

6.1 Staffing Plan

The GEMMA program management team consists of the program scientist, project managers, project scientists and sponsors for the four projects. The team will review staffing plans quarterly to determine adequate resources are identified to manage the work required to maintain budget and schedule and to identify and mitigate resource risks to the program. In

addition the Portfolio Management Office monitors and updates a resource allocation sheet which lists all projects in the Gemini portfolio. The Directorate reviews the allocation sheet quarterly to identify projects and reallocate staff according to project priority. The allocation sheet covers the following:

- Resource
- Role
- Location
- Duration
- FTE as a function of time

For specific staffing plans, please refer to Appendix A for each project and the program resource allocation plan. The plans may identify goal evaluation, analyzing the current state of the function, envisioning needs, conducting a resource gap analysis and developing a solution plan.

6.2 Hiring and Staff Transition Plan

Please refer to the program Resource Allocation Plan listed in Appendix A. It lists the resource, their role, their location, the cost associated with the resources and the duration of the employment. The hours per week/month are listed as well as the requirements and training. A Hiring and Staff Transition Plan is yet to be fully developed.

7 Program Risk and Opportunity Management

7.1 Risk Management Plan

A formal risk management program has been implemented in the Gemini Portfolio Management Office. This program is described in the Risk Management Plan, which is incorporated into this PEP by reference. The risk management plan follows an accepted standard risk management approach of planning, identifying potential risks, assessment, analysis and developing mitigation strategies or handling.

The risk management plan is included in Appendix A and covers:

- Program Risk Process
- Other Roles and Responsibilities
- Budgeting
- Timing
- Risk Register Scoring and Interpretation, with Impact and Likelihood scoring
- Reporting Formats
- Tracking

Each project uses the same PMO templates for the risk register and the risk management plan.

7.2 Risk Register

Please refer to the program Risk Register listed in Appendix A. The register includes:

Part I - Risk Identification

1. Categorization & Description
2. Impact, Likelihood & Total risk scores

Part II - Existing controls, per risk:

1. Effectiveness
2. Residual risk score

Part III - Risk Response, per mitigation strategy:

1. Effectiveness
2. Residual risk score
3. Contingency Plan
    a. Cost
    b. Owner
    c. Review schedule
    d. Status

7.3 Contingency Management Plan

Please refer to the Part III columns in the Risk Register for Contingency Management information.

8 Systems Engineering

8.1 Systems Engineering Plan

TDA and the RTC projects have individual Systems Engineering Management Plans (SEMPs) included with their project execution plan. The plans cover the following:

- System Design Process
- Logical Decomposition and Requirements Definition
- Requirements
- Decomposition Methodology
- System Design
- Conceptual Design
- Preliminary Design
- Critical Design
- System Development
- Software development
- Documentation Plan
- Validation & Verification

The SEMPs will be revised to include further detail within 6 months of the submission of the PEP. The revisions will include updates to the system design plan and cover system development, interface management, verification, validation, and system integration and realization plans in more detail.

8.2 Systems Engineering Requirement

The project SEMPs will list requirements for the projects as they are developed. Please refer to the individual SEMPs included with each project execution plan.

8.3 Interface Management Plan

The project SEMPs will describe the interface plan for the projects as they are developed. Please refer to the individual SEMPs included with each project execution plan.

8.4 Quality Assurance and Quality Control Plan

The project SEMPs address Quality Assurance (QA) as providing an independent assessment to the project manager and systems engineer of the items produced and processes used during the project life cycle. The Project Manager and Systems Engineer will ensure that contractors implement a quality assurance program and ensure visibility into QA processes and risk mitigation. Internally, the project manager and systems engineer will manage quality risks and enforce adherence to procedures and specifications throughout the system development and system integration.

8.5 Concept of Operations Plan

Please refer to the individual project SEMP listed in the project's Appendices.

8.6 Facility Divestment Plan

Not Applicable
Because this is not a large facility project and implementation is an addition to an existing observatory, this section is not applicable.

9 Configuration Control

9.1 Configuration Control Plan

The end product, as well as all previous product iterations, will be under Configuration Control. This means that all changes made to requirements, technical, cost and schedule are tracked and are subject to the approval of the Program Manager. This process adheres to the document control policies with all decisions and documents stored in the project team drive. This process is monitored by the project coordinator. In addition, changes that do not require control are tracked in the decision tracker and the issues list. The team sites will be the repository for all changes not under change control.

9.2 Change Control Plan

All changes to the project are requested through a Change Request Form and submitted by the individual Project Managers to the Program Manager. The Program Manager in consultation with the sponsor will assess the benefit of the change and the impact on cost, timeline and resources available based on program impact and project need and decide if the change can be

implemented. If the scope of the change is outside of the tolerances for the Program Manager, the Directorate will be asked to consult.

A Change Request Form is a PMO template to be use for change control.

9.3 Documentation Control Plan

Gemini currently has a Document Control procedure in place that describes how documents are tracked and retrieved.

For this, a Xerox supplied DocuShare application called Document Management Tool (DMT) is used. Released documents are stored in DMT and subsequent updates are uploaded while the old version is kept. Version change information is stored with each version. The tool complies with:

1. Security
2. Alerts/Notifications
3. Back-up
4. Version Control
5. Review/Approval
6. Use of different file types
7. Index/Searching (tags)
8. Reports

In addition, DMT has a secured area required for ITAR related documents.

Please refer to the Document Management Policy listed under Reference Documents.

10 Acquisitions

10.1 Acquisition Plans

Acquisition Plans will be developed as decisions are made regarding the proposed procurements during the project lifecycle. Construction for GNAO and RTC will adhere to the Office of Management and Budget's (OMB) Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards and AURA and CAS policies for all procurements. AURA policy provides levels of approval based on dollar thresholds. Approval is required from NSF, as the Executive Agency, for acquisitions >$250k.

10.2 Acquisition Approval Process

Gemini follows the AURA CAS procurement policies that can be found here.

11 Program Management Controls

11.1 Program Management Control Plan

Gemini has a Portfolio Management Office which provides guidance to the program management process by providing:

- Methodology for the Project Life Cycle
- Project Management and Systems Engineering Templates
- Reporting and resource allocation tools
- Training

Please refer to the Project Methodology documents listed under Reference Documents:

- The Project Life Cycle
  - Project Startup
  - Initiation
  - Execution
  - Closeout
- The System Development Life Cycle
  - Analysis and Requirement
  - Design
  - Development
  - Validation and Verification

In addition, there are documents describing:

- Monitor and Control
- Change Management Process

This methodology and the applicable templates are used throughout this project.

11.2 Earned Value Management System (EVMS)

Earned Value Management (EVM) will be implemented to measure the efficiency for the work accomplished on the program and projects as well as track the Estimate at Completion (EAC) and predict the duration of the project through Earned Schedule (ES). To measure the efficiency of the individual projects the following will be collected: Planned Value (PV), Actual Costs (AC) and Earned Value (EV). From the PV, AC and EV calculations can be performed to analyze the Cost Performance Index (CPI), Schedule Performance Index (SPI) and To-Complete Performance Index (TCPI). The CPI will be analyzed to examine the cost efficiency with which the money is being spent on the project. The SPI will be analyzed to measure the efficiency with which the schedule was progressing. The TCPI is used to predict the future cost performance that must be achieved for the project to meet the planned budget or Budget at Completion (BAC). The BAC will be derived at the beginning of the projects by performing a bottom-up estimate which will be calculated by adding up all the work packages which include all of the direct and indirect costs associated with each work package.

11.3 Financial and Business Controls

AURA Central Administrative Services (CAS) provides AURA Operating Centers funded by NSF with business services. These services are aligned with federal and state laws and regulations, AURA policy and CAS procedures. CAS provides the following services:

- Procurement
- Sub-awards
- Property management
- Logistics
- Cash Management and Disbursement
- Accounting
- Payroll
- Financial and Compliance Audits
- Compliance
- Business IT

AURA CAS and Human Resources policies and procedures can be found here.

12 Site and Environment

12.1 Site Selection

Not Applicable

The projects under the GEMMA program are funded by the NSF through an added CSA to an existing observatory management and operations CSA, and not the construction of a large facility.

12.2 Environmental Aspects

Not Applicable

The projects under the GEMMA program are funded by the NSF through an added CSA to an existing observatory management and operations CSA, and not the construction of a large facility.

13 Cyber Infrastructure

13.1 Cyber-Security Plan

The Cyber-Security Plan is posted on the internal website and covers the following topics:

- Acceptable Use Policy
- Computer Asset Management Policy
- Computer Equipment Refresh Policy
- Computer Equipment Provisioning Policy
- Information Security Awareness & Training Policy
- Internet Postings Policy
- Master Information Security Policy
- Mobile Devices Policy
- Password Policy
- Physical Security Policy
- Remote Access Policy
- Wireless Access Policy

13.2 Code Development Plan

Gemini standards for writing, testing and verifying, deploying, and documenting software, including configuration control during the stages of development are maintained by the software group and are posted on the internal website and cover the following topics.

- Documenting the Code
- Coding Practices
- Coding Styles
- 5 EPICS Tools
- ADE Concepts
- Software Development using the ADE
- Managing External Software

13.3 Data Management Plan

The Gemini Data Management Plan is listed with the Reference Documents.

14 Environmental Safety and Health

14.1 Environmental Safety and Health Plans

Gemini has an extensive Safety Manual in place that covers the following:

- Gemini Safety Organization Chart
- Roles and Responsibilities Matrix
- Normative References and Documentation
- Safety Manual Sections Applicable by Work Area
- External Injuries/Illness reporting
- Internal Accident Investigation and Review
- Safety and Health Training and Education
- Generally Safe Working Practices
- Assessment of Hazards and Mitigation of Risks
- Fire Safety
- Emergency Preparedness
- Laboratories
- Workplaces, Ergonomics, and Manual Handling
- Work Equipment and Machinery
- Electrical Installations
- Inspections
- Hazardous Substances
- Design and Construction Policies
- Cryogenics
- Laser
- Ionizing Radiation Protection
- Work Permits
- Building and Construction Safety
- Work at High Altitudes
- Personal Protection Equipment

- Safety Signage
- Summit Facility
- Stretching Program
- Safety Boards
- New Hire Safety Orientation

In addition, there is a Gemini Site Safety Plan in place that subjects all personnel and contractors.

For all work performed a Job Hazard Analysis is performed before work commences and precautions are taken to mitigate possible hazardous conditions.

Personnel receive ongoing training through Gemini's SafetyPlus web-based program.

15 Review and Reporting

15.1 Reporting Requirements

Gemini is required by the CSA to provide quarterly financial reports and an annual report in September. The reports are to coincide with other observatory reports required for the governance committees and Board. During the course of the program, Gemini will define and analyze the benefits of the projects to the observatory mission. Programmatic and science metrics will be developed with community input to demonstrate benefits and to identify how operations and the user community will capitalize from the project's completion.

15.2 Audits and Reviews

Gemini will provide comprehensive written reports twice a year, in March and September and, if required by NSF, additional ad hoc reports. These reports shall complement the observatory's usual reporting (as outlined in CSA AST-1539773) and will specifically focus on the technical, schedule, budget, and risk status of the four projects referenced above in 2.1.B funded by this award.

All reports will be submitted per the CSA programmatic reporting requirements. Each report will be shared with the Gemini Board and its Science and Technology Advisory Committee prior to their twice-yearly meetings.

16 Integration and Commissioning

16.1 Integration and Commissioning Plan

When the project nears the final product delivery an Integration and Commissioning plan will be developed. This will be based on the outcomes of the Systems Engineering Development efforts. The following items will be addressed as applicable for GNAO and RTC:

- Pre-assembly and Testing

- Integration
- Verification and Validation
- Pre-shipment Review
- Reliability and Cost of Ownership
- Installation plan
- Manuals
- Spare parts lists
- Maintenance plan
- Shipping

16.2 Acceptance / Operational Readiness Plan

Please refer to the program Acceptance Test Plan listed in Appendix A. This plan has the following structure:

- Verification Methods Matrix
- Optical Requirements
- Mechanical Requirements
- Detector Requirements
- Control System Requirements
- External Interfaces
- Environmental Requirements
- Other Requirements
- Post-Delivery Test
- Inspection for Transport Damage
- Acceptance Test Repeated After Delivery
- Summary of Test Equipment and Test Software

17 Program Close-out

17.1 Program Close-out Plan

Please refer to the program Closure Report listed in Appendix A. This plan has the following structure:

- Program Definition
  - Program Background
  - Program Objectives
- Summary of the project's performance:
- Review of Benefits achieved to date
  -
- Review of Residual Benefits Expected
- Review of Relevant Program Deliverables and Products:
- Accountability
  - Actual time required
  - Actual costs required
  - Actual resources required
  - Lessons Learned

- Location of Program Archive

17.2 Transition to Operations Plan

When the project nears the final product delivery an Integration and Commissioning plan will be developed to transition to operations.

18 Appendix A: Support Documents

1. Communication Plan External
2. Communication Plan Internal
3. Program Plan
4. Resource Allocation Plan
5. Risk Register (Programs)
6. Scope Management Plan

19 Reference Documents

1. Gemini Cost Estimating Plan
2. Gemma Funding Profile
3. Document Management Policy
4. Gemini Data Management Plan
5. The Program Life Cycle Framework
    a. Startup Phase
    b. Initiation Phase
    c. Execution Phase
    d. Closure Phase
    e. Monitor and Control
    f. Change Management Process
6. The System Development Framework
    a. Analysis and Requirements Phase
    b. Design Phase
    c. Development Phase
    d. Validation and Verification Phase

20 Reference Documents

(PMO templates not included in the PEP submission)

Acceptance Test Plan
Acquisition Plan
Change Request
Closure Report (Programs)
Risk Management Plan (Programs)
Staffing Plan
Stage Plan

GEMMA

Gemini in the Era of Multi-Messenger Astronomy

Program Plan

December 20, 2018

A-GPM-001

Issued By:	Catherine Blough
Sponsored By:	Jennifer Lotz
Approved By:	Jennifer Lotz

Table of Contents

1 Plan Description

The purpose of the Program Plan is to provide a high level view that shows the major products to be delivered by the program, when and at what cost. It states how and when a program's objectives are to be achieved, by showing the major products, milestones, activities and resources required on the project. This is revised as information on actual progress appears. It is a major control document for the program and sponsor to measure actual progress against expectations.

The GEMMA Program Plan supports the observatory's strategic mission, to preserve and enhance PI-driven science and position Gemini as the premier 8m-class facility. The program will oversee and monitor the project management processes involved in producing the deliverables for the following projects:

GNAO

1. The integration between GNAOI and GNAO is inside the scope of the NSF CSA award and GNAO project.
2. Successful first-light science demonstration and a significant science result press-release is inside the scope of the GNAO project.

RTC

1. Gemini Common RTC platform.
2. Replacement GeMS RTC
3. GNAO RTC

TDA

1. Gemini TDA APIs: A new set of application programming interfaces (APIs) that comply with a set of standards that will be generally applicable across a wider network of follow-up facilities. These will allow observations to be requested, provide the required feedback, and allow automated data access.
2. Gemini Plugins for Target Observation Managers (TOMs): Provide software to help Gemini users work with these new APIs.
3. Scheduler: Provide an efficient, dynamic way to schedule large numbers (order 10-100) of transient observation requests per night.
4. Real Time Pipelines: Provide a mechanism to automatically reduce imaging and longslit spectroscopic data in real-time for rapid characterization of transient sources and more responsive decision-making during night operations.
5. Product Distribution Manager: Updates the Gemini Observatory Archive to be able to deliver reduced data to users.

PIO

1. MTCS: Identify needs and best practices for the effective communication of MMA/TDA with the public and students
2. MTMW: Inform journalists about MMA and TDA, the technologies involved and the scientific horizons ahead in these areas
3. MMA/TDA Planetarium Program: Present the excitement of MMA and TDA to K-12 students in an engaging and understandable and accurate manner using video technologies available in portable planetaria

4. MMA/TDA Staff Media Training: Provide staff likely to interact with the media with skills to improve their communications with the media and more effectively tell the story of MMA and TDA to the public through the media
5. MMA/TDA Internships: Provide an environment where undergraduate-level interns can develop effective and tested educational materials for K-12 students

2 Plan Pre-requisites

Gemini's project management methodology developed to be scalable and flexible will support the Gemma projects. This framework and methodology is the backbone of an internal website, the Project Management Knowledge Base (PMKB), the repository for all Gemini programs and projects. The projects in the GEMMA program will follow the methodology built into the PMKB and be managed using the available tools and templates accessible through the website. Each project is assigned a support person who assists with setting up team sites, team drives and answers questions regarding the tools and templates.

3 Planning Assumptions & External Dependencies

Gemini and NOAO will be restructuring into the National Center for Optical/IR Astronomy (NCOA) starting in 2019. It is assumed that the four projects, structure and personnel will be retained during this transition. We assume also that a similar process for resource allocation and portfolio management will continue.

4 Lessons Incorporated

Gemini Project management methodology requires lesson learned documentation for both operations and development projects. The Lessons Learned have contributed to the implementation of a project management methodology. These lessons have been incorporated into the current PMKB methodology and are currently being used for the management of the GEMMA projects. An ongoing lessons learned log will be managed at the program level during the program lifecycle. Each project will also maintain a lessons log to use during the project lifecycle and specifically to ensure lessons during each project phase are incorporated into the next phase.

5 Monitoring & Control

The process of tracking, reviewing, and reporting the overall progress and the performance objectives of the program is the responsibility of the program manager. The program manager is responsible for monitoring the individual project's schedule, scope, resources, and risk. Projects are required to use a "Project Status Report" that highlights those four areas as well as update the team site to reflect the current status of their project. The program team site are part of the PMKB and open observatory wide to view progress on projects.

Further monitoring is done through various tools. Expenses against budget will be monitored by KCI Control a Gemini software budget projection software, and Casnet maintained by AURA's

Central Administrative Services for expenses and labor. Maintaining quality using decision trackers, issues register and other PMO tools will be implemented as needed and as projects mature. The program manager is also responsible for communicating project progress to stakeholders, escalation of scope, budget and schedule changes and issues to the directorate, and programmatic decision making. This will require regular monthly reviews of the overall budget and of individual project budgets. Regularly scheduled meetings with project managers will be held to ensure consistent communication on project activities, address potential competition for resources, other observatory priorities and their impact and review schedule, risk, budget and scope addressing issues before they have an impact on the projects and or program.

6 Budget & Schedule

WBS - Task	Start	End	Assigned	Status	% Complete
1.1.1 Project Management Structure	10/1/2018	12/31/18	Directorate, Program Manager	In Progress	80
1.1.2 Risk Management	11/9/2018	1/31/19	Program Manager Project Managers	In Progress	50
1.1.3 PEP & sub plans	11/9/2018	9/30/2019	Program Manager Project Managers	In Progress	75
1.1.4 Develop EVM system	2/1/2019	6/30/2019	Program Manager, Project Coordinator Project Managers	Not Started	
1.1.5 Define program and project benefits at baseline	1/14/2019	6/30/2019	Program Manager, Project Coordinator Project Managers Program & Project Sponsors Chief Scientist	Not Started	
1.1.6 Identify Science Metrics	1/14/2019	3/30/2019	Program Manager Project Scientist	Not Started	
1.1.7 Develop post project plan	7/1/2019	12/31/2019	TBD	Not Started	

Please refer to individual project execution plans for detailed budget and schedule.

6.1 Summary

GR2110000 MMA Mgmt Account							
	FY 2019	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**-Total Fiscal Years**

010 Salaries Wages - Regular	291,007	338,786	348,950	359,419	370,201	381,307	2,089,670
-TOTAL SALARY & WAGES	291,007	338,786	348,950	359,419	370,201	381,307	2,089,670
0FB Fringe Benefits	90,823	105,735	108,907	112,175	115,540	119,006	652,186
-TOTAL EE BENEFITS	90,823	105,735	108,907	112,175	115,540	119,006	652,186
-TOTAL WAGE & BENEFITS	381,830	444,522	457,857	471,593	485,741	500,313	2,741,856
500 Travel - Domestic - Operations	4,942	12,806	0	0	0	0	17,748
-TOTAL DOMESTIC TRAVEL	4,942	12,806	0	0	0	0	17,748
-TOTAL TRAVEL	**4,942**	**12,806**	**0**	**0**	**0**	**0**	**17,748**
-TOTAL EXPENSE	386,772	457,328	457,857	471,593	485,741	500,313	2,759,604
-GRAND TOTAL	**386,772**	**457,328**	**457,857**	**471,593**	**485,741**	**500,313**	**2,759,604**

6.2 Resource Plan

The program and each project have created a resource plan during project initiation (the current stage) with the understanding that resource needs and management will change throughout the PLC. The resource plan can be adjusted during the course of the year, as it may be affected by progress and by the progress achieved during the year. The staff resource plan informs the Resource Allocation System (RAS) which tracks staff time attributed to predetermined categories and projects. The RAS is reviewed monthly by the directorate. As observatory priorities change resource allocation will reflect those changes.

The program Resource Allocation Plan is in Appendix A

6.3 Acquisition Plan

The Program Manager will monitor the procurements for the individual projects providing input for developing sole source justifications, request for proposals, purchase orders and contracts that conform to the Uniform Guidance, and AURA and CAS procurement policies.

See individual project plans for acquisition strategy and plan.

6.4 Milestone/Product Plan

Program milestones are the cumulative milestone and product plans for the projects. Refer to the Project Plans Milestone tables in individual project execution plans. Other milestones related to programmatic reporting to the NSF include:

- Performance indicators and milestones set forth in a Project Execution Plan (PEP)
- Comprehensive written reports twice a year, in March and September.
- GNAO Conceptual Design within the first 12 months of the award period.
- Develop EVM system for program and project performance measurements
- Define program and project benefits at baseline
- Identify observatory benefits at project end
- Identify Science Metrics
- Develop post project plan

Program and Projects	Schedule
Program Management	Oct 2018 - Sept 2024
Gemini North Adaptive Optics Facility (GNAO	Oct 2018 - Sept 2024
Adaptive Optics Real Time Computer (RTC)	Oct 2018 - Sept 2024
Time Domain Astronomy	Nov 2018 - Nov 2021
PIO MTCS, MTMW, Media Training, MMA/TDA Planetarium	Jan 2019 - July 2021

7 Program Tolerances

Program Resource/Staff	Baseline value	Proposed Project Tolerance
Program management	1.0 FTE	-.2 FTE
Program Scientist	.075	-.025 FTE
Program Coordinator	1.0 FTE	-.2 FTE
Schedule	**Baseline value**	**Proposed Project Tolerance**
TBD		
Budget	**Baseline value**	**Proposed Project Tolerance**
TBD		
Scope	**Baseline value**	**Proposed Project Tolerance**
TBD		

Completed resource, schedule and budget tolerances are yet to be fully determined as they are based on the individual projects plans still being developed. Whenever the tolerance for one of these baseline values is exceeded (or expected to be exceeded), the Directorate will be alerted of the exception.

8 Applicable Reference Documents

None.

GEMMA

Gemini in the Era of Multi-Messenger Astronomy

Scope Management Plan

December 20, 2018

A-GPM-001

Issued By:	Cathy Blough
Sponsored By:	Jennifer Lotz
Approved By:	Jennifer Lotz

Table of Contents

1 Introduction

The purpose of this document is to provide an explanation of the goals and objectives of the GEMMA program, the scope and related boundary conditions of the program, and how they will be managed. The program will provide coordinated management of the projects funded through NSF Award AST-1839225.

2 Scope Statement

2.1 Program Purpose

The program and its constituent projects are an outgrowth of scientific planning efforts over the past 5 years and is motivated in part by rapidly expanding development of computational, robotic, communications, and adaptive optics capabilities. Our main deliverables include:

1. The initial Program Execution and Project Execution plans, and quarterly and annual reports to the governance bodies.
2. The Gemini North Adaptive Optics (GNAO) system;
3. Real Time Computer (RTC), includes replacing the existing RTC of GeMS with a new design, and providing the RTC for the new GNAO system;
4. Time-Domain Astronomy (TDA);
5. Multi-Messenger Astronomy educational and public outreach efforts;

The GEMMA program consists of the above 4 projects with separate execution plans covering all details of each project. The GEMMA program management approach has been organized to conform to MREFC guidance contained in the various NSF management and oversight documents while providing a structure that will efficiently deliver the required elements of GEMMA. The Program Manager for GEMMA has overall responsibility for oversight of the four projects. Each of the individual projects has a project manager who has overall responsibility for the oversight of their assigned project.

The GEMMA Program is responsible for integrating the work of the 4 projects and other sub-awardees, guiding and monitoring their progress and compliance with annual work plans and budgets, and assuring and issuing modifications as necessary for the implementation of the program. The GPO is responsible for overall compliance with award terms and conditions, collaboration between projects, formal reporting to the NSF, and representing the program with a single voice to the NSF and the scientific community.

The Program Manager for GEMMA, project managers and project scientists form the management team of the program and will generally make decisions by consensus with input from the community advisory structure; however, the Program Manager has the authority and

responsibility to make executive decisions in consultation with the Gemini Directorate when necessary.

2.2 Service Goals & Objectives

GNAO

1. The integration between GNAOI and GNAO is inside the scope of the NSF CSA award and GNAO project.
2. Successful first-light science demonstration and a significant science result press-release is inside the scope of the NSF CSA award and the GNAO project.

RTC

1. Gemini Common RTC platform.
2. Replacement GeMS RTC
3. GNAO RTC

TDA

1. Gemini TDA APIs: A new set of application programming interfaces (APIs) that comply with a set of standards that will be generally applicable across a wider network of follow-up facilities. These will allow observations to be requested, provide the required feedback, and allow automated data access.
2. Gemini Plugins for Target Observation Managers (TOMs): Provide software to help Gemini users work with these new APIs.
3. Scheduler: Provide an efficient, dynamic way to schedule large numbers (order 10-100) of transient observation requests per night.
4. Real Time Pipelines: Provide a mechanism to automatically reduce imaging and longslit spectroscopic data in real-time for rapid characterization of transient sources and more responsive decision-making during night operations.
5. Product Distribution Manager: Updates the Gemini Observatory Archive to be able to deliver reduced data to users.

PIO

1. MTCS: Identify needs and best practices for the effective communication of MMA/TDA with the public and students
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3. MMA/TDA Planetarium Program: Present the excitement of MMA and TDA to K-12 students in an engaging and understandable and accurate manner using video technologies available in portable planetaria
4. MMA/TDA Staff Media Training: Provide staff likely to interact with the media with skills to improve their communications with the media and more effectively tell the story of MMA and TDA to the public through the media
5. MMA/TDA Internships: Provide an environment where undergraduate-level interns can develop effective and tested educational materials for K-12 students

2.3 Scope Summary

WBS #	WBS Title	Deliverable	Responsible Organization
1.1	Program Management	Compliance & Project Integration, Project deliverables	Gemini
		Program Execution Plan	
1.2.1	Gemini North Adaptive Optics Facility (GNAO)	Successful first-light science demonstration and a significant science result is **inside** the scope of the NSF CSA award and the GNAO project	Gemini
		A conceptual design to the extent which allows relevant trade studies to keep an ASM as a future possible GNAO upgrade is **inside** the scope of the NSF CSA award and GNAO project.	Gemini
		Project Execution Plan	
1.3	Adaptive Optics Real Time Computer (RTC)	Real Time AO control for GNAO and GEMS	Gemini
		Project Execution Plan	
1.4	Time Domain Astronomy (TDA)	Gemini TDA APIs to support TDA astronomy that will allow observations to be requested, provide the required feedback, and allow automated data access Gemini Plugin for TOM Toolkit Automatic Scheduler for Gemini. Defines mechanisms and the specification of a merit function to optimize observing schedules.	Gemini
		Project Execution Plan	

1.5	Public Information & Outreach (PIO)	MMA-TDA Planetarium Program	Gemini
		Project Execution Plan	

2.4 Scope Boundary Conditions

The scope boundaries for the GEMMA program are delineated by the NSF Cooperative Support Agreement (CSA.) The program is not responsible for management and operations projects of the observatory although the interface between the M&O and the GEMMA program is within scope.

2.5 Scope Details

In Scope	*Out of Scope*
Coordination of multiple projects	Management of individual project
Alignment of projects to overall observatory program benefits	Delivery of individual project deliverables
Compliance with programmatic terms and conditions	Responsibility for quality of deliverables

3 Change Management

The Configuration and Change Management Plan (CCMP) is under development to formally establish the activities, responsibilities, processes and methods used to maintain the configuration of the GPO and to manage changes to the scope and design of the GPO (CCMP, incorporated by reference). The plan also outlines the approach to be followed to control the modification of the individual projects. The plan provides details as to how program documents shall be prepared, configuration management requirements for use, and the operation of the change control process employed by the Directorate.

The CCMP addresses which key documents are under configuration control, file formats, and applications will be used, naming and numbering conventions. The CMP establishes change control at the project level, system level, and program level, and defines which level will consider what type of change depending on its impact. The CMP defines membership of the change control levels and defines which changes must be forwarded to the NSF for approval.

GEMMA

Gemini in the Era of Multi-Messenger Astronomy

Program Risk Management Plan

December 20, 2018

A-GPM-001

Issued By:	Catherine Blough
Sponsored By:	Jennifer Lotz
Approved By:	Jennifer Lotz

Table of Contents

1 Introduction

Gemini follows a risk management process that manages project, program, division, and observatory risk. This document discusses program risk management only. For more detailed information on the complete risk management system at Gemini, see Gemini Risk Management in the Project Management Knowledge Base.

Programs are a collection of related projects that when managed together achieve higher benefits than would be achieved if they were managed separately. The lack of knowledge of and/or understanding of the overall project objectives, changes in scope, time, cost, and quality can impact the program. Awareness of new risks arising from already identified risks may not be communicated from project to project or to the program and will impact the program objectives. The lack of transparency and a communication gap within and outside the program and project teams can impact the projects with dependencies on each other, ie. GNAO and RTC, and impact the programmatic goals.

2 Process

In order for program risk management to be successful, the program manager must establish program metrics at the beginning of the program. Program metrics can be indicators such as scientific impact, community satisfaction, program delivery, and quality. Once metrics are in place, program risk management includes identifying, assessing, mitigating, monitoring, contingency planning, and closing program risks. The program manager maintains a risk management plan for the program and creates a risk register at the beginning of the program. The program manager will also facilitate risk reviews through a program risk management advisory group, if needed. Once the program risk management plan and risk register are created, any project presented for inclusion into the program should be evaluated against the program metrics.

2.1 Identifying Risks

Program risk identification occurs in several ways. The program manager will review the program's projects' risk registers and consider any of the medium or high project risks for inclusion in the program risk register. The program manager will monitor the overall program's projects' performance to detect any areas of potential risk not originally identified. The program manager will also maintain status on the program metrics performance set at the beginning of the program. Finally, risk identification can also come from other program managers.

A program manager may also choose to create a program risk advisory board made up of project managers in the program and key functional leaders. The program risk advisory board would be responsible for identifying program risks, reviewing program risks in the risk register, reviewing mitigation plans and making adjustments as necessary, and activating contingency plans. Program risk advisory boards should meet at an appropriate interval based on the length of the program.

2.2 Assessing Risks

Once the risks are identified, the program manager, with help from the program risk advisory board if applicable, will score the risks in the program risk register on a scale of 1-5 in two areas, impact and likelihood. The impact score reflects the impact to the category of the risks based on program metrics. For example, recommended instrument metrics are research knowledge base (i.e. number of publications), program delivery, community satisfaction, public outreach, and quality. Likelihood reflects the probability that the risk will be realized. The program will follow the scales shown below for rating impact and likelihood of risks. The program manager is responsible for setting or changing any tolerances with respect to impact based on the risk tolerances of the stakeholders. All risks are categorized in the risk register as shown.

2.2.1 Impact

4-5 (High)
Research knowledge base < nn publications
Program delivery (schedule slip) > 10%
Public outreach < nn events
Project Risk
Community satisfaction unlikely
Quality guidelines will not be met

3 (Moderate)
Research knowledge base < nn publications
Program delivery (schedule slip) > 5%
Public outreach < nn events
Project Risk
Community satisfaction questionable
Some quality guidelines will not be met

1-2 (Low)
Research knowledge base < nn publications
Program delivery (schedule slip) > 10%
Public outreach < nn events
Project Risk
Community satisfaction likely with some negotiating
Most quality guidelines will be met

2.2.2 Likelihood

4-5 (High)
Realization of this risk is inevitable. Risk mitigation is weak; there is minimal to no effective contingency plan.

3-4 (Moderate)
Realization of the risk is likely. Risk mitigation does not cover all areas of the risk; contingency plan is inadequate.

1-2 (Low)

Realization of the risk is unlikely but still possible. Mitigation plan is strong, contingency plan is effective.

For ongoing program risk assessment, the program manager will periodically review the risks and make necessary changes to the risk register, as needed.

2.3 Mitigation Plans

When the program manager creates the risk register, he or she will create action plans with help from the program risk advisory board, if applicable, and the program's project managers. Periodically, the program manager will review the risk register to ensure the mitigation plans are correct and being applied at the appropriate program level. If a mitigation plan is not working as expected, the program manager will raise the concern to the appropriate project manager and adjust the mitigation plan accordingly.

2.4 Contingency Plans

Once a risk is identified, the program manager needs to create contingency plans and enter them in the risk register. Contingency plans should be created as soon as the risk is identified not when the risk is realized.

If a risk is realized, the program manager will ensure that the appropriate contingency plan is activated. The exact steps to follow will depend on the documented contingency plan.

2.5 Internal Risk Controls

The risk register includes a column for internal risk controls. These controls are organizational processes or procedures that are part of the organizational operations or culture and not program specific. If any internal risk controls exist, the program manager will add the description to the risk register and rank its effectiveness. Effectiveness is rated on a scale of one to five with one being most effective and five having minimal effect.

2.6 Monitoring Risks

The program manager will regularly review the risks for his or her program with the program's project managers and with the program risk advisory board, if applicable. The reviews will include review of mitigation and contingency plans and adjustments to the risk register when necessary. The program manager will report the status of the medium and high risks on the periodic program status report to the division leaders.

2.7 Closing Risks

Once a risk is mitigated, it will remain in the risk register but moved to the closed status. Once the program has ended, the program team will review the risk register at a program closure

review as part of lessons learned. The program manager will ensure all risks are closed and archive the risk register.

GEMMA Program Risk Register A-GPM-001

Part I. Risk Identification						Part II. Risk Analysis for Existing Controls			Part III. Risk Response							
Name	**Program Risk Category**	**Risk Description (ignoring controls)**	**Impact 1-5 (ignoring controls)**	**Likelihood 1-5 (ignoring controls)**	**Total Risk Score** Low = 1 - 8 Med = 9 - 16 High = 17 - 25	**What Controls (if any) are currently in place?**	**Control Effectiveness 1-5**	**Residual Risk Score** Low = 1 - 8 Med = 9 - 16 High = 17 - 25	**Control or Risk Mitigation Strategy**	**Control effectiveness based on mitigation strategy 1-5**	**Residual Mitigated Risk** Low = 1 - 8 Med = 9 - 16 High = 17 - 25	**Contingency Plan**	**Cost of contingency plan**	**Owner**	**Review Due Date**	**Status**
Program Costs	Cost	If the funding does not cover the costs then current program scope will need to change	3	3	9	None	2	2	Rebudgeting eliminating activites and or capabilities			Shift under utilized resources from other projects		PM	12/31/18	Open
Program/Project Resources	Schedule	Unable or delay in hiring specialized resources required when needed because there is a shortage of qualified people, the program delivery could be negatively affected	3	4	12	None	5	12	Increase M&O staff time on Gemma	3	6	1) Work with PM to reorder team member's tasks to maintain critical path, 2) reduce		PM	12/31/18	Open
Program/Project Resources	Schedule	If existing resources are not assigned to the project because of competing priorities then program delivery could be negatively impacted	4	2	8	The Resource Allocation Process	2		Watch project portfolio for any at risk projects that could cause the risk and recommend coaching for project teams.	3		Escalate to Directorate		PM		Open
Program/Project Resources	Scope	If costs of staff from CSA1 exceed available funding in CSA2 projects may need to down scope delivering less than promised	4	2	8	None	5	8	Reduce and shift other line items between projects	4	6	1) Work with PM to reorder team member's tasks to maintain critical path, 2) reduce scope to meet project due date		PM		Open
Procurements	Schedule	If procurements cannot be completed in a timely manner because insufficient aquisition planning, business services staff shortages or NSF delayed approvals then the program delivery could be negatively affected	4	4	16	None	5	16	Work with Cas on ways to streamline process beneficial to both parties	2	4	Escalate to AURA corporate; Contract with a temp agency	$13k per mth.	PM	12/31/2018	Open
Communications	Benefits	If Gemini and AURA, the STAC, the Governance Board, and the user community are not aligned because of miscommunication then the long term goals may not be met.	4	2	8	Governance reports and meetings, User committee	2	2	Create a communications advisory board	4	6	Hire marketing firm	$50 per hour	PM	5/30/19	Open

GEMMA

Gemini in the Era of Multi-Messenger Astronomy

Program
External Communication Plan

December 20, 2018

A-GPM-001

Issued By:	Andrea Blank
Sponsored By:	Jennifer Lotz
Approved By:	Catherine Blough

Introduction

This document describes how the status of the GEMMA program will be communicated to external organizations. In addition to high level objectives, this plan includes types of communication, method of communication, frequency of communication, who owns distribution, and who will receive what communication.

Objectives

Communicate the program and project information ensuring the program and related projects engage stakeholders and the Gemini community to maintain open communication between the observatory and the community.

Communication Matrix

Written Communication						
Communication Type	**Description**	**Frequency**	**Format**	**Participants/ Distribution**	**Deliverable**	**Owner**
Newsletters	Program News/Events	As Appropriate	GeminiFocus/e-newscast	Existing Distribution Channels	Milestones	Program Manager
Social Media announcements	Program News/Events	As Appropriate	FaceBook, Twitter, Instagram	SM networks	Milestones	Program Manager
Website	Program news/ Events	As Appropriate	GEMMA project page on Gemini website	GEMMA team	Milestones	Program Manager
STAC / Board Reports	Program status updates	Every 6 months	Standard Format	Gemini STAC, Board, Directors	Status Report	Program Manager
NSF Reports	Program status updates	Every 6 months	Mandated Format	Program Sponsor, Project Managers, and others as needed	Status Report	Program Manager
Real-time Communication						
Communication Type	**Description**	**Frequency**	**Format**	**Participants/ Distribution**	**Deliverable**	**Owner**
STAC / Board Meetings	Program status updates	Every 6 months	Presentation	Program Sponsor, Project Managers, Directorate	Presentation	Program Manager
Other Communication Methods						
Communication Type	**Description**	**Frequency**	**Format**	**Participants/ Distribution**	**Deliverable**	**Owner**
AAS, CASCA,	National &	3 per year	Conference	Program	Status	Program

and other related science conferences/meetings	International Astronomy Meetings			Sponsor, Directorate	Update/Town Hall	Scientist

GEMMA

Gemini in the Era of Multi-Messenger Astronomy

Program
Internal Communication Plan

December 20, 2018

A-GPM-001

Introduction

This document describes how the status of the GEMMA program will be communicated across the Observatory. In addition to high level objectives, this plan includes types of communication, method of communication, frequency of communication, who owns distribution, and who will receive what communication.

Objectives

Communicate information, to the team and stakeholders enabling the program team to make correct decisions, in a timely manner, to benefit of the program.

Communication Matrix

Written Communication						
Communication Type	**Description**	**Frequency**	**Format**	**Participants/ Distribution**	**Deliverable**	**Owner**
Status Report	Summary of program status	Every other week	Email, stored in Google team drive folder and on PMKB Team Site	Program Sponsor, Project Managers / accessible to all staff via PMKB and email exploder subscription	Status Report	Program Manager
Change Request	Submission, acceptance or rejection of changes in scope	As Appropriate	Change Request Form	Change Request Board - Primarily Project Sponsor	Form	Program Manager
Risk log	Identified Open Risks	Ongoing	Standard Format	Program Sponsor, Project Managers, and others as needed	Log	Program Manager
Issues log	Identified Open Issues	Ongoing	Standard Format	Program Sponsor, Project Managers, and others as needed	Log	Project Coordinator
Decision Tracker	Identification and tracking mechanism for decisions	Ongoing	Standard Format	Program Sponsor, Project Managers, and others as needed	Log and other documentation as needed	Program Manager
Program	Program	Ongoing	Website	Available to	Gemini Internal	Project

Dashboard	dashboard located on the Project Management Knowledge Base			Gemini-all	Webpage	Coordinator
Action Items	Internal team tasks to complete the work detailed in the project schedule	Ongoing	JIRA Atlassian	Internal Team	List of Action Items	Project Team

Real-time Communication

Communication Type	Description	Frequency	Format	Participants/ Distribution	Deliverable	Owner
Directorate Meeting	Meeting to review program's status, schedule, risks, issues.	Weekly	In Person/ Zoom	Directorate	Minutes	Program Manager
Program Team Meeting	Meeting to review program's status, schedule, risks, issues, and action items	Weekly	In Person/ Zoom	Program Team	Updated Teamsite	Program Manager
Sponsor Meeting	Sponsor meeting	Every other week	In Person/ Zoom	Program Manager and Sponsor	Meeting Notes	Program Manager
Project Advisory Board Escalations	Updates during PAB meetings	When meetings are called	In Person/ Zoom	Program Team and PAB	Minutes	Program Manager
Quarterly Review	Quarterly review meeting	Every 3 months	In Person/ Zoom	Program Team, Project Managers, and Project Sponsors	Review documents	Project Manager

Other Communication Methods

Communication Type	Description	Frequency	Format	Participants/ Distribution	Deliverable	Owner
Gemini staff updates	Progress / Delivery / Program News	Monthly All-Hands meetings,, lunch and learns, Ops/Dev Tea, etc.	Presentation, discussion	Gemini-all	Information	Program Manager
Gemini Dev Blog	Program news	As Appropriate	Post	Gemini-all	Blog post	Program Manager or Sponsor

GEMMA Program Resource Allocation A-GPM-001									
Resource	**Role**	**Location**	**Duration**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**
Progam									
Cathy Blough	Program Manager	Tuscon	72 months	0	1	1	1	1	1
Marcel Tognetti	Program Support	Hilo	72 months	0.2	0.2	0.2	0.2	0.2	0.2
John Blakeslee	Program Scientist	Chile	72 months	0.1	0.1	0.1	0.1	0.1	0.1
GNAO									
Stephen Goodsell	Project Manager	Hilo	72 months	0.6	0.6	0.6	0.6	0.6	0.6
Natalie Provost	Systems Engineer	Chile	72 months	0.4	0.4	0.4	0.5	0.5	0.5
Gaetano Sivo	Principal Investigator	Chile	72 months	0.5	0.5	0.5	0.5	0.5	0.5
Paul Hirst	Project Scientist	Hilo	72 months	0.3	0.3	0.3	0.3	0.3	0.3
Andrea Blank	Project Coordinator	Chile							
RTC									
David Henderson	Project Manager	Hilo	72 months	0.3	0.3	0.3	0.3	0.3	0.3
Natalie Provost	Systems Engineer	Chile	72 months	0.3	0.3	0.3	0.5	0.5	0.5
Paul Hirst	Project Scientist	Hilo	72 months	0.2	0.2	0.2	0.2	0.2	0.2
TDA									
Arturo Nunez	Project Manager	Chile	36 months	0.5	0.5	0.5			
Natalie Provost	Systems Engineer	Chile	36 months	0.3	0.3	0.3			
Bryan Miller	System Scientists	Chile	36 months	0.5	0.5	0.5			
Andrea Blank	Project Coordinator	Chile							
PIO									
Peter Michaud	Project Manager	Hilo	33 months	0.8	0.8	0.6			

GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

Gemini in the Era of Multi-Messenger Astronomy: High Image Quality and Rapid Response

Cost Estimating Plan

Table of Contents

Summary

This Cost Estimating Plan defines the guidelines and methodology used to prepare the cost estimate for Gemini Operations and Instrumentation Development. This document is applicable to NSF funded operations subject to the Office of Management and Budget's (OMB) Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards.

Referenced Documents

Proposal for the Management and Operations of the Gemini Observatory – Submitted to the NSF on February 27, 2015.

Acronyms and Definitions of Terms

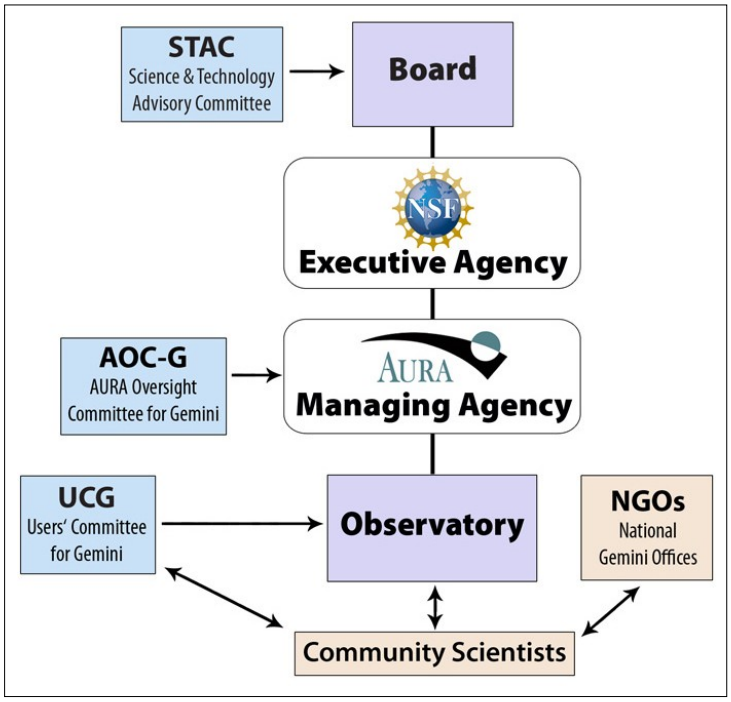
AURA – Association of Universities for Research in Astronomy
BOE – Basis of Estimate
AOCG – AURA Oversight Council for Gemini
BY – Base Year
CAS – Central Administrative Services
CEP – Cost Estimating Plan
CLP – Chilean Peso
CP - Complexity Factor
GBOD - Gemini Board of Directors
IDF - Instrument Development Fund
IP - International Participants
Control - KCI Control
F&A – Facilities and Administrative
FTE – Full Time Equivalent
FY – Fiscal Year
HR – Human Resources
NSF – National Science Foundation
PMKB - Project Management Knowledge Base
STAC – Science and Technology Advisory Committee
TY – Then Year
USD – US Dollars
WBS – Work Breakdown Structure

Objective

This Cost Estimating Plan (CEP) defines the guidelines and methodology used to prepare the cost estimates and budget for instrument development at Gemini Observatory. The CEP primary objective is to document the processes for estimating those costs including descriptions of high−level methods and the approach to bases of estimate (BOE), a description of the model for non-labor resources necessary to support the NSF− funded project. AURA requests a 2019-2024 budget of $ 25,948,088.

Overview

Current Gemini Governance, showing the relationships among the Gemini Board and its STAC Advisory Committee, the Executive Agency NSF, the Managing Organization AURA, the Gemini and groups with community interactions such as the AOC-G and the Users' Committee.



The funds supporting Gemini are requested from the National Science Foundation (NSF) and flow to the managing organization, AURA. Funds contributed by the International Participants (IP) flow to NSF to be distributed to AURA through Cooperative Support Agreement,

Program Planning Process

The Directorate plans staffing and establishes the Operations and Maintenance budget with a three-year outlook. The projected contributions to the Instrument Development Fund (IDF) set the boundaries for the development plan for instrument procurement and upgrades. Gemini updates the development plan regularly because the International Participants provide IDF funds on a best-effort basis in the period 2017-2022.

AURA/Gemini's structured framework for planning can accommodate short-term changes. The Observatory collects suggestions from users continuously and discusses those suggestions twice a year at Operations Working Group meetings attended by the heads of the science operations departments and the heads of the National Gemini Offices.

Each year, after updating the long-range planning, the Directorate develops a program plan for the next calendar year (Table 4). The Directorate takes into consideration suggestions voiced by the Gemini Users' Committee at its annual meeting.

The AOCG reviews the management aspects of the annual program plan. The STAC reviews the annual plan's operations and development projects. At year's end, the management team, including both Gemini and AURA leadership, submits to NSF the annual program plan for the upcoming year, together with the annual report for the past year. Internally, the Observatory Directorate partitions the annual program plan into individual projects and communicates them to the entire staff by releasing a Top Observatory Goals for 201X document.

Methods and Tools

Software

Tools used to collect detailed cost estimates, documentation, calculate then-year costs and overheads include Microsoft Excel, KCI Control - Budgeting and Reporting Software. KCI Control contains historical expense and budgeting data used for estimation, as well as customizable reporting functionality for creation of detailed and summary reports.

Project management tools and processes are built into the Project Management Knowledge Base. Projects are initiated with a project request and justification, reviewed and approved by the Directorate. Approved projects are then categorized for size (small, medium, and large) and governance level. The categorization determines the amount and type of management oversight, detailed analysis and documentation required for the project.

Project Cost Planning

Once the Directorate approves the initial project request the project manager creates the project mandate and begins the planning process developing a WBS, schedule and cost estimate. The basis of estimate is a detailed WBS estimate of labor and non-labor resources based on current fiscal year dollars. The project budget base year is escalated 3% for each year of planned spending.

Cost of labor estimates are derived from the operations plan staffing profiles which detail the type of labor needed and the number of full time equivalents (FTEs) per year. Non-labor costs are identified for each WBS by subject matter experts who are responsible for providing the their Basis of Estimate (BOE) using prior instrumentation contract costs, vendor quotes, etc.

The Budget is reviewed by the project sponsor and the Associate Director for Development.
The Gemini finance team reviews the budget and calculates labor & fringe benefit costs based on FTE, allowability on non-labor costs as well as MTDC and the indirect costs.

During the project lifecycle, project information, detailed and summary reports for all cost estimates and any other supporting documentation, are collected and maintained in the project team drive and permanently stored in the Xerox DocuShare (DMT) enterprise content management application providing document storage.

Project Cost Management

Each project is assigned an account code beginning with a two letter prefix followed by 7 numbers. Labor is charged directly to the project account code and tracked on a web-based timesheet system. Each non-labor resource is assigned an identifying code from a standardized list of resources. If there are subcontractors, the same account code is used with an expense code identifying the expense as a contracted service. Spending is tracked in Control and in Casnet, the web-based financial reporting

system used by AURA Central Administrative Services. Indirect rates are applied to expenses monthly and are reflected in Casnet reports.

Labor Costs

The salary compensation methodology used in this proposal follows the principles and guidelines provided in the AURA Compensation policy. Salaries are based on a 2080-hour work-year.

Gemini salaries and wages are estimated based on the current AURA / Gemini staff salary scales. AURA's Human Resources Services assigns a job and salary grade to each staff position at each geographical location where the Gemini Observatory operates. Each position is then benchmarked against the median or mid-point of the various surveys for comparison purposes. Actual compensation is determined based on individual skill sets, internal equity, and prevailing supply and demand conditions.

The salary and wage (S&W) rate are estimated based on wages for similar positions at Gemini Observatory. An applied fringe rate of 56.2% which includes health and welfare benefits and paid leave time was calculated on 83% of estimated salary/wage (work hours).

Salary increases of US paid employees occur in the month of May of each year in accordance with the Compensation Guidelines AURA-HR publishes at the beginning of each calendar year.

2019 -2024 salaries are the result of escalating the prior year salary base by the cumulative inflation of the prior year. For instance, 2019 salaries are the result of escalating 2018 salaries by 3% estimated inflation for US and Chile.

Non Labor Costs

Non-labor costs were identified for each WBS by subject matter experts who were responsible for providing the FY19 dollar amount estimated for each of the 5 years in the project plan and their BOE. The BOEs, and associated costs, were derived based on experience from Gemini operations and instrumentation projects, Gemini documents, experience from other operating facilities, and quotes from vendors.

FTEs within each WBS element, associated non-labor costs to be estimated include sub-contracted services, equipment, materials and supplies, and travel. A project-wide top-down approach was adopted based on the number of FTEs and the type of labor resource – manager, engineer, scientist, systems engineer, and support staff, and is described below.

Travel

Travel costs estimates for number of trips and the length of each trip were estimated by project based on fy18 travel budgets and on historical records for the large instrumentation projects.

Manufacturing of project components may be highly geographically distributed, with key facilities in the US, Chile, Canada and Europe. Effective management of, and efficient communication across, these distributed sites of operations will require significant travel by the Las Serena and Hilo-based project teams.

Contracts

Manufacturing of project components may be obtained through a procurement process resulting in a contract. BOE for contracted services is based on historical data and experience from past and current instrumentation projects.

Other Direct costs

Supplies & materials and freight costs are based on estimated requirements for each project by a subject matter expert in the referenced project.

Economic Assumptions

Inflation is estimated at 3% per year based on historical data and applied to each estimated direct cost and is computed annually. Both labor and non-labor resources are escalated at 3%.

Complexity Factor Analysis

For large projects, Gemini, utilizes an analysis of project complexity factors to help determine the appropriate budget allowance. Table 1 introduces the 11 individual complexity factors currently used to evaluate new instrument projects. With slight variations, the list is appropriate for each set of projects proposed. Specific factors generated are based on past experience with Gemini instruments, most notably GPI, GHOST, and Gen 4#3.

Factor	Title
C1	Basis of Estimate
C2	Technical Complexity
C3	Schedule Complexity
C4	Past Performance
C5	Team Experience
C6	Project Structure Complexity
C7	Management Control Systems
C8	Underestimation Bias
C9	Gemini Strategic Environment
C10	Interface and Requirement Complexity
C11	Gemini Staff Complexity

Table 1 *List of currently used Complexity Factors*

Table 2 below, provides the complexity factors from Table 1 along with a brief description of the considerations included in determining each factor's value

Complexity Factor	Considerations
Basis of Estimate	Is the detail and quality of the project's budget and basis of estimate in proportion to its complexity?
Technical Complexity	Are key project technologies at the needed technical readiness level? Are there alternate technologies and/or alternate vendors available? How complex is the overall instrument design? How thoroughly did the Contractor consider technical complexity in their costs?
Schedule Complexity	Are there numerous dependencies between subsystems or institutes? Is there sufficient funded and unfunded schedule contingency? Are there long-lead items on the critical path? Is schedule constrained by competitive (ex. Sphere for GPI) or complementary (ex. LSST for Gen 4#3) projects?
Past Performance	Has the team historically delivered on time, to budget, and to scope?
Team Experience	Is the team new? How much experience do they have working together? Have they built this kind of instrument? Do they have strong science and PI support?

Project Structure Complexity	Is there wide geographic breadth in the project or complex or inadequate organizational structures? How many institutes contract directly with AURA? Are the communication plan and reporting paths sufficient? Will there be appropriate line-of-sight for management to view project details?
Management Control Systems	Does the team have appropriate project control systems, including cost and effort reporting in place? Are changes required in organizational systems to deliver required information to Gemini?
Underestimation Bias	Is the team more/less motivated than average to submit optimistic cost/schedule estimates? Is competition fierce? Are budgets tightly constrained by the cost cap?
Gemini Strategic Environment	Is there strong support for this project and its budget within Gemini and its stakeholders?
ICD and Requirement Complexity	Are Gemini Interface Control Documents (ICDs), requirements, supporting infrastructure, and Statement of Work ready and unlikely to need changes? Have new interfaces been developed for this project?
Gemini Staff Complexity	Are Gemini project staff new staff to this kind of project? Is there expected staff turnaround, a new contract structure, limited staff availability, or a large amount of training and knowledge transfer needed to operate and maintain the instrument?

Table 2 *Complexity factors and considerations*

Each complexity factor has a corresponding assessed severity, weight, and budget adjustment. The severity is either -1, 0, or 1 based on whether or not the risk associated from that factor is below average, average, or above average. The weight is the percentage of budget affected by each factor. The final budget impact of each complexity factor, then, is its assessed value times its weight. Because we base each complexity factor's severity on its relative importance in each particular case compared to a historically average instrument, the final budget adjustment is determined by a base amount plus the sum of each complexity factor's budget impact.

Fifteen percent of the total project's cost is used as a baseline adjustment for the average project. For a relatively non-complex project, the total budget adjustment will be less than this amount; for a more complex project than average, more. Although the formalism allows for a negative total budget adjustment, we do not expect to see such results in practice and certainly would not reduce the budget below the contractor amount.

The tables below show the complete complexity factor analysis table for the major WBS elements of this work.

Table 3 *The GNAO complexity factors analysis, WBS element 1.2*

Complexity Factor	Factor Severity			Factor Weight	Budget Scaling Factor
	Below Average	Average	Above Average		
Basis of Estimate			**x**	3%	3%
Technical Complexity			**x**	3%	3%
Schedule Complexity			**x**	3%	3%
Past Performance		**x**		3%	0%
Team Experience	**x**			2%	-2%
Project Structure Complexity		**x**		2%	0%
Management Control Systems		**x**		2%	0%
Underestimation Bias	**x**			2%	-2%

Gemini Strategic Environment	**x**			2%	-2%
ICD and Requirement Complexity			**x**	2%	2%
Gemini Staff Complexity			**x**	2%	2%
Combined Scaling Factor					**7%**
+ Baseline Scaling factor					15%
=Total Budget Scaling Factor					**22%**

Table 4 *The RTC complexity factors analysis, WBS element 1.3*

Complexity Factor	Factor Severity			Factor Weight	Budget Scaling Factor
	Below Average	Average	Above Average		
Basis of Estimate			**x**	3%	3%
Technical Complexity		**x**		3%	0%
Schedule Complexity			**x**	3%	3%
Past Performance	**x**			3%	-3%
Team Experience	**x**			2%	-2%
Project Structure Complexity		**x**		2%	0%
Management Control Systems		**x**		2%	0%
Underestimation Bias		**x**		2%	0%
Gemini Strategic Environment		**x**		2%	0%
ICD and Requirement Complexity			**x**	2%	2%
Gemini Staff Complexity			**x**	2%	2%
Combined Scaling Factor					**5%**
+ Baseline Scaling factor					15%
=Total Budget Scaling Factor					**20%**

Table 5 *The "Optimizing operations for multimessenger science" work package complexity factor analysis, WBS element 1.4*

Complexity Factor	Factor Severity			Factor Weight	Budget Scaling Factor
	Below Average	Average	Above Average		
Basis of Estimate			**x**	3%	3%
Technical Complexity			**x**	3%	3%
Schedule Complexity			**x**	3%	3%
Past Performance		**x**		3%	0%
Team Experience	**x**			2%	-2%

Project Structure Complexity			x	2%	2%
Management Control Systems		x		2%	0%
Underestimation Bias		x		2%	0%
Gemini Strategic Environment	x			2%	-2%
ICD and Requirement Complexity			x	2%	2%
Gemini Staff Complexity			x	2%	0%
Combined Scaling Factor					**9%**
+ Baseline Scaling factor					15%
=Total Budget Scaling Factor					**24%**

Indirect Costs

AURA provides administrative and human resource services to it is NSF-funded Centers: NOAO, NSO, LSST, and Gemini. The Central Administrative Services group (CAS) provides accounting, procurement, and business IT services. The Human Resources department provides benefits, recruitment, performance evaluation, and senior management strategic planning support.

All AURA F&A, CAS and HR cost allocation rates are approved annually by the NSF. Rates for FY19 have been submitted and are pending approval.

Total CAS and HR costs are allocated based on Center spending activity. AURA uses a Modified Total Direct Cost (MTDC) methodology, where all direct costs, but only the first $25,000 paid on each sub contract payment per fiscal year, are included in the spending base for the purpose of allocating CAS/HR costs. For FY19, the CAS/HR combined indirect rate is 6.03%.

AURA Corporate Facilities and Administrative (F&A) group also provides senior management support and audit, legal, insurance, and consultant services to each of its Centers. The base used to calculate this indirect charge is the MTDC cost used for the CAS/HR base, as described above. The FY19 AURA F&A submitted rate is 4.32%.