



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

## **Cost Estimating Plan**

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## **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

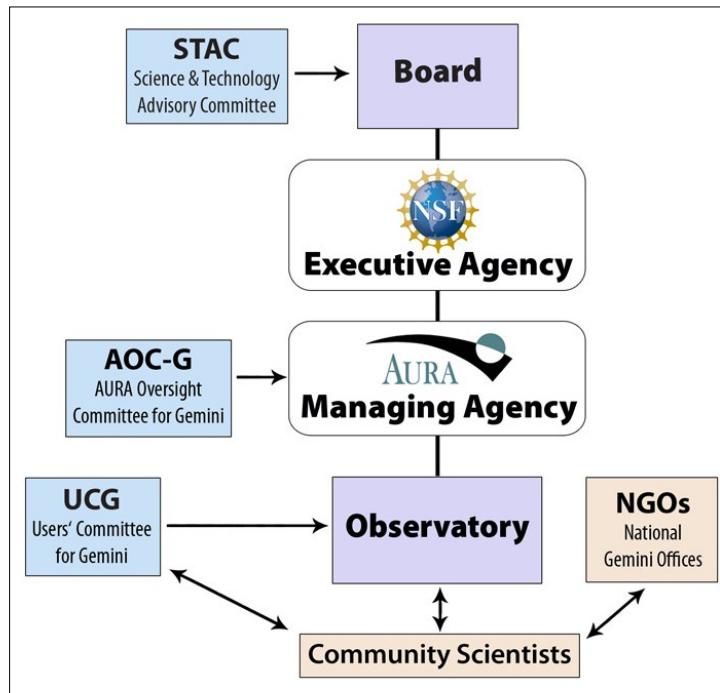
WBS – Work Breakdown Structure

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

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
<b>Basis of Estimate</b>	Is the detail and quality of the project's budget and basis of estimate in proportion to its complexity?
<b>Technical Complexity</b>	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?
<b>Schedule Complexity</b>	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?
<b>Past Performance</b>	Has the team historically delivered on time, to budget, and to scope?
<b>Team Experience</b>	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?

<b>Project Structure Complexity</b>	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?
<b>Management Control Systems</b>	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?
<b>Underestimation Bias</b>	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?
<b>Gemini Strategic Environment</b>	Is there strong support for this project and its budget within Gemini and its stakeholders?
<b>ICD and Requirement Complexity</b>	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?
<b>Gemini Staff Complexity</b>	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		
<b>Basis of Estimate</b>			x	3%	3%
<b>Technical Complexity</b>			x	3%	3%
<b>Schedule Complexity</b>			x	3%	3%
<b>Past Performance</b>		x		3%	0%
<b>Team Experience</b>	x			2%	-2%
<b>Project Structure Complexity</b>		x		2%	0%
<b>Management Control Systems</b>		x		2%	0%
<b>Underestimation Bias</b>	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%

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

## Indirect Costs

AURA provides administrative and human resource services to its 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%.