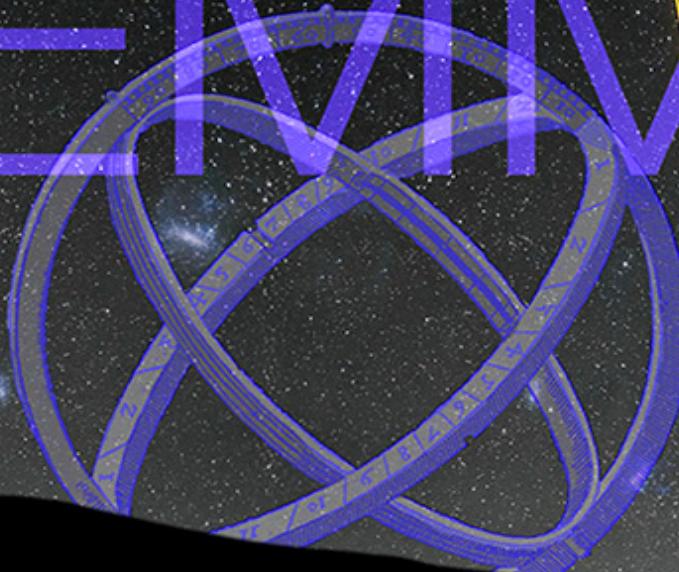


GEMINI



Gemini in the Era of Multi-Messenger Astronomy

Gemini North Adaptive Optics

Annual Report FY2019

Cooperative Support Agreement 1839225
Submitted September 30, 2019



Summary

This report references the May 24th version of the GNAO Project Execution Plan. It provides updates on the work packages as defined in the PEP: Project Management, Science, Systems Engineering, Adaptive Optics and the GNAO Facility including the progress made on the Adaptive Optics Bench (AOB), Laser Guide Star Facility (LGSF) and the Real-time Computer (RTC).

Until early May, 2019, the GEMMA Program contained 2 separate projects, namely the Gemini North Adaptive Optics (GNAO) project and the Real-Time Computer (RTC) project (plus 2 other projects, TDA and PIO). Due to considerable synergies between the GNAO and RTC projects and to improve management and execution efficiencies, the two were merged into one project, GNAO. The RTC is a subsystem of GNAO and, therefore, has the same upper level requirements as GNAO.

The observatory made GNAO the priority project across the observatory and identified and added the staff needed to manage and perform the GNAO activities. During the past year the project has moved from the initiation and planning stage of project development to the execution of the conceptual design stage. A Project Execution Plan (PEP) was written within the first 90 days of the award laying out the project stages and phases, work breakdown structure, resources and associated costs. During the second quarter of 2019, the project team was solidified under the direction of Stephen Goodsell who began the first stage tasks focusing on progress towards the conceptual design review to be held by the end of FY19. During the writing of the Project Execution Plan, a Science Working Group was formed to provide both internal and external expertise for key science areas and advise and explore which parameters are critical to the development of science cases and requirements.

An Adaptive Optics Working Group was also established to review and comment with the GNAO technical team on the development of the CoD study.

In early May, the NSF asked the GEMMA program to submit revised budgets and PEPs for the 3 projects. The revised GNAO PEP described how the combined GNAO and RTC projects will deliver the new GNAO facility, including a modular RTC subsystem that will also be suitable to serve as the RTC foundation for other instruments. Taking advantage of that suitability, the project will also deliver a new RTC implementation for GeMS.

In Q4, Dave Palmer, Project Manager since April, resigned and has been replaced by Manuel Lazo and Celia Blain as Deputy PM. Some changes were made during the transition with team members and assignments in order to complete the documentation required for the conceptual design review.

Major Goals

The major activity for this phase is developing the conceptual design of the facility and its components based on the science cases and the concept of operations supplied by the science and the AO working groups.

Major Activities Accomplished Under these Goals

Project Management

Cost Management

Current overall budget, actual expenditures and open commitments as of August 31, 2019 are shown below in Table 1. Payroll for September will increase the total expenditures for FY19. The negative percentage remaining is caused by open commitments for services that span multiple fiscal years. Carry forward of unspent funds will likely be minimal and will be finalized when FY19 is closed by CAS accounting.

Table 1. FY 19 Budget and Expenditures

GNAO					
	Approved Budget	Total Expense FYTD	Current Open Commits	-Spend Remaining	-% Remaining
TOTAL WAGE & BENEFITS	665,355	578,174	0	87,181	13.10%
TOTAL TRAVEL	28,032	24,551	33,271	(29,790)	-106.27%
TOTAL OTHER DIRECT COSTS	34,272	75,634	399,875	(441,237)	-1287.46%
TOTAL EXPENSE	727,659	678,359	433,146	(383,846)	-52.75%
GRAND TOTAL	727,659	678,359	433,146	(383,846)	-52.75%

Open Commitments –

Professional services - Mersenne Optical Consulting Limited - Flat Wave Front Sensors

Contracted services - TEKSYSTEMS - R. Rambold, RTC, POP to 9/30/2023

Resource Management

Staffing plans based on the work breakdown structure for the project were created in May and submitted with revised PEPs in Q3. Due to continued under spending, NSF requested a revised budget and WBS submitted in August. The revised WBS is the current baseline in the GEMMA RAS. The project managers receive monthly reports from the Portfolio Management Office allowing them to compare the planned resources in the WBS to actual resources used. The WBS will be refined after the CoDR to reflect comments from the review panel as well as a better understanding of required activities leading to the preliminary design review planned for Q3 2020.

Milestones and Schedule

Table 2 Milestones

GNAO+RTC	Finish Date	
Submit documentation for CoDR	9/5/19	Completed
CoDR* - 1 week delay due to schedule conflicts	9/18/19	9/26/19
CoDR concludes	9/30/19	Completed
Preliminary Design Phase Commences	10/23/19	

Risk Management

The Risk Management Plan is under revision based on overall input from systems engineering. Implementation of the plan is currently via google sheets. In Q1 2020, the manual use of spreadsheets for risk tracking will be discontinued in order to track risk and issues in Jira.

Jira is the software currently used by Gemini to manage Telescope Fault Reporting, ITS helpdesk, and Software Issue tracking. For the GEMMA program, Jira will be used to support project management and will organize, track and monitor risks and issues as well as providing document configuration management and change control.

The main Jira advantages:

- visibility and traceability of all information associated with an issue (risk/issue/change)
- easy to sort and display information about issues i.e. searches/tables/reports
- easy to customize/tailor to suit the project's needs
- Gemini has established experience with this tool

The highest risk to the GEMMA projects continues to be availability of resources. However, implementing the WBS baseline resource requests and the boundary conditions process described above will provide more consistent resources to the projects. Each project maintains their risk registers. Only two risks have been escalated to the GEC in FY19, involving a shortage of resources for GNAO and PIO. Both mitigated and retired.

Plans, Reviews and Reporting

Per the Cooperative Support Agreement (CSA), Gemini was tasked to produce Project Execution Plans (PEPs) for the GNAO project by January 1st, 2019. Semi-annual reports are required to coincide with Gemini governance meetings. GNAO is also required to submit quarterly progress reports. As a result of underspending in Q1 & Q2, request was made by the NSF for a revised PEP for each project. An NSF review was held in July to assess the progress of the project. A revised WBS, budget and justification were requested at the NSF review as a result of the FY19 underspending. All reports and plans were submitted timely and the CoDR was scheduled on September 26 & 27th, 2019.

Progress toward Conceptual Design Review

Science

The GNAO science team (consisting of experts internal and external to Gemini) has defined science cases and linked each science case to a list of scientific requirements. The final collection of science cases covers a wide range of research areas including solar system, Galactic, and extragalactic topics. The science cases have been reviewed and driving science cases extracted to isolate the primary scientific requirements for GNAO. These have been flowed-down into technical requirements in discussion with the system engineer, the management team, and subsystem leads and implemented into the conceptual design.

The concept of operations is derived in close collaboration between the science team, subsystem leads, and system engineering and the definition of operational concepts is largely finalized.

AO Working Group

The design has changed significantly since the last report as a result of the trade-offs that have been identified. The AOS bench is designed to support five LGS WFS even if only 4 laser guide stars will be created on-sky, responding to the requirements derived from several science cases that require a more narrow field of view, yet better performance on-axis. Optimizing the reconstructor of the AO correction and steering one of the lasers on axis to feed an on-axis LGS WFS fulfill this performance requirement. The results obtained in simulations are very promising.

Laser Guide Star Subsystem Engineering

The Laser Guide Star Facility (LGSF) for the GNAO system has seen a large change from initial concept to a first draft of the design. This includes identifying the major systems of the LGSF. Toptica lasers are readily available, well known to the observatory from the current use of these lasers at both sites, and procuring an additional one poses the least risk to the observatory. We have baselined to use the same LLTs as those that are used at the ESO VLT. For the BEaCoN module, the decision was made to make this component in house.

Work continues on the LGSF system requirements, how they flow down from the GNAO top level requirements along with functional flows of the LGSF system based off the GNAO concept of operations.

AOS Subsystem

The science cases have been developed and key science cases have been identified and the requirements matrix has been produced. This has helped the AOS team to flow down the Top-level requirements for the AO system itself.

Optical Engineering

Engineering development of the conceptual design advanced in both the optical and mechanical. A summary of the work included in the conceptual design document is listed below:

- A depiction of the general layout of the optical components. (COMPLETED)
- A summary of optical elements contained and coatings that could be used. (COMPLETED)

- A description of optical mounting schemes, including the general approach used to mount and align major optical components. (ONGOING)
- A description of the throughput budgets and estimated throughput. (COMPLETED)
- A description of key risks associated with the optical design, e.g., long-term stability of optical alignment, manufacturability, coating reliability, expected lifetimes, etc. (ONGOING)
- An overview of the facility's mechanical design. (COMPLETED)
- An overview of the facility's subassemblies in the mechanical layout. (~70% COMPLETED)
- Ongoing items: Volume for SFS defined but no design, early design concepts for LGSWFS and TTWFS are completed, and CAL needs development of requirements before advancing design.
- Designs (3D models / drawings) for all subassemblies are ongoing. Models are all working versions. (50% COMPLETED)
- A description of the design elements that are common to multiple assemblies. (90% COMPLETED. The optical mechanical mount is the principal remaining item.

Real Time Computer

Work is ongoing on the RTC foundation documents which will evolve throughout the design process. These documents will also serve as inputs to the CoDR documentation package.

Software Selection

RTC packages are being investigated as possible baselines for the GNAO RTC AO package. Adaptations required to support GeMS are ongoing as well.

Following the WBS activities identified in the May PEP, the team worked toward producing the required conceptual design documents for review in September. These documents were internally reviewed by the executive committee and sent to the external CoDR review panel with the committee charge mid-September.

The CoDR documents are attached as an appendix.

Next Reporting Period Plan

- Respond to CoDR panel recommendations
- Preliminary Design Phase Kickoff
- AOS subcontract
- LLT subcontract
- On-site laser acceptance and ready to start installation
- RTC data stream prototype

Conference Presentations / Papers

Conference Presentations / Papers:

- Sivo et al 2019 AO4ELT6 proceeding
- Schawaechter et al 2019 AO4ELT6 proceeding

Other Publications:

- Sivo et al 2019 Astro 2020,
- Blakeslee et al 2019 Astro 2020

Websites:

- [GEMMA website](#)



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1.0 GNAO CoDR Committee Charge

The Conceptual Design review will be held in Hilo, HI on September 26th and 27th, 2019. The committee is requested to give an assessment of the project and consider the following questions:

Science

1. How compelling and well-developed are the set of science cases to allow GNAO to operate as a workhorse AO facility?
2. How likely will the GNAO facility generate significant interest within the Gemini astronomical community?
3. How well developed is the GNAO concept of operations?

Systems Engineering

1. Is the team using appropriate modern systems engineering practices to guide the technical development?
2. Has the project generated a set of system level technical requirements which are adequate for the development of a design concept and which reflect and traceable to the desires of stakeholders?
3. Has the project adequately identified external and internal interfaces?
4. Have the critical system budgets and design trades been identified?

GNAO Concept

1. Are the various subsystems well defined, and are they likely to satisfy their intended objectives?
2. Is the overall system design (mechanical, control, optical) sufficiently mature for Concept stage?
3. Is the GNAO concept as presented well-suited for use at the Gemini Observatory?

Project Management

1. Does the project have adequate project management resources and methodologies in place for a project of this scope?
2. Is the project baseline (scope, cost, and schedule) feasible?
3. Is the project on schedule according to the project baseline?
4. Are risks being adequately managed?
5. Is the proposed procurement model well developed and likely to deliver a robust system on schedule?
6. Is the design of the facility at an appropriate level of maturity for a Conceptual Design Review?
7. Is the project on-schedule and on-track to meet requirement and ready to proceed to the next stage?

2.0 Scope of the Review

This document describes the scope of the GNAO Conceptual Design Review. It does not present any review material itself, nor discuss outcomes.

Conceptual Design Stage Definition

The Conceptual Design Stage has been defined by the project as follows:

- Activities – The Conceptual Design Stage includes all labor, non-labor and travel required to initiate and plan the scope, cost and schedule of the project.
- Science and technical requirements are defined, and an illustrative concept that addresses these requirements is developed.
- Phase Gates – The CoDS closes with the successful passage of the Conceptual Design Review (CoDR).
- Deliverables – Conceptual Design Review.



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3.0 Conceptual Design Stage Deliverables

The deliverables for this phase include 6 project documents, shown below. These documents represent the full scope of the review.

<u>Document Number</u>	<u>Title</u>
GNAO-CoD-01	- Project Management Plan (PMP)
GNAO-CoD-02	- System Engineering Management Plan (SEMP)
GNAO-CoD-03	- Safety Management Plan Document (SMP) Not included as a deliverable until PDR
GNAO-CoD-04	- Science Cases (SC)
GNAO-CoD-05	- Operational Concept Document (OCD)
GNAO-CoD-06	- System Requirements Document (RD)
GNAO-CoD-07	- Conceptual Design Document (CoDD)

4.0 Review Committee

Tim Morris (Chair)	Durham	Optical Expert, AO expert
Ravinder Bhatia	TMT	Project Management
Sylvain Cetre	Keck	SW
Julian Christou (Observer)	LBTO	AO Operations - AOWG Chair
Mark Chun	IfA	Turbulence, AO design
Elliott Horch	Southern Connecticut State University	STAC
Paul Jolley	ESO	Mechanical expert
Jessica Lu	Berkeley	Astrometry, GeMS, Galactic Center
Enrico Marchetti	ESO	AO design, AO management
Suresh Sivanandam (Observer)	University of Toronto	Astronomer, PI GIRMOS - GNAO Science Team Chair
Gelys Tranco	TMT	System Engineer
Shelley Wright	UC San Diego	Astronomer, PS IRIS
Chris Davis (Observer)	NSF	Governance

5.0 Location

The GNAO Conceptual Design Review will be held Sept 26 – 27, 2019 at the Gemini Observatory Hilo Base Facility operations, Hilo, Hawaii, USA.

6.0 Document Delivery

Review documents will be delivered to the committee on Sept. 16, 2019. The deliverable documents will be presented as a PDF, held in a Google team drive and comment access given to each committee member.



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7.0 Review Pre-Meeting

A “pre-meeting” is proposed if schedule permitted between the review committee and the GNAO PI and Project Managers soon after document delivery. This meeting will be held by zoom video-meeting and is intended to answer any questions regarding the scope of the review, or the process in general. It is not intended to address any specific aspects of the instrument design at this stage.

8.0 Comment Period

For 10 days following the document delivery, there will be a comment period. Committee members may post questions/comments/concerns to a shared Google Sheet. The GNAO team will monitor and respond to these comments continually throughout this period.

When comments are initially posted, they should be marked as “OPEN”. Once the GNAO team responds, the committee member is asked to update the disposition to either “Remain Open for Review” or “Closed”. Items that are marked “remain open” will be prioritized to be discussed during the review.

9.0 The Review Meeting

The review will span 2 days. The GNAO team will prepare presentations which summarize relevant aspects of GNAO development and address any review committee questions which are marked “remain open”.

The meeting ends with a closed session during which the committee will discuss the state of the project, and write the assessment report. The agenda is provided to the team as a PDF attachment to this e-mail.

10.0 Committee Review Response

The committee will respond to the charge in the form of a written report. The report will indicate a grade of either: “pass”, “fail” or “pass with action items”. In addition, the report is expected to summarize the committee’s assessment of the project and highlight any relevant supporting information. The report will be sent to the GEMMA Executive Committee and the GNAO PI by October 14th. The PI, in consultation with the GEMMA Executive Committee, will determine the process to address the comments contained in the report.

GNAO CoDR Agenda

Thursday, 26th September 2019

Time	Topic	Presenter	Duration
8:00 AM	Breakfast – Coffee at HBF	ALL	30 min
8:30 AM	Review Committee Closed Session	Review Committee only	30 min
9:00 AM	Welcome Introduction + Round table	Gaetano Sivo + CoDR Chair + all	15 min
9:15 AM	GNAO Science Overview	Morten Andersen	30 min
9:45 AM	GNAO Facility Overview	Gaetano Sivo	30 min
10:15 AM	Coffee Break	ALL	30 min
10:45 AM	GNAO Project Summary	Manuel Lazo / Celia Blain	30 min
11:15 AM	GNAO System Engineering, Definition	Natalie Provost	30 min
11:45 AM	Questions & Answers	ALL	45 min
12:30 PM	LUNCH - LANAI	ALL	60 min
1:30 PM	GNAO Concept of Operations	Julia Scharwächter	30 min
2:00 PM	GNAO Trades / Performance Assessment	Marcos van Dam	30 min
3:00 PM	GNAO AOS Optical Design	Emmanuel Chirre	30 min
3:30 PM	GNAO AOS Mechanical Design	Brian Chinn	30 min
4:00 PM	Coffee Break	ALL	30 min
4:30 PM	GNAO LGSF System Overview	Eduardo Marin	30 min
5:00 PM	GNAO LGSF Mechanical Design	Chas Cavedoni	30 min
5:30 PM	Question & Answer	ALL	30 min
6:00 PM	Adjourn Day 1		
6:30 PM	Dinner – Lanai at HBF	ALL	120 min

GNAO CoDR Agenda

Friday, 27th September 2019

Time	Topic	Presenter	Duration
8:00 AM	Breakfast - Coffee at HBF	ALL	30 min
8:30 AM	Review Committee Closed Session	Review Committee only	30 min
9:00 AM	GNAO RTC System Overview	Paul Hirst	30 min
9:30 AM	GNAO RTC Software Architecture	David Jenkins	30 min
10:00 AM	Coffee Break	ALL	30 min
10:30 AM	GNAO System Controller Architecture	William Rambold	30 min
11:00 AM	Question and Answer	ALL	60 min
12:00 PM	LUNCH - LANAI	ALL	60 min
1:00 PM	Review Committee Closed Session: Debrief and Report	Review Committee only	180min
4:00 PM	Coffee Break	ALL	15min
4:15 PM	CoDR Conclusion	ALL	45 min
5:00 PM	Adjourn Day 2		