REQUEST FOR PROPOSALS (RFP) – ND3091C

FOR

GEMINI NORTH ADAPTIVE OPTICS (GNAO)

“REAL TIME CONTROLLER (RTC)”

STATEMENT OF WORK
# Table of Contents

1. **Introduction** .......................................................................................................................................... 5  
   1.1 Program Background ............................................................................................................................ 5  
   1.2 Technical Background ........................................................................................................................... 5  

2. **Scope** ..................................................................................................................................................... 6  
   2.1 Interfaces ...................................................................................................................................... 6  
   2.2 Common Codebase ............................................................................................................................... 6  
   2.3 Template RTC................................................................................................................................ 6  
   2.4 GNAO RTC ..................................................................................................................................... 7  
   2.5 GeMS RTC...................................................................................................................................... 7  
   2.6 Electronics, Cabling, Software and Controls .................................................................................... 7  
   2.7 Maintenance and Testing Equipment ................................................................................................. 7  
   2.8 Factory Testing ................................................................................................................................. 7  
   2.9 Packaging and Shipping ...................................................................................................................... 8  
   2.10 Onsite Installation and Acceptance Testing .................................................................................... 8  
   2.11 Documentation ................................................................................................................................. 8  

3. **Contractor Work** ................................................................................................................................... 8  
   3.1 Management and Project Plan ............................................................................................................. 8  
      3.1.1 Contract Changes ...................................................................................................................... 9  
      3.1.2 Non-Conformance and Remediation .......................................................................................... 9  
      3.1.3 Request for Deviation/Waiver ................................................................................................. 9  
      3.1.4 Task Completion and Payment Application ............................................................................. 10  
      3.1.5 Facility Access ....................................................................................................................... 10  
   3.2 Project Phase Work ............................................................................................................................. 10  
      3.2.1 Initial Engineering Review Phase ........................................................................................... 10  
      3.2.2 Preliminary Design Phase ....................................................................................................... 10  
      3.2.3 Critical Design Phase ............................................................................................................ 11  
      3.2.4 Common Code Base Realization Phase .................................................................................. 12  
      3.2.5 Implementation, Integration, Verification and Validation Phase ........................................... 12  
      3.2.6 Delivery, Integration, and Acceptance Phase ........................................................................ 13  
   3.3 Acceptance Test Plan .......................................................................................................................... 13  

4. **Communication, Reports and Reviews** ................................................................................................. 14  
   4.1 Communications .............................................................................................................................. 14  
   4.2 Progress Reports ............................................................................................................................. 14
4.3 Informal Weekly Progress Reports ................................................................. 14
4.4 Monthly Progress Reports ............................................................................ 15
4.5 Non-Conformance Reporting ....................................................................... 15
4.6 Access to Work and Information ................................................................. 15
4.7 Delays ........................................................................................................... 15
4.8 Specific Meetings and Reviews ................................................................. 16
  4.8.1 Kick-Off Meeting ..................................................................................... 16
  4.8.2 Architecture Readiness Review ............................................................ 17
  4.8.3 Preliminary Design Review ................................................................. 17
  4.8.4 Critical Design Review .......................................................................... 18
  4.8.5 Common Code Base Code Review ....................................................... 19
  4.8.6 FAT Review ......................................................................................... 19
  4.8.7 OAT Final Review ................................................................................. 19
  4.8.8 General Status Review Meetings ......................................................... 19
5 Deliverables ..................................................................................................... 20
  5.1 Hardware/Software Equipment .............................................................. 20
  5.2 Design Documentation ............................................................................. 20
  5.3 Written Reports ........................................................................................ 20
  5.4 Reviews and Meeting Documents ............................................................ 20
  5.5 Results of Analysis and Modeling ............................................................ 20
  5.6 Interface Control Documentation ............................................................ 20
  5.7 Drawings, and Specifications ................................................................... 20
  5.8 Documentation and Models ...................................................................... 21
  5.9 Monthly Progress Reports ....................................................................... 21
6 Customer Furnished Equipment ..................................................................... 21
7 Schedules ....................................................................................................... 21
  7.1 Work Schedule ........................................................................................ 21
  7.2 Payment Schedule ................................................................................... 21
Document Acceptance and Release Notice

The Statement of Work Document is a managed document. For identification of amendments, each page contains a release number and a page number. Changes will only be issued as complete replacement. Recipients should remove superseded versions from circulation. This document is authorised for release once all signatures have been obtained.

PREPARED: William Rambold
(for release)
William Rambold
RTC Work Package Manager

APPROVED: Natalie Provost
Date: 10/30/2019
Natalie Provost
Project Systems Engineer

APPROVED: Manuel Lazo
Date: 10/30/2019
Manuel Lazo
Project Manager

APPROVED: Gaetano Sivo
(for release)
Gaetano Sivo
GNAO Prime Investigator

Change Record

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Description</th>
<th>Owner name</th>
</tr>
</thead>
<tbody>
<tr>
<td>RevA</td>
<td>10/31/19</td>
<td>Doc ready for release</td>
<td>WR</td>
</tr>
</tbody>
</table>
1 Introduction

The Gemini Telescope requires a facility Adaptive Optics Real Time Controller (RTC) that will serve its current and future needs. This Statement of Work (SOW) document identifies the content, general approach, deliverable items, and overall work content required of a Contractor to provide:

1. an adaptable code base for RTC Systems (the Common Code Base);
2. a fully functional simulation-mode stand-alone implementation of the Common Code Base (the Template RTC);
3. a complete Real Time Control System for the Gemini North Adaptive Optics facility, based on the Template RTC (the GNAO RTC); and
4. a replacement for the existing Real Time Controller computer in the Gemini Multi-conjugate AO System (GeMS) facility, based on components of the Template RTC (the GeMS RTC); hereafter collectively referred to as the Product.

This SOW provides programmatic and technical background, defines the scope of work to be performed, defines the tasks, defines reports and reviews to be completed, and defines deliverables required from the Contractor. Technical specifications are contained in the RTC Specifications Document (GNAO-RTC-RFP-002). Specific contractual requirements are contained in the contract document.

1.1 Program Background

The GNAO project is one of three projects in the GEMMA program funded by the National Science Foundation through a Cooperative Support Agreement with the Association of Universities in Astronomy.

The GNAO facility consists of 4 major products: the Laser Guide Star Facility (LGSF), the Adaptive Optics System (AOS), the GNAO System Controller (SyCo) and the Real Time Controller (RTC) System. All efforts associated with this SOW are under the auspices of the Gemini GNAO Project Office Technical Representative.

The Product, as defined in this SoW, is a deliverable of the GNAO Real Time Controller System product.

1.2 Technical Background

The GNAO system is a Multi-conjugate Adaptive Optics (MCAO) system for Gemini North. GNAO is a next generation MCAO system designed for a wide range of science cases. The aim is to produce near diffraction-limited image quality for near-infrared observations. The requirement is for stable image quality across a 2’ diameter field, with a K-band Strehl of between 0.3 (requirement) and 0.5 (goal) under median seeing conditions and nominal 3-NGS constellation. The RTC System is an integral part of the GNAO System. It integrates closely with the other GNAO systems, the telescope, and the science instrument(s) to reduce optical aberrations introduced by the atmosphere.

The RTC System accepts information from external Natural and Laser guide star wavefront sensors, analyses wavefront distortions, generates correction signals, and drives external wavefront correction optics which correct the measured distortions.
Three versions of the RTC System shall be developed based on a Common Codebase, one for use as a test, characterization and development system, one for use in the GNAO facility, and one to replace the existing RTC in the GeMS facility.

2 Scope

The Contractor shall provide all materials and labor, either directly or through appropriate subcontractors, for the engineering, design, implementation, verification, validation, packaging, shipping, onsite installation, and onsite acceptance testing as necessary to provide an operational RTC product, according to the RTC Specification document (GNAO-RTC-RFP-002) and its associated compliance documents. This effort includes design interactions with the Gemini GNAO Project Office (GNAO PO) Technical Representative and Gemini Contractors, development of plans, and documentation to finalize and optimize interfaces between GNAO subsystems and other elements of the telescope system. This SOW includes all hardware, software, control systems, electronics, and sensors that are required to operate the RTC to required specifications. This SOW defines reports, reviews, and final deliverables.

2.1 Interfaces

The Contractor shall provide all the components necessary to interface the RTC System to the GNAO and GeMS systems, as defined in the associated Interface Control Documents (ICDs). Since the GNAO system is still under development, many of the related ICDs have not yet been completely defined. These ICDs will be developed in collaboration with the Contractor during the design phase of the RTC.

Although interfaces will be developed in collaboration between the RTC Contractor and Gemini GNAO project, the Contractor shall have control over all internal interfaces of the RTC. The Gemini GNAO Project Office Technical Representative shall have control over all external interfaces between the RTC and other systems. Both the Contractor and the Gemini GNAO Project Office Technical Representative shall analyze all external interfaces.

2.2 Common Codebase

The Contractor shall develop a Common Codebase of wavefront correction and telemetry software that satisfies the requirements defined in the Specification document (GNAO-RTC-RFP-002).

The Common Codebase shall have four main components:

1. A Hard Real Time component for high-speed, low latency wavefront analysis and correction;
2. A Soft Real Time component for optimizing and offloading the Hard Real Time processes;
3. An Interface component for defining common data structures to be used when connecting the Hard and Soft Real Time components to application specific interfaces to external systems; and

The structure of the Common Code Base shall allow it to be readily adapted by the Gemini Telescope to develop Real Time Control Systems for other AO facilities and instruments.

2.3 Template RTC

The Contractor shall develop, based on the Common Code Base, a fully functional standalone simulation-mode RTC System that meets the Hard Real Time, Soft Real Time, and Telemetry requirements defined in the RTC Specification document (GNAO-RTC-RFP-002). The Template RTC will accept wavefront sensor
data from simulated wavefront sensors, processes the wavefront, and generate corrections which are sent to the simulated wavefront correction optics. The simulation hardware/software developed for this application shall be complete enough to ensure that the generated corrections are appropriate for the input wavefront. Full closed-loop simulation is a goal and is strongly preferred, but it is not a requirement.

The Template RTC will be controlled via the GNAO PO supplied RTC System Controller.

2.4 **GNAO RTC**

The Contractor shall develop, based on the Template RTC, a GNAO RTC System that provides all of the functionality required to support the GNAO facility. The GNAO RTC System will accept wavefront sensor data from GNAO wavefront sensors, processes the wavefront, and generates corrections which are sent to the GNAO wavefront correction optics.

The GNAO RTC will be controlled via the GNAO PO supplied RTC System Controller.

2.5 **GeMS RTC**

The Contractor shall develop, based on the Template RTC, a GeMS RTC that provides all of the functionality of the current DSP-based RTC in the GeMS facility, while providing the enhanced telemetry of the GNAO System product. The GeMS RTC will only implement the Hard Real Time components of the Template RTC. The Soft Real Time component will be supplied by the existing GeMS RTC control system.

The GeMS RTC will use existing hardware and software interfaces to communicate with the GeMS wavefront sensors, tip tilt mirror, deformable mirrors, telescope systems, and RTC control system.

The GeMS RTC will be controlled via a GNAO PO supplied custom interface layer that makes the existing GeMS controller look like the RTC System Controller.

2.6 **Electronics, Cabling, Software and Controls**

The Contractor shall develop and provide all electronics, computing hardware, cabling, and software from their fixed locations to their terminations.

2.7 **Maintenance and Testing Equipment**

The Contractor shall develop and provide all the equipment required to integrate, test, maintain and operate the RTC. This includes written manuals for operation, maintenance and tests of all the components. The Contractor shall provide all plans, specifications and procedures required to fabricate, assemble, integrate and test the RTC.

2.8 **Factory Testing**

The Contractor shall perform individual component, subsystem, and system testing at their facility as required and deemed necessary to verify that it is built and operating in accordance with design specifications, to reduce risks, minimize onsite integration schedule, and support manufacture, integration, and overall system testing for operational optimization and onsite acceptance. The Contractor is required to furnish all equipment and supply all utilities required to operate the RTC during factory testing except for the GNAO PO supplied RTC System Controller.
2.9 Packaging and Shipping
The Contractor shall provide appropriate packaging materials and devices required for safe transport of the entire product and shall provide shipping from the manufacturer’s facility to the telescope site in Hawaii or Chile as appropriate.

2.10 Onsite Installation and Acceptance Testing
The Contractor shall supply supervision, labor, equipment, operators, and procedural support for onsite installation of the GNAO RTC at the telescope site on MaunaKea, Hawaii and the GeMS RTC at the telescope site on Cerro Pachon in Chile. The Contractor shall perform onsite acceptance testing of the GNAO RTC and GeMS RTC at the appropriate times to confirm performance and facilitate final delivery.

2.11 Documentation
The Contractor shall supply to the Gemini GNAO project all drawings, models, specifications, material certification, literature and manuals, as well as complete as-built design specifications and drawings of the product, all in a common electronic format. The Gemini GNAO Project Office Technical Representative will add all documents to its electronic archive (document control system). All documents shall be in English.

3 Contractor Work
The Contractor shall perform the following tasks and work phases under the scope of this effort:

1. Management and Project Plan
2. Initial Engineering Review Phase
3. Preliminary Design Phase
4. Critical Design Phase
5. Common Code Base Realization Phase
6. Template RTC System Integration, Implementation, Verification, and Validation Phase
7. GNAO RTC Integration, Implementation, Verification, and Validation Phase
8. GNAO RTC Delivery, Integration, and Acceptance Phase
9. GeMS RTC Integration, Implementation, Verification, and Validation Phase
10. GeMS RTC Delivery, Integration, and Acceptance Phase

The Contractor shall define specific work tasks defined in Section 3.2 of this SOW and provide schedules as defined in Section 3.1 of this SOW.

3.1 Management and Project Plan
The Contractor shall provide a Management Plan that describes the technical and management teams that will be responsible for the work and specify the key individuals, their responsibilities, and lines of reporting. The Management Plan shall provide identification of a single technical and contractual point of contact within the Contractor organization. Status, reviews, meetings, and daily technical issues will be coordinated with the technical point of contact.
The Contractor shall provide a Program Plan to include at a minimum the following:

1. Work Breakdown Structure (WBS)
2. Work Schedule and Milestones
3. Cost Management Plan (labor and materials)
4. Realization Plan
5. Factory Integration and Test Plans and Procedures
6. Onsite Acceptance Test Procedures
7. Payment Schedule
8. Final Delivery Date

The Work Schedule shall be consistent with the contract Payment Milestones and is established to incorporate clear transition points from design and specification tasks to Realization and custom purchases. The Program Plan shall identify target dates for Specific Design Review meetings defined in Section 4.8 of this SOW.

The Contractor shall include a Quality Assurance Plan which details quality processes and procedures to be used in the Contractor’s facility during the execution of this work. The Contractor will also include a Systems Engineering Management Plan that details the systems engineering processes and procedures to be used in the Contractor’s facility during the execution of this work. The Contractor Management and Program plan submitted will be subject to negotiation and final approval by AURA and the Gemini GNAO Project Office Technical Representative.

### 3.1.1 Contract Changes

Any changes or non-conformance in the contracted effort that affect technical requirements, schedule, or cost shall only be authorized through written notification from the Gemini GNAO Project Office Technical Representative and the Contractor. The formal contract change request process is detailed in the contract document. Issues not affecting performance, schedule, or cost will be addressed individually.

### 3.1.2 Non-Conformance and Remediation

During the course of this effort, the Contractor shall immediately report any non-conformance to the Gemini GNAO Project Office Technical Representative. No remedy shall be allowed until approval is granted from Gemini GNAO Project Office Technical Representative. The formal contract change request process is detailed in the contract document.

### 3.1.3 Request for Deviation/Waiver

During the course of this effort the Contractor may submit a Request for Deviation prior to the manufacture of an item seeking a planned variance from specified requirements. The Contractor may submit a Request for Waiver to accept an item which, during manufacture or after inspection, was found to depart from specified requirements, but is considered suitable for use as is or after rework by an approved method. Neither waiver shall be allowed until reviewed and granted from the Gemini GNAO Project Office Technical Representative. The formal contract change request process is detailed in the contracts document.
3.1.4 Task Completion and Payment Application

The Contractor Project Plan shall identify and define deliverable documentation necessary to define task completion, specifically those linked to payment milestones. Generally, the Contractor shall submit invoices for milestone payments upon successful completion of milestone events. Milestone events may be successfully completed in advance of the date appearing in the milestone schedule. The contract documents will define the payment application process.

3.1.5 Facility Access

The Contractor shall provide general site access to their facility where RTC activity is specifically occurring for Gemini GNAO individuals identified and pre-authorized by both parties during normal business hours and operations. Gemini GNAO individuals will comply with all Contractor safety rules and facility policies. The Contractor shall provide the Gemini GNAO individuals with facility phone and internet capabilities adequate to support technical interactions as necessary and access to observe testing as required.

3.2 Project Phase Work

3.2.1 Initial Engineering Review Phase

This section of the SoW describes the Work conducted by the Contractor during the Initial Engineering Review Phase of the project.

The Contractor shall perform a detailed analysis of the requirements summarized in the RTC Specifications Document (GNAO-RTC-RFP-002). The Contractor shall prepare a compliance matrix which addresses all requirements for which the Contractor can completely meet and those clearly identified as requirements for which the Contractor is unable to fully or partially meet.

The matrix shall define how each requirement in the specification will be verified (i.e. analysis, test, inspection, demonstration). In the Kick-off Meeting defined in Section 4.8.1 of this SOW, the Contractor shall review their compliance matrix to address all RTC requirements, identifying any stressing or critical risk requirements and present a risk register to include mitigation strategy and schedule.

3.2.2 Preliminary Design Phase

This section of the SoW describes the Work conducted by the Contractor during the Preliminary Design Phase of the project.

The Contractor shall develop a Preliminary Design for the Common Code Base, the Template RTC, the GNAO RTC, and the GeMS RTC. Also included shall be detailed analysis and/or modeling necessary to verify performance of the Template RTC, the GNAO RTC, and the GeMS RTC. All integration and test plans shall be developed to the conceptual stage.

Early in the Preliminary Design Stage the Contractor shall deliver a preliminary design for the Common Code Base architecture, providing schematic details of the of the main components, and the interactions between them, in sufficient detail to understand how each of these components will work and will work together to satisfy the system requirements.
After completion of the architecture design, the Contractor shall provide specific details of the architecture for GNAO PO review in a System Architecture Review, as defined in Section 4.8.2 of this SOW. The intent if this review is to confirm that the proposed architecture aligns with the system requirements and is sufficiently flexible that it can be adapted for use in other applications.

Upon review completion and GNAO PO approval, the Contractor shall continue to complete the preliminary design work.

Early in the Preliminary Design stage the Contractor and the GNAO PO will define and agree on the interface protocol between the Common Code Base and the RTC System Controller to be developed by the GNAO project. This is to allow the RTC System Controller to progress in parallel with the Common Code Base work.

As an integral part of the Preliminary Design, the Contractor shall prepare detailed error budgets for all critical system performance attributes illustrating the Preliminary Design will meet requirements. Any prototyping required to evaluate options should be done during this phase to confirm that the chosen solution is fit for purpose.

The Preliminary Design Phase shall culminate in a Preliminary Design Review at the Contractor’s facility, as defined in Section 4.8.3 of this SOW. The meeting will focus on the design as developed, critical risk areas, and those requiring decisions by the GNAO PO and the Contractor to enable continued design work.

### 3.2.3 Critical Design Phase

This section of the SoW describes the Work conducted by the Contractor during the Critical Design Phase of the project.

Following completion of the Preliminary Design Phase, the Contractor shall proceed with the Critical Design Phase of the product and implementations. The Critical Design effort entails completion all design work necessary for the realization of the Common Code Base and implementation of the Template RTC, GNAO RTC, and GeMS RTC. During the Critical Design Phase the Contractor shall not deviate from the Preliminary Design without written permission from the GNAO PO.

Work performed by the Contractor in this phase shall include all required analysis and modeling required to ensure viability of the design as developed. Any outstanding issues regarding definition of mechanical, electrical, utility, and software interfaces shall be completely resolved during the earliest phases of the Critical Design effort.

Any sub-system testing needed to support analysis and modelling should be done in this phase. The Contractor shall finalize all external RTC ICDs and develop an internal ICD for each interface between the major hardware and software components. These documents shall be provided to the GNAO PO for final approval.

The Critical Design Phase shall culminate in a Critical Design Review (CDR) as defined in Section 4.8.4 of this SOW. The CDR will focus on the design as developed and remaining critical risk areas.
3.2.4 **Common Code Base Realization Phase**

This section of the SoW describes the Work conducted by the Contractor during the Common Code Base Realization Phase of the project.

Following completion of the CDR the Contractor shall proceed to create the Common Code Base by re-using existing code, modifying existing code, or creating new code, as per the critical design.

It is expected that this phase may overlap to some extent with the Template RTC Implementation phase since the Template RTC may be required to test and verify the functionality of the Common Code Base. To the greatest extent possible, however, the Common Code Base components shall be tested independently as they are developed.

The Common Code Base Realization Phase shall culminate in a Common Code Base Code Review (CCBCR), as defined in Section 4.8.5 of this SOW. The CCBCR will focus on completeness of the code and documentation, deviations of the realized code from the critical design, and the compliance of code to Gemini programming standards.

3.2.5 **Implementation, Integration, Verification and Validation Phase**

This section of the SoW describes the Work conducted by the Contractor during the Implementation, Integration, Verification and Validation Phase for the Template RTC, GNAO RTC and GeMS RTC.

Following completion of the Critical Design Phase the Contractor may acquire all equipment, materials, and components to be used in the design approved at CDR.

The Contractor shall implement and test the specified interfaces and hardware simulators, progressively adapt the common code base, and integrate these components to develop a functional RTC System.

During this phase the GNAO PO will provide an RTC System Controller adequate to support the integration and test of the RTC System software. This does not preclude the Contractor from developing a test controller and user interfaces to exercise their software, provided that the final operation of the RTC System is in no way dependent on the Contractor’s test controller or interfaces.

The Contractor shall begin system acceptance testing once the RTC System is fully assembled and characterized.

The Factory Acceptance Test (FAT) plan, as defined in Section 4.8.6 of this SOW, shall be completed during the Integration, Implementation, Verification, and Validation phase. The contractor shall execute the FAT plan and prove, to the greatest extent possible with the simulators employed, that the RTC System meets all of the applicable requirements detailed in the RTC Specifications Document (GNAO-RTC-RFP-002).

The Contractor shall complete the Onsite Assembly and Installation (OAI) plan, and Onsite Acceptance Test (OAT) plan for the RTC System under development.
The Contractor shall create a Pre-Delivery Acceptance Test Report documenting the results of all of the tests described in the Acceptance Test Plan, including the completed compliance matrix, and documenting any revisions or changes to the ATP which were made during the integration and testing procedures.

The Integration, Implementation, Verification, and Validation Phase shall culminate in a Factory Acceptance Test at the Contractor’s facility, as defined in Section 4.8.6 of this SOW. The FAT will focus on the verification of the RTC System performance through the execution of selected tests from the FAT. The suite of tests required to be passed for acceptance at FAT shall be agreed in advance between the Contractor and GNAO PO.

The Template RTC may remain at the Contractor’s facility after the FAT, if the Contractor requests this, so it can be used to aid in the development of the GNAO RTC and GeMS RTC. Following delivery of the GeMS RTC the Template RTC must be shipped to the Gemini Hilo base facility.

3.2.6 Delivery, Integration, and Acceptance Phase

This section of the SoW describes the Work conducted by the Contractor during the Delivery, Integration, and Acceptance Phase for the GNAO RTC and GeMS RTC.

Once AURA approves shipment, Contractor shall package the GNAO RTC in a manner that shall protect it from harm during transit in accordance with the specifications contained in ICD-G0013(Gemini Environmental Requirements), and shall then ship the instrument to the Gemini Telescope facility in Hawaii or Chile as appropriate.

The Contractor shall perform onsite assembly and installation of the product as defined in the Onsite Assembly and Installation (OAI) plan. The Contractor plan shall be presented at the Final Acceptance Test Review defined in Section 4.8.6 of this SOW. The Contractor OAI plan shall specify all required procedures, identify any specialized tooling and required handling equipment, and provide a detailed schedule of planned tasks. The Contractor shall supply supervision, labor, equipment, operators, and procedural support for assembly and installation of the RTC System at the appropriate Telescope facility.

The Contractor shall perform onsite acceptance testing as defined in the Onsite Acceptance Test (OAT) plan. The Contractor plan shall be presented at the Final Acceptance Test Review defined in Section 4.8.6 of this SOW. The Contractor shall conduct and complete the OAT plan to confirm full system conformance to all RTC System specifications and requirements. The OAT plan shall address and verify all items in the compliance matrix.

The Contractor shall demonstrate all maintenance procedures during the onsite acceptance tests. Where necessary, the Contractor shall provide Gemini personnel training activities required for operations or maintenance. The results of the OAT Phase shall be presented at the OAT Final Review defined in Section 6 of this SOW.

3.3 Acceptance Test Plan

For every requirement that is to be verified, the ATP shall contain sufficient information to plan the verification, perform the verification, and to repeat the verification at a later date.

The ATP shall clearly state the success criteria and any test prerequisites, including specific software or hardware needed, for each tested requirement.
For the OAT, the ATP shall include a test set-up section to describe any special set-up involving the facility (such as calibration sources or turbulence injector).

The step-by-step procedure for each verification procedure shall be sufficiently detailed to allow the GNAO PO to both evaluate the appropriateness of each procedure (with respect to the requirements and success criteria) and to repeat the test independently of Contractor.

The OAT plan shall include a subset of the pre-delivery tests that shall be performed post-delivery to demonstrate that nothing has changed during transportation or in changing environments. The ATP does not include on-sky tests.

4 Communication, Reports and Reviews

4.1 Communications
No aspect of the Work may be modified by verbal or informal email communications. In order to be binding on the parties, a modification to the Work must be executed by the proper AURA representative (either AURA Contracts Officer or COTR) as provided in the Contract.

When Contractor requires technical information from AURA, the COTR will provide the information using a standard Technical Directive form and shall sign the form. All Technical Directives shall be numbered in sequential order.

Staff from AURA and Contractor may informally communicate in order to explore issues and ideas related to the Work, provided, however, the Gemini GNAO Project Office Technical Representative and the COTR must be copied on all substantive email communications between AURA and Contractor personnel and be provided with summaries of all meetings and discussions where they were not present.

Once informal communications have converged on a solution to an issue the Gemini GNAO Project Office Technical Representative will either document the agreed solution using a Technical Directive or shall ask the AURA Contracts Officer to prepare a Contract Amendment or Change Order, depending on the nature of the resolution of the issue.

4.2 Progress Reports
The Contractor shall perform the following reporting and reviews throughout the duration of this effort. Where designs or other information are proprietary, AURA and Gemini and Contractor participants will execute non-disclosure agreements with the Contractor as required to support information transfer. Each review requires delivery of both a written report and an actual presentation (in English). All written reports shall include a title, date, author, and version number.

4.3 Informal Weekly Progress Reports
The Contractor shall support informal progress updates at least weekly via telephone or email. Formal presentations of overall program status are not required, but the Contractor shall be prepared to discuss schedule status, technical issues, critical risks and resolutions, and staffing. The objective of these updates is to keep the Gemini GNAO Project Office Technical Representative informed of progress and problems and to enable interactive efforts toward arriving at effective engineering designs and issue resolutions.
4.4 Monthly Progress Reports
The Contractor shall provide written monthly progress reports (in MS Word or PowerPoint form). Monthly reports shall be delivered via email by the 20th of each month, and shall highlight progress and activities performed the previous month to include:

1. Report on status of action items
2. Percentage of completion of scheduled tasks and indicate schedule variances
3. Cost and Schedule performance indicators
4. Identify new problems or issues for tracking and resolution
5. Identify closed issues and resolution.
6. Major activities and tasks planned for the upcoming month
7. A table summarizing risks and associated mitigation strategies
8. An updated schedule to consist of the current approved project plan to completion compared to the approved baseline plan schedule, percent completed and margin for completion date uncertainty

Specific report format details shall be discussed and negotiated during the Kick-Off meeting defined in Section 4.8.1 of this SOW. The action list shall be maintained and updated by the Contractor.

4.5 Non-Conformance Reporting
The Contractor shall report any non-conformance to the Gemini GNAO Project Office Technical Representative for remediation. The report shall summarize the non-conformance and propose a corrective action plan for review. The formal contract change request process is detailed in the contract document.

4.6 Access to Work and Information
The Contractor shall grant AURA personnel and representatives access during working hours to all places where the Work is being performed, including access to locations where the Contractor’s subcontractors are performing any part of the Work.

Upon request, the Contractor shall allow AURA personnel to view and copy any design documentation, reports, or data produced under this Contract. AURA will make the request for the information not less than three (3) working days in advance of the desired time of receipt.

4.7 Delays
If events occur that may cause an impact to the schedule, the Contractor shall evaluate every possible method to avoid a negative outcome (e.g., a schedule slip or a delay of achieving critical milestones). These methods may include utilization of additional Contractor staffing and facilities and or changing Contractors. The Contractor shall immediately notify the Gemini GNAO Project Office Technical Representative of an intention or plan to change contractors and or utilize additional contractors and or their facilities.

The Contractor shall promptly notify the Gemini GNAO Project Office Technical Representative via email of any event that may result in a delay in performance or completion of the Work. The Contractor shall
revise the Project Plan accordingly to any subsequent delay and submit the revised plan to AURA for approval.

4.8 Specific Meetings and Reviews

The Contractor shall host specific meetings and reviews throughout the duration of this effort as described below and identified by the Contractor in their Program Plan described in Section 3.1 of this SOW. These meetings shall provide the Gemini GNAO Project Office Technical Representative the ability to review and agree on Contractor plans and results to ensure work compliance and to enable payment. Where necessary, the Gemini GNAO Project Office Technical Representative will provide written approval of the completion of activities for payment. Specific requirements for Milestone completion, payment application, and purchaser review are provided in the contract document.

The Contractor is encouraged to integrate multiple topics (where plausible) to minimize the number of in-person meetings. The Contractor shall submit agendas and provide all supporting presentation materials at least two weeks in advance of meeting dates for Gemini GNAO Project Office review. The Contractor Project Plan schedule dates shall be updated and adjusted as required during the duration of this effort.

4.8.1 Kick-Off Meeting

The Contractor shall hold a contract Kick-Off Meeting held by video conferencing unless otherwise agreed to by the Contractor and the Gemini GNAO Project Office Technical Representative to present the Project Plan and a Management Plan clearly identifying personnel, approach to work, schedule, and major milestones as described in Section 3.1 of this SOW. The meeting will also serve to converge on expectations for meeting content, review responses, report content and format.

The Contractor shall present the results of the review of the RTC requirements defined in GNAO-RTC-RFP-002 as identified in Section 3.2.1 of this SOW. The Contractor shall review their compliance matrix to address all RTC requirements, identifying any stressing or critical risk requirements and present a risk register to include mitigation strategy and schedule. This Compliance Matrix shall not be construed as giving the Contractor permission to deviate from the Specifications; i.e., all Specifications are mandatory and the Compliance Matrix only provides for an efficient means of disclosure of failures to meet the Specifications. The Compliance Matrix shall be accompanied by a report detailing any noncompliance noted, or any other technical or interface issues that will need to be resolved during the Critical Design effort and describing proposed methods of resolving these issues.

The Contractor and the Gemini GNAO Project Office Technical Representative shall agree upon a process for resolution of action items and close-out/planning of meetings and reviews to support the engineering design cycle.

The Contractor’s staff required to be present at the Kick-Off Meeting shall include at least the Project Manager and lead engineers, other participants may participate in the video-conference.

The Contractor shall document their presentation along with unresolved questions and issues. This documentation shall be submitted to the Gemini GNAO Project Office Technical Representative 10 business days in advance of the Kick-Off meeting. The Contractor shall submit to Gemini GNAO Project Office Technical Representative a summary of the Kick-Off meeting discussions and a list of action items within 10 business days after the Kick-Off meeting. The Contractor shall include their responses to items
raised by Gemini GNAO Project Office Technical Representative and the GNAO team in this summary. AURA will provide the Contractor with a list of comments for response within 10 business days after the Kick-Off meeting.

4.8.2 **Architecture Readiness Review**

The Contractor shall conduct an Architecture Readiness Review following completion of RTC System product architecture work identified in Section 3.2.2 of this SOW. The goal of the meeting is to review and confirm the product design will be sufficient to support the Contractor’s preliminary design, be adaptable to the required implementations, and to identify any required modifications.

4.8.3 **Preliminary Design Review**

The Contractor shall host and conduct a Preliminary Design Review following completion of work identified in Section 3.2.2 of this SOW. The goal of the meeting is to demonstrate a product design and the outline of associated interfaces and subsystems in the product.

The Contractor shall complete the following tasks for the design to be considered ready for a preliminary design review:

1. All design trade options shall be resolved.
2. All major design risks shall be eliminated or reduced to an acceptable level.
3. Technical Performance Metrics (TPM) shall be identified and tracked.
4. All system budgets (latency, jitter, etc) and tolerances shall be established and documented.
5. The software design shall be detailed as follows:
   a. An overview of the software architecture for the chosen solution. All the major software components shall be described. The associated hardware and physical layout of the software components shall be included.
   b. A software design document that describes the proposed solution at a level of detail adequate to explain how the system will operate under typical required situations, using a uniform methodology.
   c. A preliminary list of software configuration items.
   d. A preliminary set of internal system interface documents. All interfaces between internal hardware or software subsystems shall be defined and documented, including any software systems from third-party vendors.
   e. A description of required development platforms and tools, highlighting what needs to be acquired. Development plans that show collaborative development and testing as outlined in the “Guidelines for Designing Gemini Instrument Software” document shall be described.
   f. A list of software milestones, releases, and schedule points for Gemini collaborative testing at each milestone (at least once every four months).
   g. A description of the computing hardware, networking, and any extra hardware needed to interface the computing system to external hardware. The information shall be final, or near final, at this stage.
6. An outline of the Factory Acceptance Test (FAT) plan, Onsite Assembly and Installation (OAI) plan, and Onsite Acceptance Test (OAT) plan for each RTC System implementation.
7. A complete stage plan for the Critical Design Stage.

The Preliminary Design shall be considered complete when all of the tasks listed above are complete for the Common Code Base and three implementations.

4.8.4 Critical Design Review

The Contractor shall conduct a Critical Design Review following completion of work identified in Section 3.2.3 of this SOW. The meeting shall present a detailed product design to be engineered and tested which meets requirements.

In preparing for the critical design the Contractor shall prepare, at least:

1. A set of software documentation that completely explain the design of the software system and demonstrates proper execution of the required functions. The information shall include
   a. An overview of the software architecture.
   b. Description of all major software components.
   c. Description of the instrument’s status and commands.
   d. Description of configuration file purpose and format
   e. Description of development platform and tools.
   f. Description of processing design choices.

All the major software components shall be described at the level needed to code. The documentation shall be at a stage such that any senior software engineer can understand how the software system works.

2. A final list of software configuration items identifying, for each configuration item, any existing code to be used, any existing code to be modified and used, and any code that is to be developed from scratch.

3. A final dictionary of command and status items.

4. A build set of Internal System Interface Documents. All interfaces between internal and external hardware or software subsystems shall be finalized and documented.

5. A final list of software milestones, releases, and schedule points for Gemini collaborative testing with associated dates. Software release milestones shall be no less frequent than approximately once every four months.

6. A final design of the computing hardware, networking, and any extra hardware needed to interface the computing system to external hardware.


8. A draft Factory Acceptance Test (FAT) plan, Onsite Assembly and Installation (OAI) plan, and Onsite Acceptance Test (OAT) plan for each RTC System implementation.

9. A complete phase plan for the Common Code Base Realization Phase

10. A complete phase plan for the Template RTC Implementation, Integration, Verification, and Validation phase
11. A draft phase plan for the GNAO Implementation, Integration, Verification, and Validation phase
12. A draft phase plan for the GeMS Implementation, Integration, Verification, and Validation phase

The Critical Design shall be considered complete when (1) all of the tasks listed above are complete for the RTC System product, the Template RTC, the GNAO RTC, and the GeMS RTC, and (2) the design is complete and demonstrated to meet all the stated requirements.

4.8.5 Common Code Base Code Review

The Contractor conduct a Common Code Base Review Meeting following completion of work identified in Section 3.2.4 of this SOW. The Contractor shall deliver to the GNAO PO the complete Common Code Base two weeks in advance to allow time for review by the GNAO PO.

4.8.6 FAT Review

The Contractor shall host and conduct a FAT Review following completion of work identified in Section 3.2.5 of this SOW. These meetings shall review the documented results of the Contractor’s factory acceptance tests and repeat a subset of the tests carried out by the Contractor in executing the Factory Test Plan.

The suite of tests required to be passed for acceptance at the FAT Review shall be agreed two months in advance between the Contractor and GNAO PO.

A Factory Acceptance Test Review shall be considered complete when all of the tests defined in the Factory Acceptance Test Plan, including those repeated at the FAT Review, have been successfully passed, documented, and reviewed by the GNAO PO.

4.8.7 OAT Final Review

After successful completion of the Delivery, Integration, and Acceptance Phase defined in Section 3.2.6 of this SOW, the Contractor shall present a review of the onsite acceptance testing results. Technical notes, calculations, measurements, etc., supporting the testing shall be presented and made available to the GNAO PO. Measurements shall be performed, recorded, presented, and provided. The Contractor shall archive and make available to the GNAO PO all test results.

At the conclusion of this review, the Contractor shall deliver a written Onsite Acceptance Test Report within three weeks summarizing all data, measurements (including uncertainties), inspection reports, calculations, etc. conducted during the integration and testing and traceability to requirements.

4.8.8 General Status Review Meetings

During the course of this effort, an informal general status meeting shall be held at a minimum of every three months (Quarterly Project Reviews) if no specific meetings or reviews described in Section 4.8 of this SOW are scheduled. The proposed date and the agenda of these general status meetings will be cooperatively developed. The intent is to communicate Contractor progress on the effort and to address any potential issues regularly and proactively. The QPRs will alternate between remote and on-site meetings.
5 Deliverables

The Contractor shall provide the deliverables described below following completion of this contracted effort. Where designs or other information are proprietary, AURA will execute non-disclosure agreements with the Contractor as required to support information transfer.

5.1 Hardware/Software Equipment

The Contractor shall deliver all the computer hardware, electronics, cables, software, support equipment, and packaging required to the appropriate Gemini Telescope facility in Hawaii or Chile. During the development of the product, the Contractor shall develop and deliver controller simulator software to AURA Gemini to enable testing of the interfaces as their definitions mature. All licenses shall be registered to AURA. The Contractor shall deliver all software in source format and shall include the manuals to provide the documentation needed to support operation of the product.

5.2 Design Documentation

The Contractor shall provide design documents sufficient to allow functional reviews of the Preliminary and Critical Design. All documents shall be provided in common electronic formats and include title, date, author, and version number in English.

5.3 Written Reports

The Contractor shall provide all written reports as specified in Section 4 of this SOW. Each review meeting requires both a written version and may require an actual presentation. All written reports shall have a title, author, date, and version number.

5.4 Reviews and Meeting Documents

The Contractor shall provide all materials presented during the specific meetings and reviews in Section 4.8 of this SOW. Materials shall include presentations, analysis reports, and measurement summaries.

5.5 Results of Analysis and Modeling

The Contractor shall provide results from all design calculations, analysis, and modeling conducted by the Contractor to support the product design and engineering effort. Where available, copies of the analyses shall be provided in computer media or via file transfer in native format if possible to enable additional analysis by AURA Gemini.

5.6 Interface Control Documentation

The Contractor shall provide as needed the documentation required to define and to describe the interfaces between the product and other GNAO subsystems. Specifically, this shall include interfaces described in document GNAO-RTC-RFP-002.

5.7 Drawings, and Specifications

The Contractor shall provide electronic versions of all drawings and specifications (pdf format acceptable) derived from this effort. Drawings shall be updated to reflect any variation between the drawings and the as-built condition. These shall be delivered at the time of design review and at the delivery of the product respectively.
5.8 **Documentation and Models**
The Contractor shall provide documentation as specified in this SOW. The Contractor shall provide all software engineering models and computer media copies of designs, drawings, models, etc. All documentation shall be available in common digital formats and should be in native format if possible (3D models, drawings) for future AURA Gemini use. All documents shall be written in English and have a title, author, date, version number.

5.9 **Monthly Progress Reports**
The Contractor shall provide progress updates via email each month as defined in Section 4.4 of this SOW. These reports are intended to aid the Gemini GNAO Project Office Technical Representative in maintaining visibility into Contractor status and provide inputs for AURA Gemini’s monthly status report to partners and funding agencies. Due dates shall be established in the contract document.

6 **Customer Furnished Equipment**
The GNAO PO shall provide an RTC System Controller and user interface adequate for the testing, verification, and validation of the RTC System implementations. The RTC System Controller shall conform to the control interfaces developed during the design phase.

7 **Schedules**

7.1 **Work Schedule**
The Contractor shall provide a detailed work schedule for all major activities and indicate the relevant work milestones per their Project Plan defined in Section 3.1 of this SOW. The work schedule shall identify proposed dates for review meetings and indicate timelines for all tasks with a minimum resolution of 1 month duration.

7.2 **Payment Schedule**
The Contractor shall provide a payment schedule for work activities. Payments shall be made upon the successful completion of specific milestone activities identified in the Contractor Project Plan in Section 3.1 of this SOW.