

**REQUEST FOR PROPOSALS (RFP) – Contract  
N00006593C**

**FOR**

**GEMINI NORTH ADAPTIVE OPTICS (GNAO)**

**“ADAPTIVE OPTICS BENCH (AOB)”**

**STATEMENT OF WORK  
GNAO-AOB2-RFP-001**



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### Document Acceptance and Release Notice

The Statement of Work Document is a controlled project document. To identify changes, each page contains a release number and a page number. This document is authorized for release with the Request for Proposals documentation set once all signatures have been obtained.

PREPARED:	Signature on file _____ Célia Blain GNAO Deputy Project Manager/AOB Product Manager	Date:	21-09-29
APPROVED:	Signature on file _____ Manuel Lazo GNAO Project Manager and GNAO Project Acting Lead Systems Engineer	Date:	21-09-29
APPROVED:	Signature on file _____ Gaetano Sivo GNAO Principal Investigator	Date:	21-09-29
APPROVED:	Signature on file _____ Stephen Goodsell GNAO Project Director	Date:	21-09-29

### Change Record

Version	Date	Description	Owner Name
0.1	2020-01-15	Initial draft	C. Blain
0.2	2021-07-19	Draft released to CAS for review	S. Goodsell
0.3	2021-09-02	Update and merging of content	C. Blain
1.0	2021-09-15	Released for CCB approval	C. Blain
1.1	2021-09-21	Content update	C. Blain
2.0	2021-09-29	Released for CCB approval	C. Blain





# 1 Applicable Documents

Applicable documents are binding to the contract to be signed.

Doc. #	Doc. ID	Rev.	Title
[AD-01]	GNAO-AOS-SPE-002	1	GNAO AOB SubSystem Specifications Document (SSSD) (Level 3 Reqs)
[AD-02]	GNAO-SCI-REQ-002	1	GNAO OPERATIONAL REQUIREMENTS DOCUMENT
[AD-03]	ICD 1.6/1.15.2.1	A	ICD 1.6 to 1.15.2.1 A&G Telescope Beam to AOB ( <i>aka AO Fold to AOB ICD</i> )
[AD-04]	ICD 1.9/3.6	J	ICD 1.9 to 3.6 Science and Facility Instrument to ISS System Services
[AD-05]	ICD 1.5.3/1.15.2.1	A	Instrument Support Structure to GNAO Adaptive Optics Bench (GNAO-AOB) Interface Control Document
[AD-06]	ICD 1.9/2.7	E	Science and Facility Instrument to Facility Handling Equipment
[AD-07]	ICD 1.9/5.0	D	Science and Facilities Instrument to Transport, Observatory and Operational Environment Interface Control Document
[AD-08]	IDD 1.15.2.1/1.15.2.2	1	GNAO AOB to RTC Interface Definition Document
[AD-09]	IDD 1.15.2.1/1.15.2.3	1	GNAO AOB to AOS Controller Interface Definition Document
[AD-10]	IDD 1.15.2.1/1.6	1	GNAO AOB to A&G Science Fold Mirror Interface Definition Document
[AD-11]	IDD 1.15.2	1	GNAO AOS Interface Definition Document
[AD-12]	GNAO-RTC-RFP-002	4	RTC Specifications and Requirements
[AD-13]	NA	2	Gemini Safety Manual
[AD-14]	INST-REQ-0001	C	Science and Facility Instruments Common Requirements Specification
[AD-15]	GNAO-MGT-005	1	GNAO Acronym List



## 2 Reference Documents

Document #	Document ID	Revision	Title
[RD-01]	GNAO-SCI-002	3	Concept of Operations Document
[RD-02]	GNAO-SCI-001	2	Science Case Document
[RD-03]	GNAO-SCI-REQ-001	5	GNAO Science Requirements Document (L0 Reqs)
[RD-04]	GNAO-SYS-SPE-002	3	GNAO Systems Specification Document (SSD) (L1 reqs)
[RD-05]	GNAO-SYS-DSN-001	2	GNAO Facility Architecture Design Document
[RD-06]	GNAO-AOB-SIM-002	1	Distortion in Gemini MCAO Systems
[RD-07]	GNAO-AOB-SIM-003	1	GNAO Laser Launch Telescope Location
[RD-08]	GNAO-SYS-SIM-013	1	Error Budget for GNAO narrow field and wide field modes
[RD-09]	GNAO-SYS-SIM-012	2	Simulations of GNAO narrow field and wide field modes
[RD-10]	SPE-ASA-G0008	10	Gemini Electronic Design Specification
[RD-11]	NA	0.6	AOB Level 3 Requirements Identification v0.6
[RD-12]	NA	1	Monthly report template



### 3 Definitions

In this document, the following capitalized (shown here also in **boldface**) terms shall have the following meanings:

**Associated Hardware:** This term refers to the contract deliverable hardware items that are not part of the Gemini North Adaptive Optics (GNAO) Adaptive Optics Bench (AOB) but are necessary for its successful operation and maintenance. These items include any necessary non-commonly available hardware and tools used for alignment, assembly, calibration, handling, installation, maintenance, service, testing, and transportation (including shipping containers). Associated Hardware also includes a set of agreed spares.

**Associated Software:** This term refers to the project deliverable software items that are necessary for the successful maintenance of the instrument. These items include any software required for alignment, calibration, maintenance, service, simulation, and testing.

**Completion Date:** This term refers to the date by which all the Work is completed, all deliverables have been accepted, and the contract is considered complete. The Completion Date is the date provided in Article 3, Section 4 of the Contract (Contract Draft - N00006593C)

**Contract Price:** This term refers to the total Contract amount as provided in Article 4 of the Contract (Contract Draft - N00006593C)

**Contract Deliverables:** This term refers to the complete set of final contract deliverables that are to be delivered to AURA by Contractor. The Contract Deliverables consist of:

(i) Phase A Deliverables:

- Documented AOB Conceptual Design, presented at the Conceptual Design Review
- Updated Proposal for the Contract Phase B

(ii) Phase B Deliverables:

- GNAO Adaptive Optics Bench
- Associated Hardware
- Associated Software
- Deliverable Documentation Set

**Contractor:** The Contractor is defined as the organization, or the representative of a group of organizations, selected to perform the work stated in this document.

**Delivery Location:** This term refers to where the Contract Deliverables shall be delivered upon acceptance. Delivery Location is:

Gemini Observatory,  
Northern Operations Center,  
670 N. A'Ohoku Place,  
Hilo, Hawaii, 96720, USA



**Deliverable Documentation Set:** This term refers to the complete set of documents associated with the Contract. The set is listed in Appendix A.

**GNAO Adaptive Optics Bench:** This term refers to the optomechanical adaptive optics bench that is the subject of this contract. This includes, but is not limited to:

- The bench's support structure, interfacing with the Instrument Support Structure.
- All optical, mechanical and hardware elements needed to meet the requirements contained within the AOB Specification document [AD-01].
- Low-level electronics and software for controllable devices (deformable mirrors, wavefront sensors, etc.)
- Controllers, and cabling from their fixed locations to their terminations, as described in [AD-03] to [AD-11] and [AD-14].

**Key Performance Metrics:** This term refers to a number of identified metrics that Contractor shall track against during the lifetime of the project. The values tracked for each metric shall include the requirement, the current best estimate (obtained by design, analysis, or measurement), and the current margin.

**AOB Requirements:** This term refers to the set of contractual technical requirements included in the AOB Specification document [AD-01].

**AURA Contracts Officer:** See Article 6 of the Contract (Contract Draft - N00006593C)

**Technical Representative:** See Article 6 of the Contract (Contract Draft - N00006593C)

**Project Manager:** See Article 7 of the Contract (Contract Draft - N00006593C)

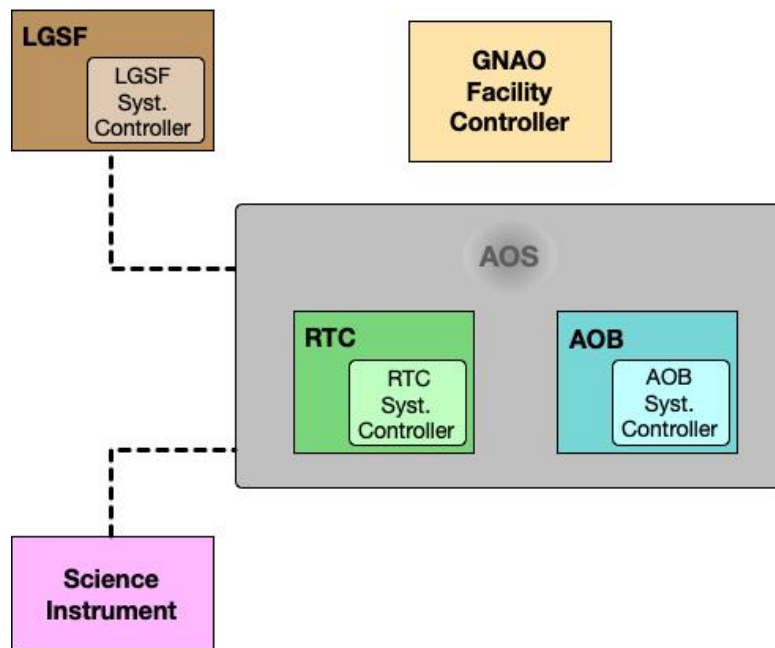
## 4 Introduction

(a) The Gemini North Adaptive Optics (GNAO) facility is a Ground Layer Adaptive Optics (GLAO) and Laser Tomography Adaptive Optics (LTAO) system.

(b) The GNAO facility will provide wide-field GLAO correction over a 2' circular field of view and a LTAO correction over a narrower field of ~20"x20" to make Gemini North the premier site for high-resolution astronomy for the Gemini International partnership.

(c) GNAO will provide the required corrected wavefront to the upcoming Gemini Infrared Multi-object Spectrograph (GIRMOS) for spectroscopy and imaging science. GNAO will operate in the nightly queue. GNAO is a next-generation AO System (AOS) designed for a wide range of science cases [RD-02].

(d) The GNAO facility is organized into 4 main products: the Adaptive Optics Bench (AOB), the Real-Time Controller (RTC), the Facility Controller and the Laser Guide Star Facility (LGSF) (see Figure 1).



**Figure 1: GNAO products organization overview**

(e) The GNAO Adaptive Optics Bench (AOB) will correct the telescope science field from the optical aberrations created by the Earth's atmosphere. The AOB is an integral product of the GNAO facility, integrating closely with the other GNAO products, the telescope, and the science instrument(s). All GNAO products work together to reduce the optical aberrations introduced by the atmosphere.

(f) The AOB performs the wavefront correction over the telescope science field by:

- simultaneously collecting the incoming light from the science target, the natural guide stars, and the laser guide stars
- optically decoupling the information relative to each of these entities and sending it for measurement toward the corresponding wavefront sensors
- sampling the wavefront and sending wavefront sensor data to the RTC, using it to generate correction signals for the Tip-Tilt Mirror (TTM) (if applicable) and DM(s).
- sending the corrected wavefront to the science instrument, GIRMOS.

(g) GIRMOS is currently being developed by a consortium of Canadian universities and institutes. GIRMOS will have multiple deployable Integral Field Spectrograph (IFS), with spectroscopic and imaging capabilities and will operate at wavelength between 0.95 and 2.4 microns. For spectroscopic capabilities, GIRMOS will be able to operate under either a multi Integral Field Unit (IFU) mode (MOAO mode) or a tiled IFU mode (LTAO mode). For imaging capabilities, GIRMOS will be able to operate under either a Wide Field (GLAO) mode or a Narrow Field (LTAO) mode.



## 5 GNAO Project - Contract Structure

The AOB Contract will adopt the following two-phase procurement model:

- **Contract Phase A:** a competitive phase, based on a **Cost-Plus Fixed Fee (CPFF)** contract, during which two or more contractors develop an independent design of the AOB, from the start of the Conceptual Design (including a System Requirement Review (SRR) within 3 months of the kick-off meeting) to the end of the Conceptual Design Stage, concluding with a Conceptual Design Review (CoDR). The contractor should provide an updated Cost-Plus Incentive proposal for the Contract Phase B.
- **Contract Phase B:** following a down-select, one team will continue with their design. The selected contractor, based on a **Cost-Plus Incentive<sup>1</sup>** contract, will progress to the Preliminary Design Stage followed by the Critical Design stage, before building, testing and integrating the AOB with the rest of the GNAO facility on the Gemini North Telescope. The Contract Phase B will include an Architectural Design Review (ADR), Preliminary Design Review (PDR), a Critical Design Review (CDR), the Factory Acceptance Test (FAT) review and On Site Acceptance Test (OAT) review.

## 6 GNAO AOB Contract Scope

(a) The Contractor shall provide all materials and labor, either directly or through appropriate subcontractors, for the engineering design, implementation, integration, verification, validation, packaging, shipping, onsite installation, and onsite acceptance testing as necessary to provide an operational AOB product, according to the AOB Specification document [AD-01] and its associated compliance documents. The Contractor shall provide project management and systems engineering resources commensurate with the size and complexity of the project.

(b) This SOW includes applicable requirements, referenced interfaces and the expected development lifecycle structured by a number of stages, each stage containing a review with defined entrance and exit criteria (see Appendix B). This SOW defines reports, reviews, and final deliverables reports.

(c) During the Contract Phase B, this effort includes design interactions between the GNAO Project Technical Representative and the Contractor, and development of plans and documentation to finalize and optimize interfaces between GNAO subsystems, GIRMOS and other elements of the telescope system.

(d) Contractor shall own (be responsible for) all system technical budgets (image quality, sensitivity, latency, pointing, mass, framerate, etc.) related to the AOB specification, and demonstrate that the AOB technical budgets conform to specifications (optical quality, distortion, WFE, phase reconstruction, etc.)

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<sup>1</sup> It is anticipated that incentive will include telescope time.



(e) This SOW scope includes all hardware, software, control systems, electronics, and sensors that are required to operate and monitor the AOB to the required specifications. The development of the system controller component specific to the AOB will be managed as part of the Gemini in-house GNAO Facility Controller development and is not to be included in this scope.

However, the contractor shall provide the means to remotely operate all controllable devices (including wavefront sensors) including engineering control software.

(f) The Contractor work shall culminate with the on-sky commissioning of the AOB, fully integrated within the GNAO system, at the Gemini North Telescope. The on-sky commissioning of the GNAO system is defined as sending the corrected incoming light from the GNAO system to the science instrument GIRMOS, with the AOB running in closed-loop.

(g) The on-sky commissioning will not include verification of the science. Science verification is outside the scope of this agreement.

(h) The development of the AOS System Controller, the Real Time Controller (RTC) and GIRMOS are all outside the scope of this contract. The AOS System Controller and RTC will be provided to the project during the Implementation, Integration, Verification and Validation (IIV&V) stage of the project for integration and test. The vendor may choose to use their own engineering software for control of AOB devices to support integration and testing in addition to the Gemini supplied control software, however all formal acceptance tests will be performed using the AOS Controller software provided by Gemini.

(i) Wherever practical, Contractor shall design to use Commercial off-the-shelf (COTS) components.

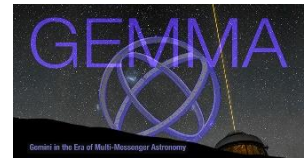
## 7 GNAO Deliverables

(a) The GNAO AOB Contractor Deliverables are reviewed and formally accepted at the ends of both the Contract Phase A and the Contract Phase B. Each of these deliverables has the following specific details:

### Contract Phase A:

- **GNAO AOB Conceptual Design:** the Contractor shall develop and document the Conceptual Design of the AOB. Toward the beginning of the Conceptual Design Stage (see Section 14), the Contractor shall review the AOB Specification presented in [AD-01] and present an updated version of the AOB Requirements during a formal System Requirement Review. The Conceptual Design shall also be presented for review at the end of the Conceptual Design Stage, during a formal Conceptual Design Review.
- **Updated Proposal for the Contract Phase B:** while progressing on the AOB Conceptual Design, and based on the findings of the Conceptual Design Stage, the Contractor shall update and refine the Proposal for the Contract Phase B. A final version of the Proposal for the Contract Phase B shall be submitted to AURA at the end of the Conceptual Design Stage for review.





Both the proposed AOB Conceptual Design and updated Proposal for the Contract Phase B will be used to downselect to a single contractor to continue on toward the Preliminary Design Stage.

#### Contract Phase B:

- **GNAO AOB:** The GNAO AOB shall be transported to the Delivery Location during the Transition to Operations Stage.
- **Associated Hardware:** All items shall be transported to the Delivery Location during the Transition to Operations Stage.
- **Associated Software:** Versions of the **Associated Software** shall be made available to Gemini during the Build Phase and the Transition Phase. Some items may change (under Change Control) during the Transition to Operations Stage.
- **Deliverable Documentation Set:** A subset of documents shall be reviewed at the end-of-stage reviews, as detailed in Appendix A.

(b) Whenever applicable, all licenses shall be registered to Gemini. Contractor shall deliver any software developed in source format and shall include the manuals to provide the documentation needed to support the operation of the product.

(c) Contractor shall provide results from all design notes, documents, technical budgets, calculations, analysis, and modeling conducted 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, to enable additional analysis by the GNAO team.

(d) In addition to the Contractor Deliverables, a set of intermediate deliverables are required by AURA in each stage. They include:

- Kickoff Meetings: Presentation report
- Weekly Status Meeting: Verbal report
- Monthly Progress Reports: Written report
- Quarterly Progress Meetings: Presentation report
- Intermediate Stage Reviews: Review documentation
- End-of-Stage Reviews: Review documentation

Further details on meetings and reviews are in Section 12.

## 8 GNAO AOB Requirements and Interfaces

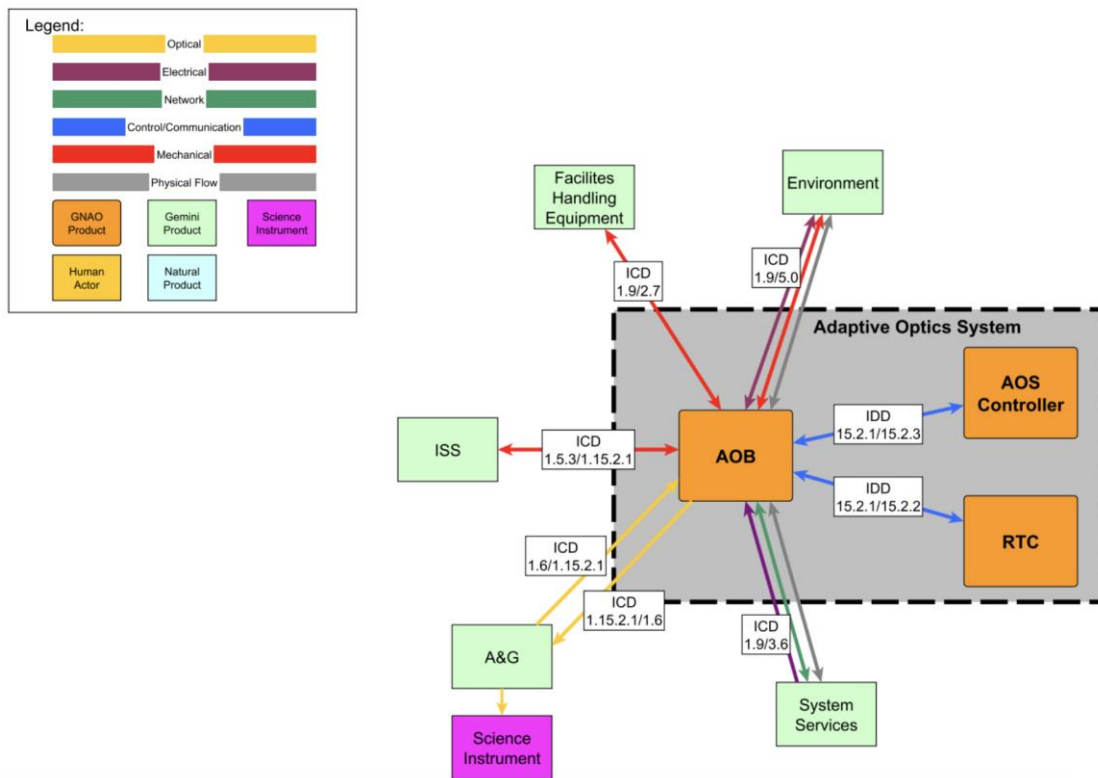
(a) The GNAO AOB Requirements are provided in the AOB Specification document [AD-01]. The AOB Specification can be categorized under 3 groups:

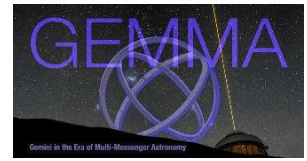
- Requirements that have been derived by the GNAO team and presented in [AD-01]
- Requirements that are TBC, needed to be derived by the Contractor in [AD-01]
- Design Requirements to be derived by the Contractor.

The AOB Specification document includes an appendix with a list of TBC specifications that Contractor shall derive.



- (b) GNAO AOB must conform with the interfaces contained within the Interface Definition Documents and Interface Control Documents listed in the Applicable Documents table ([AD-03] to [AD-11]).
- (c) The Contractor shall provide all the necessary components to interface the AOB product with the entirety of the GNAO system, as defined in the associated Interface Definition Documents (IDD) and Interface Control Documents (ICDs), and the GIRMOS instrument.
- (d) The GNAO system is under development, therefore some of the related ICDs are not completely defined. These ICDs shall be developed by the Contractor in collaboration with the GNAO Project Technical Representative during the Design Phase (see Fig 3) of the AOB.
- (e) Although interfaces will be developed in collaboration between the AOB PM Contractor and GNAO Project Technical Representative, the Contractor shall have control over all internal interfaces of the AOB. The GNAO Project Technical Representative shall have control over all external interfaces between the AOB and other systems. Both the Contractor and the GNAO Project Technical Representative shall analyze all external interfaces.
- (f) The Contractor shall provide all documentation showing the defined internal and external interfaces of the product, and describe the design for their implementation using Interface Control Documents of the interfaces between the product and other GNAO products. Specifically, this shall include external and internal interfaces presented in Fig. 2.





## 9 Budget Management

- (a) Contractor shall manage the Work so that it is successfully completed for a total cost to AURA that is equal to or less than the Contract Price.
- (b) Contractor shall maintain a baseline budget and a cost management plan throughout the contract duration (in a separate document or included in the Project Management Plan).
- (c) Contractor shall routinely monitor amounts expended in performing the Work and the remaining Work to be completed, and shall promptly inform the GNAO Project Technical Representative if at any time there is reason to believe that the total project costs may exceed the total project budget (see also GNAO Contract document, Article 4).
- (d) Contractor shall notify the Contracts Officer in writing whenever it has reason to believe that:
  - (i) The costs the Contractor expects to incur under this contract in the next 60 days, when added to all costs previously incurred, will exceed 75 percent of the estimated cost specified in the Schedule; or
  - (ii) The total cost for the performance of this contract, exclusive of any fee, will be either greater or substantially less than had been previously estimated.

As part of the notification, the Contractor shall provide the Contracts Officer a revised estimate of the total cost of performing this contract.

## 10 Schedule Management

- (a) Contractor shall manage the Work so that it is successfully completed by the Completion Date.
- (b) Contractor shall maintain a baseline schedule and include schedule contingency beyond the baseline of an appropriate amount. The schedule, including schedule contingency, shall not exceed the Completion Date.
- (c) The schedule cannot be re-baselined more often than at the beginning of each stage without the approval of the GNAO Project Technical Representative and the AURA Contract Officer.
- (d) Contractor shall routinely monitor the progress of the schedule based on the Work performed to date and the remaining Work to be completed, and shall promptly inform the GNAO Project Technical Representative if at any time there is reason to believe an end-of-stage completion date or Completion Date will be exceeded (relevant dates are contained in Article 3 of the Contract).
- (e) Contractor shall monitor the deliverables schedule for each of the subcontractors. If Contractor believes there will be a delay in deliverables that will impact the critical path, Contractor must notify the GNAO Project Technical Representative promptly.

# 11 GNAO AOB Project Life Cycle

The GNAO AOB development life cycle is divided into 3 phases and 5 stages as shown in Figure 3 below.

Each stage shall begin with a kickoff meeting (see Section 12.2) and conclude with an end-of-stage review (see Section 12.5).

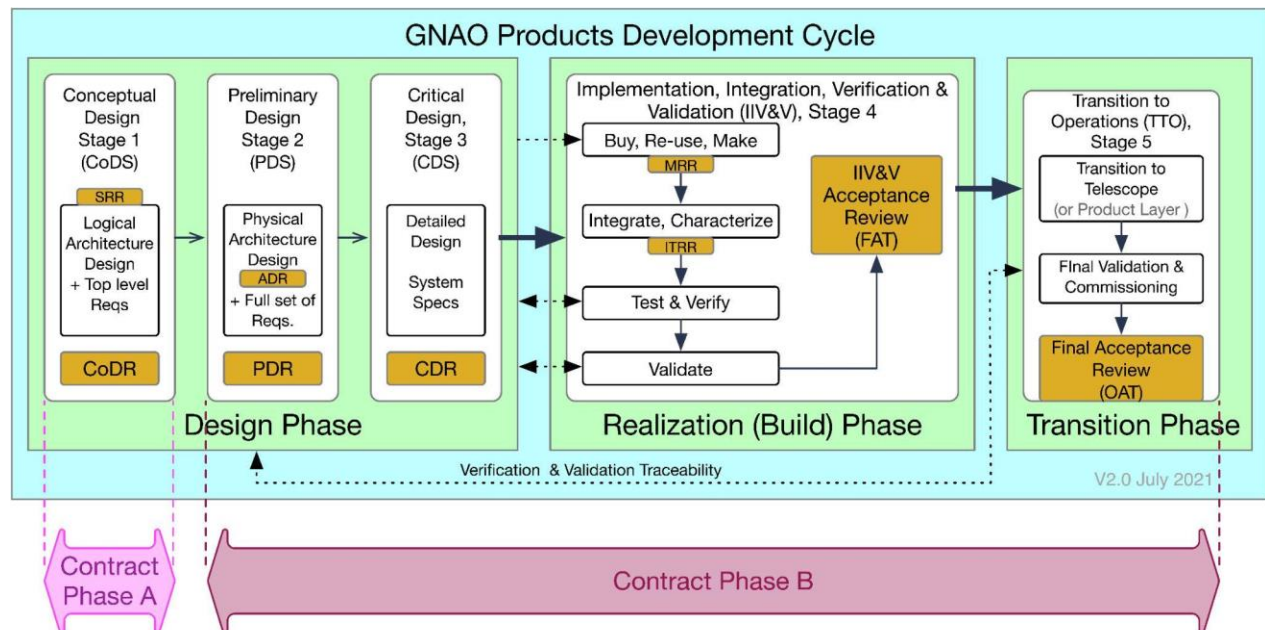


Figure 3: The proposed GNAO AOB project phases and stages.

## 11.1 Design Phase

The Design Phase of the project is the phase in which Contractor develops the design of the GNAO AOB Contract Deliverables. It is divided into three stages:

- Conceptual Design Stage: See Section 14 for its statement of work
- Preliminary Design Stage: See Section 15 for its statement of work
- Critical Design Stage: See Section 16 for its statement of work

The successful completion of the Critical Design Review (CDR) shall mark the closure of the project's Design Phase. Once completed, the entire design of the GNAO AOB Contract Deliverables shall be under Change Control and can only be changed with the approval of a project change control process that includes approval by the GNAO Project Technical Representative.



## 11.2 Realization (Build) Phase

The Realization Phase of the project is the phase in which Contractor manufactures, procures, creates, measures, assembles, integrates, characterizes, optimizes, tests, and verifies the GNAO AOB Contract Deliverables. This phase consists of a single standalone stage:

- Implementation, Integration, Verification and Validation (IIV&V) Stage: See Section 17 for its statement of work

The successful completion of the IIV&V Stage shall mark the closure of the project's Build Phase. Once the phase is completed, all hardware associated with the GNAO AOB and Associated Hardware should be in their final state and placed under Change Control. Any changes, such as remanufacturing or reassembly, shall require approval by the GNAO Project Technical Representative.

## 11.3 Transition Phase

The Transition Phase of the project is the phase in which Contractor transports, tests, integrates, and commissions the Contract Deliverables. This phase consists of a single standalone stage:

- Transition to Operations (TTO) Stage: See Section 18 for its statement of work

The successful completion of the Transition Phase shall mark the closure of the project, the formal acceptance of the Contractor Deliverables by Gemini, and the instrument's handover to regular operations.

## 12 Meetings and Reviews

(a) Contractor shall organize, hold, and conduct specific meetings and reviews throughout the duration of this effort as described below and identified by the Contractor in their Project Management Plan. Travels to all on-site locations for the reviews listed in this Statement of Work will be depending on travel restrictions related to Covid-19.

(b) The meetings shall provide the GNAO Project Technical Representative the ability to

- (i) monitor, review and agree Contractor plans,
- (ii) ensure work compliances with the statement of work,
- (iii) enable payments.

(c) Contractor shall provide all materials presented during the specific meetings and reviews. Materials shall include contract deliverable documentation (Fig.4), presentations, analysis reports, and measurement summaries.

(d) Contractor shall submit agendas and provide all supporting presentation materials at least 5 business days in advance of the reviews.



(e) Contractor Project Management Plan scheduled reviews dates shall be updated and adjusted as required during the duration of this effort.

(f) Travel budget allocation for reviews: Kick-Off meetings, Quarterly Project Reviews (QPRs), End-of-Stage reviews and reviews presented in Sections 14.1, 15.1 and 17.1-17.3 shall be attended in person either at the Gemini North Base Facility or at the Contractor location.

- For meetings/reviews held at the Contractor location (or subcontractor location), Gemini shall be responsible for all travel costs and travel plans related to the GNAO team and/or AURA members travelling on location (or at the subcontractor location). Contractor shall be responsible for the travel cost and travel plans of the Contractor team members if a review is held at a subcontractor location.  
Contractor shall be responsible for the logistics and costs associated with the on-site meeting/review organization.
- For meetings/reviews held at the Gemini North Facility, Contractor shall be responsible for all travel costs and travel plans of the Contractor team members travelling to Gemini North. Gemini shall be responsible for the logistics and costs associated with the on-site meeting/review organization.  
Contractor shall plan to have, at a minimum, the Project Manager and Lead Systems Engineer attending in person, as well as any critical team member requested for the specific needs of a given review.
- Gemini shall be responsible for all travel costs and travel plans for external committee members participating in the reviews (held at Gemini North or at Contractor/subcontractor locations).

## 12.1 Monthly Progress Reports

(a) By the 15th day of each month, Contractor shall submit a written progress report (in .pdf format) to the GNAO Project Technical Representative describing the technical, schedule, and financial progress of the Work as of the end of the previous calendar month. Each monthly report must include the entire project and incorporate the Work performed by subcontractors. The report can be supplemented with additional information provided by subcontractors. Each report shall include:

(i) Information regarding the technical status of the Work overall, and in each engineering discipline; the report should include what was accomplished last month and what is planned for the next month, as well as a comparison of the work done with respect to the work originally planned. The report should include the work of major subcontractors.

(ii) An updated schedule consisting of the most current project plan to completion. Contractor shall compare the current schedule to the last approved baseline schedule and to the original approved baseline schedule. Contractor shall maintain the schedule in Microsoft Project, or equivalent (Excel format is not acceptable), and present it with a Gantt chart and with a column showing percent complete for each listed task. Contractor shall report the current expected project completion date, including its associated margin and uncertainty;



(iii) A table of the major milestones, and cross-institute deliverables, with the original, previous, and current dates by which they will be attained. Contractor shall explain any significant changes from the previous date and include all the explanations from previous lists;

(iv) Issues and problem areas related to the Work, including potential for delays, risk mitigation plans, and the status of identified risks;

(v) Key Performance Metrics including the requirement, current best estimate, and the current margin. Contractor shall retain and present the entire log of previous monthly values for comparison;

(vi) The following metrics shall be presented monthly and Contractor shall report a time series of these metrics showing at least the most recent 12 months. Descriptions related to the schedule performance, cost performance, and work performed against the critical path shall be included;

- Table of financial data comparing<sup>2</sup>:
  - Contract value (i.e., total approved budget)
  - Stage budget (approved budget of current stage)
  - Contract spends to date
  - Stage spends to date
  - Open Commitments
- Total dollar values of invoices
- Payments received to date
- Estimate of Total Project Cost to Completion, presented as a 3-point estimate, summarized by budget per fiscal year through the end of the contract.
- Estimate of Cost to Stage Completion
- Costed list of risks and connection with estimates to project and stage completion
- Schedule Performance Index  
[SPI = Earned Value (EV) / Planned Value (PV)],
- Cost Performance Index  
[CPI = Earned Value (EV) / Actual Cost (AC)]
- Mitigation and restoration plans for CPI and SPI numbers falling outside of the 0.9-1.1 range.

(vii) High-level action items for Gemini and Contractor (both open and closed), and associated status. Contractor shall be responsible for recording and tracking the high-level action items.

(b) These reports shall be reviewed at the next weekly telecon between the GNAO Project Technical Representative, Project Manager, and any key personnel needed to discuss the current status of the project.

(c) Gemini will provide a monthly report template to Contractor prior to the start of the contract.

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<sup>2</sup> Budget and expense information must be presented by major category (e.g. direct labor, capital equipment, indirect cost, etc.).





## 12.2 Kickoff Meetings

(a) Contractor shall host a kickoff meeting with AURA personnel, key Contractor personnel, and key subcontractor personnel within 15 days of the beginning of each stage.

(b) Pending the lift of travel restrictions related to covid-19, the kickoff meetings associated with the following stages shall be held at the following locations:

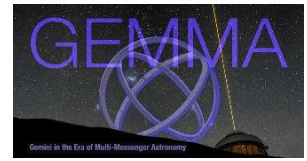
Phase/Stage	Location
Conceptual Design Stage (Contract kickoff)	Contractor's location
Preliminary Design Stage	Contractor's location
Critical Design Stage	Contractor's location
Assembly, Integration and Verification Stage	Contractor's location
Transportation & Telescope Integration Stage	Contractor's location
Commissioning and Science Verification Stage	HBF, Hilo, Hawaii

(c) At each kickoff meeting, Contractor and the subcontractors shall present any changes to the Project Plan (including the schedule, budget, and risks) requested as a result of the previous end-of-stage review. The meeting shall focus on the upcoming stage's scope of work, plan, and deliverables, including cross-institutional deliverables.

(d) Any documentation presented at the kickoff meeting by Contractor shall be provided to Gemini, and any documentation presented by Gemini shall be provided to Contractor.

## 12.3 Weekly Meetings

During the course of the Work, Contractor shall hold weekly meetings with the GNAO Project Technical Representative and other AURA personnel as needed, to discuss the progress of the Work. These meetings may be held by telephone or videoconference. The Contractor shall be prepared to discuss schedule status, technical issues, risks and resolutions, and staffing. The objective of these updates is to keep the GNAO Project Technical Representative informed of progress and problems and to enable interactive efforts toward reaching effective engineering designs and issue resolutions.



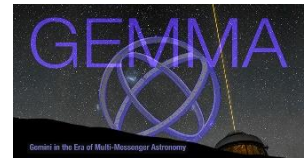
## 12.4 Quarterly Project Reviews

- (a) Quarterly Project Reviews shall start in the Preliminary Design Stage. The intent of the QPRs is to proactively communicate Contractor progress and potential issues to the GNAO Project Technical Representative and to constructively address issues and assess risks.
- (b) Starting in the Preliminary Design Stage, every three months on a date agreed to by the Program Manager and the GNAO Project Technical Representative, Contractor shall host a one-day quarterly progress review. The location of the meeting shall be rotated among major institutes involved in the project, including Contractor, Gemini, and major subcontractors. The GNAO Project Technical Representative, the GNAO Project Manager and other needed AURA personnel or representatives including the AURA Contracts Officer, the Project Manager, and other key members of Contractor's team (including subcontractors) shall attend.
- (c) A quarterly progress review will not be scheduled within one month of an end-of-stage review. Quarterly reviews shall resume three months after the next stage's kickoff meeting.
- (d) Standing agenda items for both Gemini and Contractor at the quarterly reviews shall include: project management, system engineering management, science, quality, and work package status. In addition to reviewing cost, schedule, and scope, the review should also include any current technical or project issues that could benefit from direct discussion, possibly with additional visiting Gemini staff.
- (e) If desirable and mutually agreeable, a working meeting containing a subset of attendees to address specific issues could be appended to the QPR.

## 12.5 End-of-Stage Reviews

- (a) All stages identified in Section 11 shall include a formal end-of-stage review. The stage review acts as a project health check to demonstrate that the project is on-schedule, on-budget, on-track to meet requirements, and ready to proceed to the next stage.
- (b) The required state of the Contract Deliverables at the end of each stage can be found in the Statement of Work section associated with each stage and in Appendix A, Fig.4.
- (c) The review evaluation criteria shall be based on the Statement of Work for that stage and the required status of the Contract Deliverables at the end of that stage.
- (d) Once the GNAO Project Technical Representative and Contractor are confident that Contractor and Gemini shall have all end-of-stage deliverables ready by a certain date, the GNAO Project Technical Representative shall determine the date of the review.
- (e) Contractor and AURA shall schedule two days for each end-of-stage review.
- (f) The location for the reviews is as follows:





Stage Review	SOW	Location of Review
Conceptual Design	Section 12	Gemini North Base Facility, Hilo, US
Preliminary Design	Section 13	Gemini North Base Facility, Hilo, US
Critical Design	Section 14	Gemini North Base Facility, Hilo, US
Pre-delivery Acceptance (FAT)	Section 17.3	Contractor's Integration & Test Location
Post-delivery Acceptance (OAT)	Section 18.1	Gemini North Base Facility, Hilo, US
Commissioning & Science Verification		Gemini North Base Facility, Hilo, US

(g) Gemini shall select an external review committee chair and shall select the review committee members with the advice of the review committee chair, if so requested. NSF personnel may elect to attend the review.

(h) Each end-of-stage review shall not relieve Contractor of any responsibility for the successful completion of the Work outlined in the AOB Requirements. Similarly, no part of the review, including comments made during the review, can waive any of the AOB Requirements or relieve Contractor of any contractual obligations.

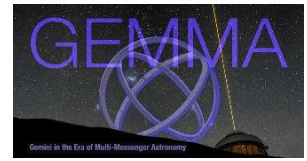
(i) Contractor shall deliver all end-of-stage documentation (see Contract Deliverables listed in Fig 4. in Appendix A) to AURA for distribution to the review committee at least four weeks before the end-of-stage review.

(j) Within 10 working days after the review:

- Contractor shall produce and deliver a Contractor Review Report to the GNAO Project Technical Representative.
- The review committee shall produce and deliver a Committee Review Report to the GNAO Project Technical Representative.

(k) Within 10 working days after receiving the Contractor Review Report and the Committee Review Report, the GNAO Project Technical Representative shall deliver:

- A Post-Review Report to the Contractor.
- A Project Executive Report to the Project Manager, containing a list of recommendations and proposed actions for the project. The GNAO Project Manager shall decide whether the GNAO AOB project can proceed to the next stage or whether to require additional work (including, possibly, an additional review) to correct identified shortcomings.



## 13 Project Communication

(a) The Contracts Officer is AURA's primary representative for oversight and administration of this Contract (see Section 6 of the AURA Contract). Primary Contacts and Communications: The primary contacts for this Work are the GNAO Project Technical Representative and the Contractor Project Manager.

(b) The GNAO Project Technical Representative's role: Contractor acknowledges that the GNAO Project Technical Representative is the only person with authority to provide technical direction with regard to the Work, and that no other person, committee, or board has any authority to direct or influence any aspect of the Work. In the event that Contractor receives direction or a suggestion from any other source that Contractor feels has merit, it shall communicate the direction/suggestions to the GNAO Project Technical Representative with its recommendations.

(c) Although regular informal communications between AURA, Contractor personnel, and subcontractor personnel are encouraged to explore possible ideas and gather information, other than issues addressed in Section (d) below, all communications that might be construed as direction or permission to modify any aspect of the AOB Requirements or design, including interfaces, must be made by means of written communications between the GNAO Project Technical Representative and the Contractor Project Manager. Both parties will explain this requirement to all staff involved in this work, and shall ensure that all design/requirement modifications go through the primary contacts.

(d) Sections 13 (a) and (b) notwithstanding, the Statement of Work may be modified only by change order and/or contract amendment, as described in Article 8 of the main contract. The GNAO Project Technical Representative does not have authority to modify anything in this Statement of Work. This Statement of Work may be modified only by means of a written document signed by the AURA Contracts Officer and accepted by Contractor. Verbal agreements or direction from anyone other than the AURA Contracts Officer to modify or add work or requirements are void; if anyone at AURA gives Contractor any direction that shall result in a change to the Contract Price, Completion Date, AOB Requirements, or Statement of Work, or that may give rise to schedule delays, Contractor shall not implement the direction but shall instead promptly contact the AURA Contracts Officer and request guidance on how to proceed.

(e) When the contract requires that something be documented "in writing," there is no requirement that the writing be in hard copy format unless a hard copy is specified explicitly; electronic documents satisfy this requirement.

(f) Communications during the Conceptual Design Stage will be limited to reporting, requesting clarifications and reviews. The GNAO Project Technical Representative will not provide technical direction which would result in a competitive advantage.

(g) The GNAO Project Technical Representative will be the single point of contact with the other GNAO Technical Representatives and Work Package Managers (RTC, Laser Guide Star and System Controller) and will provide the coordination and the necessary transfer of information between the AOB Contractor and the other GNAO Products.



## 14 Conceptual Design Stage: Statement of Work

This section describes the Work to be performed by Contractor during the Conceptual Design Stage of the project. Contractor shall prepare a conceptual design for the GNAO AOB and perform all analyses and trade studies reasonably required to demonstrate that these design concepts meet all of the GNAO AOB Requirements.

(a) The stage shall begin with a kickoff meeting, shall contain a Systems Requirement Review (SRR) and shall conclude with the Conceptual Design Review (CoDR). As this stage of the work package is completed, the Conceptual Design Review will act as the down select review (see also 14 (g), below).

(b) During the CoD stage, the Contractor(s) shall complete a detailed analysis of the top-level requirements and refine the AOB Specification.

(c) During the stage, Contractor shall create the Conceptual Design Documentation Set as described in Appendix A. These documents will be submitted prior to the Conceptual Design Review.

(d) The Contractor shall also maintain and revise the Risk Register and accompanying Risk Management Plan throughout this stage.

(e) Contractor shall read through the Documentation Set, prior to the SRR:

- AOB Specification Document [AD-01]
- ConOps Document [RD-01]
- Science Case Document [RD-02]
- Simulation reports [RD-06],[RD-08],[RD-09]
- GNAO laser Launch Telescope Location report [RD-07]

(f) Contractor shall develop and document a Contract Phase B proposal including Management Plan and Systems Engineering Management Plan for the remainder of the effort necessary to design, fabricate, integrate, test, deliver, and install GNAO on Gemini North (the "Contract Phase B Management Plan"). The Contract Phase B Management Plan should include the effort and equipment necessary, and the cost to complete the entirety of the post-Conceptual Design Stage work.

(g) The proposal for the Contract Phase B will be used by Gemini to evaluate Contractor, in addition to the evaluation of the Conceptual Design developed and presented.

(h) The proposal shall include a clear description of the plan to complete the detailed design and fabrication of the instrument (the Contract Phase B proposal) for a Cost-Plus Incentive contract. The proposed price (target cost) for the instrument must provide Contractor with enough budget to ensure that the instrument can be successfully completed. Contractor shall present all suggested amendments to the Contract Phase B Proposal.



(i) Long lead items procurements: Any long lead Commercial off-the-shelf (COTS) components wanting to be purchased during the preliminary design stage should be presented at the Conceptual Design Review.

## 14.1 Systems Requirements Review

(a) During the Contract Phase A Conceptual Design Stage, the contractor shall hold and lead a System Requirement Review (SRR). The SRR should be held within 3 months of the kick-off meeting. The review shall be held in person at the contractor site or remotely.

During the review, the vendor shall present an updated list of the requirements for the AOB. In this list, all the requirements to be derived by the vendor shall be identified and explained. All requirements shall be derived, finalized and baselined by the Conceptual Design Review.

(b) Additional entrance and exit criteria for the SRR are contained within Appendix B (Section 20.1).

(c) The goal of this review is to ensure that:

(i) The following primary technical products for the GNAO Adaptive Optics Bench, Associated hardware, Associated software and human system elements are available and defined:

- The requirements contained within the AOB Specification Document [AD-01] and Applicable Documents have been reviewed.
- The “TBC” requirements contained in the appendix of [AD-01] have been identified and assessed.
- All additional design requirements necessary to support the AOB design and build have been identified and assessed.
- The preliminary verification and validation method has been identified for each requirement.
- The technical system requirement-related risks have been identified and technically assessed.
- The interfaces with external systems are identified.
- The preliminary Key Performance Indicators (KPIs).

(ii) The functional and performance requirements defined for the AOB are responsive to the stakeholder needs and parent requirements, reflect the systems intended operational use, and represent capabilities likely to be achieved within the scope of the project.

(iii) The maturity of the requirements definition and associated supporting materials is sufficient to begin the conceptual design.

(iv) System Interfaces with external entities have been identified.

(v) Preliminary approaches have been determined for how requirements will be verified and validated.

(vi) The system requirement-related risks have been identified and technically assessed, and viable mitigation strategies have been identified.

(d) The Contractor(s) should provide an updated AOB Requirement document based on the review outcome.



(e) Contractor shall document their presentation along with unresolved questions and issues. Contractor shall submit agendas and provide all supporting presentation materials at least 5 business days in advance of the SRR.

(f) Contractor shall submit to GNAO Project Technical Representative a summary of the SRR discussions and a list of action items within 5 business days after the meeting. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and the GNAO team in this summary. The GNAO team will provide the Contractor with a post-SRR report containing a list of comments for response within 15 business days after the SRR.

## 14.2 Conceptual Design Stage Review

(a) A month before the end of the Contract Phase A's Conceptual Design Stage, the contractor shall hold and conduct a Conceptual Design Review (CoDR).

(b) Additional entrance and exit criteria for the CoDR are contained within Appendix B (Section 20.2).

(c) The Phase A to Phase B Down-Select process is presented in section 14.3.

(d) The meeting shall be held either by video conferencing or on site (pending covid-19 travel restriction) as per Section 12.5, and shall include the full Contractor team and the full AOB team.

(e) Contractor shall present a conceptual design of the AOB and an envisioned path forward to the final design, build and implementation of the AOB, including the results of the review for:

- the updated AOB requirements, if applicable, as defined in the accompanying AOB Specification document [AD-01].
- all deliverables listed in Appendix A, Fig. 4.

(f) The Contractor shall review their compliance matrix to address all AOB requirements, shall identify any critical risk requirements and present a risk register to include mitigation strategies and schedule. The 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, and any other technical or interface issues that will need to be resolved during the Critical Design effort. The report shall also describe the proposed methods of resolving these issues.

(g) Contractor and the GNAO Project 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.

(h) Contractor shall present the Contract Phase B Management Plan and Systems Engineering Management Plan for the remainder of the effort necessary to design, fabricate, integrate, test, deliver, and install GNAO on Gemini North, and shall clearly identify personnel, approach to work, schedule, and major milestones. The meeting shall also serve to converge on expectations for following meetings content, reviews responses, reports content and format. Contractor shall also present an updated Risk Register and Risk Management Plan.



(i) Contractor shall document their presentation along with unresolved questions and issues. Contractor shall submit agendas and provide all supporting presentation materials at least 5 business days in advance of the CoDR.

(j) As per Section 12.5 (j) and (k), Contractor shall submit a Contractor Review Report to the GNAO Project Technical Representative, including a summary of the CoDR discussions and a list of action items. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and the GNAO team in this summary.

### **14.3 Conceptual Design Stage Down-select Process**

(a) Gemini shall provide Contractor with a set of selection criteria at or shortly after the Conceptual Design Stage Kickoff meeting.

(b) Gemini shall select the review committee chair and review committee members and send Contractor a list of their names by no later than eight weeks before the conceptual design review. Contractor shall have 10 days to notify the GNAO Project Technical Representative of any conflicts of interest it has to any review committee member.

(c) A common target date for the competing teams to have finished their scheduled work and submitted their Conceptual Design Review documentation shall be agreed upon by Gemini and the competing Contractors.

(d) Contractor shall deliver the Conceptual Design Stage documents to Gemini at least four weeks before the CoDR.

(e) Contractors shall not be allowed to see the competing teams' CoDR documentation. This material shall only be available to the review committee and Gemini.

(f) The CoDR shall be held at the Gemini Base Facility, Hilo, and last two days.

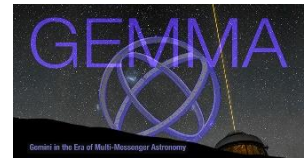
(g) The review committee shall use the selection criteria provided pursuant to item (c) above to evaluate the Conceptual Design Documents.

(h) The results of the CoDR process shall not relieve the Contractor of any responsibility for the successful completion of the Work in conformity with the AOB Statement of Work. Similarly, the committee report, including comments made during the review, cannot waive any of the GNAO AOB Requirements or relieve Contractor of any obligations under this Contract.

(i) As per Section 12.5 (j) and (k), the review committee chair shall submit a written committee report to Gemini giving the committee's recommendations on how to proceed with the project.

(j) After receiving the committee recommendations, Gemini may meet with the Contractor, either in person or via videoconference, to discuss and seek clarifications regarding the CoDR Documentation before making a final selection.





(k) Gemini shall make a final selection based on the review committee recommendations and any clarifications provided during follow-up meetings with Contractor. In consultation with its governance, AURA shall make the final decision on how Gemini will proceed.

(l) AURA reserves the right to cancel this GNAO AOB contract after the Conceptual Design Stage at its sole discretion.

## 15 Preliminary Design Stage: Statement of Work

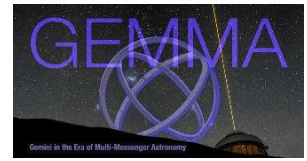
This section of the Statement of Work describes the Work conducted by the downselect Contractor during the Preliminary Design Stage of the project. Contractor shall develop a preliminary design for the AOB, as per the updated AOB Specification Document, including but not limited to optomechanics, electronics, and thermal management.

(a) The stage shall begin with a kickoff meeting, shall contain an Architectural Design Review and shall conclude with an end-of-stage review as stated in Sections 12.2 and 12.5.

(b) Contractor shall expand on the information contained within the Conceptual Design Documentation Set to create the Preliminary Design Documentation Set as described in Appendix A, Fig 4.

(c) Contractor shall prepare a Preliminary Design for the GNAO AOB, Associated Hardware, and Associated Software. Contractor shall complete the following tasks for the design to be considered a preliminary design:

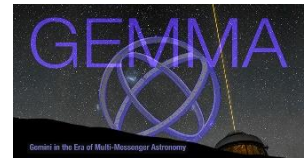
1. All design trades options shall be resolved and the detectors and controllers have been selected and justified.
2. All major design risks shall be eliminated or reduced to an acceptable level.
3. All telescope interfaces shall be verified. All the external and internal interfaces shall be defined and documented in the Interface Definition Document (IDD). Contractor shall define the AOB external and internal interfaces to generate the respective AOB ICDs (External and Internal).
4. Procurement methods for all mechanisms (purchased commercially, subcontracted, produced in-house, etc.) shall be resolved.
5. All system budgets (image quality, error, mass, power, pointing, latency) and tolerances shall be established and documented. Any prototyping required to evaluate options shall be done during this stage to confirm that the chosen solution is fit for purpose.
6. Preliminary performance analysis of the opto-mechanical design shall be performed including, but not necessarily limited to:
  - a. Sensitivity analysis;
  - b. Ghosting;
  - c. Scattered Light;
  - d. Instrument throughput vs. wavelength calculated at 100nm intervals across the entire wavelength; and
  - e. Performance degradation consistent with the flexure, vibration, and tolerance analyses of the instrument design.



7. Contractor shall prepare a compliance matrix for the top-level requirements, which addresses all requirements and clearly identifies requirements:
  - for which the contractor can completely meet.
  - 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).
8. Instrument vibration analysis, including both vibrations generated by the instrument and those received from the telescope/environment, shall be performed with particular attention paid to vibration effects on instrument stability and the vibrations transmitted to the Instrument Support Structure from the instrument.
9. Contractor shall provide a detailed analysis and/or modeling necessary to verify and validate the performance of the AOB. The Contractor shall confirm the AO dimensioning proposed during the Conceptual Design Stage and provide a list of hardware that can meet the system performance requirements. All integration and test plans shall be developed during the Preliminary Design Stage.
10. Contractor shall identify all long lead items and, if necessary, during the PDS, shall request approval from the GNAO Project Technical Representative. The Contractor shall maintain and revise the Risk Register and accompanying Risk Management Plan throughout this stage.
11. 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. Information shall be included on items to be controlled, sequencing issues. The initial dictionary of status items and configuration items shall be produced.
  - c. The software design shall be described to the level of detail required to explain how the system will operate under typical required situations using a uniform methodology.
  - d. A demonstration of how instrument status, sequence commands, and events flow in the system shall be included.
  - e. A set of user scenarios (or use cases) demonstrating how the software will enable the science objectives of the instrument.
  - f. Detector controller software/firmware preliminary design.
  - g. 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.
  - h. A description of required development platforms and tools shall be included, highlighting what needs to be acquired. Development plans that show collaborative development and testing shall be described.
  - i. Identify AOB software milestones and releases and schedule points for Gemini collaborative testing at each milestone (at least once every four months).
  - j. A description of the computing hardware, networking, and any extra hardware needed to interface the computing system to the instrument shall be provided. This information shall be final or near final at this stage.

(d) The Preliminary Design Stage shall culminate in a Preliminary Design Review, held at the Gemini North Hilo Base facility. This review will focus on the design as developed, critical risk areas, and required work or decisions by the GNAO Project Technical Representative and Contractor to enable continued design work.



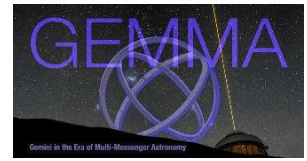


## 15.1 Architectural Design Review

- (a) During the first half of the Preliminary Design Stage, the downselect contractor shall host and conduct an Architecture Design Review (ADR). The review shall be held in person at the contractor site or remotely.

During the review, the contractor shall present an updated list of the requirements for the AOB, along with any applicable design support documents, including but not limited to any modeling and/or simulations performed. The contractor shall also provide, at least 2 weeks in advance of the ADR, an Architectural Design Document (ADD), which identifies the Functional and Physical architectures required to satisfy the requirements contained within the AOB Specifications document [AD-01]. The Physical architecture defines the implementation of a solution to provide the required functionality.

- (b) Additional entrance and exit criteria for the ADR are contained within Appendix B (20.3).
- (c) The goal of this review is to ensure that:
- (i) The following primary technical products for the GNAO Adaptive Optics Bench, Associated Hardware, Associated Software, and human system elements are available:
    - (1) Defined architectures, including major tradeoffs and options, ready to be baselined after the review.
    - (2) The requirements contained within the AOB Specifications Document [AD-01] have been decomposed to support architectural decisions.
    - (3) Preliminary internal and external system interfaces defined.
    - (4) Supporting analyses, functional descriptions, and allocations of functions to architectural elements ready for review.
  - (ii) The proposed system architecture design is credible and responsive to the functional and performance requirements defined for the AOB and that the requirements have been allocated to all functional elements of the AOB.
  - (iii) The status of technical performance related to leading KPIs, margins, and TPMs and associated technical risks have been identified and communicated.
  - (iv) The architecture tradeoffs are completed, and those planned for the remainder of the Preliminary Design Stage adequately address the defined design solution.
- (d) Contractor shall document their presentation along with unresolved questions and issues. Contractor shall submit agendas and provide all supporting presentation materials at least 5 business days in advance of the ADR.
- (e) Contractor shall submit to the GNAO Project Technical Representative a summary of the ADR discussions and a list of action items within 5 business days after the review. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and GNAO team team in this summary. The GNAO team will provide the Contractor with a post-ADR report containing a list of comments for response within 15 business days after the ADR.



## 15.2 Preliminary Design Stage Review

- (a) Contractor shall host and conduct a Preliminary Design Review following completion of the work identified in Section 15. The goal of the meeting is to describe and demonstrate a product design and the definition of associated interfaces and subsystems in the product.
- (b) Additional Entrance and Exit criteria for the PDR are presented in Appendix B (20.4).
- (c) Contractor shall complete the following tasks for the design to be considered ready for a preliminary design review:
  1. A preliminary optomechanical design shall be presented, based on an optical modeling software (such as Zemax) and matching CAD, which fulfill the requirement and performance described in the AOB Specification document [AD-01].
  2. AO dimensioning shall be finalized and major optical and hardware components shall be identified.
  3. All design trade options shall be resolved.
  4. All major design risks shall be eliminated or reduced to an acceptable level.
  5. Technical Performance Metrics (TPM) shall be identified and tracked.
  6. All system budgets and tolerances shall be established and documented.
  7. A list of all devices to be controlled and the method by which they will be controlled, via the defined interfaces, shall be established.
  8. A preliminary set of internal system interface documents shall be written. All interfaces between internal hardware or software subsystems shall be defined and documented, including any software systems from third-party vendors.
  9. A description of the computing hardware, networking, and any extra hardware needed to interface the computing system to external hardware shall be established. The information shall be final, or near-final, at this stage.
  10. An outline of the Factory Acceptance Test (FAT) plan, On-site Assembly and Installation (OAI) plan, and On-site Acceptance Test (OAT) plan shall be defined.
  11. A complete stage plan for the Critical Design Stage shall be defined.
- (d) Contractor shall provide the documents listed in the deliverable documentation table provided in Appendix A, Fig 4. The Preliminary Design shall be considered complete when all of the tasks listed above are complete for the AOB. Updated PMP and SEMP shall be provided.
- (e) Long lead items procurements: Any long lead Commercial off-the-shelf (COTS) components wanting to be purchased during the Critical Design Stage should be presented at the Preliminary Design Review
- (f) Contractor shall document their presentation along with unresolved questions and issues. Contractor shall submit agendas and provide all supporting presentation materials at least 5 business days in advance of the PDR.



(g) As per Section 12.5 (j) and (k), Contractor shall submit a Contractor Review Report to the GNAO Project Technical Representative, including a summary of the PDR discussions and a list of action items. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and the GNAO team in this summary

## 16 Critical Design Stage: Statement of Work

This section of the Statement of Work describes the Work to be performed by the downselect Contractor during the Critical Design Stage of the project. Following the completion of the Preliminary Design Stage and approval from the GNAO Project Technical Representative, the Contractor shall proceed with the Critical Design Stage of the product and implementation. The Critical Design effort entails completion of all design work necessary for the Realization (Build) of the AOB.

(a) The stage shall begin with a kickoff meeting and conclude with an end-of-stage Critical Design Review (CDR) as stated in Section 12.2 and 12.5. The CDR shall focus on the assessment of the design as developed and documented, and identification of any remaining critical risk areas. The CDR shall include a dedicated Safety Review.

(b) Contractor shall expand on the information contained within the Preliminary Design Documentation Set to create the Critical Design Documentation Set as described in Appendix A, Fig 4.

(c) Contractor shall create a budget to completion for the AOB based on obtained quotations.

(d) During the Critical Design Stage, the Contractor shall not deviate from the Preliminary Design without written approval from the GNAO Project Technical Representative.

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

(f) The Contractor shall prepare a compliance matrix for the AOB-level requirements defined by the Contractor, which addresses all requirements and clearly identify requirements:

- for which the contractor can completely meet.
- 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).

(g) The Contractor shall request approval to purchase, or request the purchase by the GNAO Project Technical Representative, of all long lead items, identified during the Preliminary Design Stage, that have not already been procured.

(h) ICDs should be finalized during the Critical Design Stage. The Contractor shall finalize all external AOB ICDs and develop an internal ICD for each interface between the major hardware and software components. These documents shall be provided to the GNAO Project Technical



Representative for final approval. The Contractor shall maintain and revise the Risk Register and accompanying Risk Management Plan throughout this stage.

(i) Any sub-system testing needed to support analysis and modeling shall be finished in this stage.

(j) Contractor shall prepare a Critical Design for the AOB, Associated Hardware, and Associated Software that is a continuation of the design presented in the Preliminary Design Study Documentation. The Critical Design shall be considered complete when (i) all of the tasks listed below are complete and (ii) the instrument design is complete and demonstrated to meet all the Requirements. In preparing the critical design, Contractor shall prepare at least:

1. A complete set of 3D models of the instrument including all its subassemblies;
2. A complete set of 2D manufacturing drawings;
3. A complete set of quotations for all component procurements;
4. Assembly drawings of all mechanisms with analyses to show they meet the Requirements (including the opto-mechanical tolerances);
5. Complete designs of any necessary cooling systems, including strap designs, length, gauge, number of strands, etc.;
6. Complete electronics design with all mechanisms enumerated, sources established (commercial, custom, etc.), and needed modifications detailed;
7. Full designs and schematics, suitable for conversion to manufacturing drawings, for all custom electronic components;
8. Final layout of electronics cabinets, including cable layout;
9. A "Finite Element Analysis (FEA)" of the instrument's flexure (including cabling, electronics cabinets, etc.) at a range of orientations to a level of detail appropriate for the instrument;
10. A "Failure Mode and Effects Analysis" (FMEA) identifying the instrument's potential failure modes and their consequences, to a level of detail appropriate for the instrument;
11. A final, appropriate baffle design;
12. A final, appropriate stray light and ghost analysis in all operational modes, demonstrating the necessary performance can be met;
13. Alignment tolerances and procedures for all optical elements;
14. Detailed layout of electronics cabinets including location and mounting of each component along with power consumption and mass estimates for each component and the fully populated cabinet.
15. The planned cable layout, illustrating for each cable its major function, power and signals, types of connectors on each end, type of cable wire used (number of conductors, wire gauge, insulating material, and shielding), length, and routing.
16. Software materials progressed since the Preliminary Design Stage to include, at a minimum, the following:
  - a. The software documentation shall completely explain the design of the software system and demonstrate proper operation of the instrument in the Gemini control system.
  - b. The information shall include the detailed design of the software. All the major software components shall be described at the level needed to code. The document shall be at a stage such that any senior software engineer can understand how the software system works.
  - c. Final information shall be included on components of the instrument controlled by software, list of sequencing issues.
  - d. A final dictionary of status items and configuration items.



- e. A thorough demonstration of how instrument status, sequence commands, and events flow in the system using diagrams.
- f. Detector controller software/firmware final design.
- g. A build set of Internal System Interface Documents. All interfaces between internal and external hardware or software subsystems shall be finalized and documented.
- h. All software milestones and releases shall be identified, and schedule points for Gemini collaborative testing at each milestone shall be identified. Software release milestones shall be no less frequent than approximately once every four months.
- i. The final design of the computing hardware, networking, and any extra hardware needed to interface the computing system to the instrument shall be provided.

## 16.1 Critical Design Stage Review

- (a) Contractor shall host and conduct a Critical Design Review following completion of the work identified in Section 16. The meeting shall present a detailed product design to be engineered and tested which meets stated requirements.
- (b) Additional Entrance and Exit criteria for the CDR are presented in Appendix B (20.5).
- (c) In preparing for the critical design the Contractor shall prepare, at a minimum:
  - 1. A set of documentation (see Fig. 4) that completely describes and explains the design of the AOB, demonstrates the AO performance attained and demonstrates the proper execution of the required functions.

The documentation shall be at a stage such that any senior engineer can understand how the AOB is designed and how the system and sub-components can be Integrated and tested to demonstrate that the system is meeting requirements and performance as presented in the AOB Specification document [AD-01]. The information shall include:

- An overview of the final optomechanical design.
  - List of the final selection for the optical and hardware components.
  - Description of all major optical and hardware components and their specifications.
  - Description of the alignment procedure
  - Description of the calibration procedure for the optical and hardware elements concerned.
  - Final Factory Acceptance Test (FAT) plan.
  - A description of how devices will be controlled via the defined software interfaces
  - Internal interface definition
- 2. All interfaces between internal and external hardware or software subsystems shall be finalized and documented in ICD format, indicating how the interfaces are designed for their integration.
  - 3. A test plan for the AOB/RTC integration and test.



4. A final design of the computing hardware, networking, and any extra hardware needed to interface the computing system to external hardware.
5. A final report on Technical Performance Metrics.
6. A draft Factory Acceptance Test (FAT) plan, Onsite Assembly and Installation (OAI) plan, and On-site Acceptance Test (OAT) plan for each RTC System implementation.
7. A complete stage plan for the AOB Implementation, Integration, Verification, and Validation stage

(d) Contractor shall provide the documents listed in the deliverable documentation table provided in Appendix A, Fig 4. The Critical Design shall be considered complete when (i) all of the tasks listed above are complete for the AOB product, and (ii) the design is complete and demonstrated to meet all the stated requirements. Updated PMP and SEMP shall be provided.

(e) Contractor shall document their presentation along with unresolved questions and issues. Contractor shall submit agendas and provide all supporting presentation materials at least 5 business days in advance of the CDR.

(f) As per Section 12.5 (j) and (k), Contractor shall submit a Contractor Review Report to the GNAO Project Technical Representative, including a summary of the CDR discussions and a list of action items. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and the GNAO team in this summary.

## **17 Implementation, Integration, Verification and Validation Stage: Statement of Work**

This section of the statement of work describes the Work conducted by the downselect Contractor during the Implementation, Integration, Verification and Validation (IIV&V) Stage of the project.

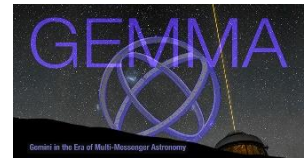
(a) The stage shall begin with a kickoff meeting, shall contain a Manufacturing Readiness Review and an Integration and Testing Readiness Review and shall conclude with an end-of-stage review, as stated in Section 12.2 and 12.5.

(b) Contractor shall create the IIV&V Documentation Set as described in Appendix A, Fig 4.

(c) Contractor shall successfully manufacture, build, and assemble subsystems and integrate, align, and characterize the AOB such that the AOB shall meet all the Requirements. Contractor shall perform the integration of the AOB in conformance with the procedures in the approved final Assembly, Integration and Verification Plan.

(d) During the Realization Phase, in order to allow the Contractor to characterize, test and verify the system, the GNAO Team will provide a version of the RTC System Controller, adequate to test interfaces and support the integration activities of the AOB with the RTC System software.





(e) Contractor shall begin system acceptance testing once the AOB is fully assembled and characterized. Contractor shall test integrated system performance as described in the final version of the Acceptance Test Plan (see Section 19.8). Contractor shall verify that the completed AOB meets all of the Requirements. Where possible, Contractor shall verify by test and include the following:

1. Tests of system performance using calibration source(s) or a telescope simulator at the input focal plane.
2. Tests of the assembled AOB in an appropriate environment to verify operation at typical telescope temperatures and temperature changes.
3. Tests of the assembled Instrument on a variable gravity vector test stand to verify expected structural flexure limits are not exceeded.
4. Characterize the vibration signature of the assembled instrument.

(f) Contractor shall promptly notify the GNAO Project Technical Representative of any testing results that indicate that a particular requirement shall not be met.

(g) Contractor shall create the Pre-Delivery Acceptance Test Report, (pre-ATR; see Section 19.13), documenting the results of all of the tests described in the Acceptance Test Plan (ATP; see Section 19.8), completing the performance matrix, and any revised changes to the ATP which were made during the integration and testing procedures.

(h) Contractor, assisted by AURA when possible, shall apply and obtain any International Traffic in Arms Regulations (ITAR) license(s) and/or other export control license(s) required before transporting the deliverables.

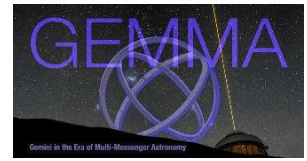
(i) Contractor, assisted by AURA when possible, shall obtain transportation and insurance quotations to transport the AOB Contract Deliverables from Contractor's facility to the AOB Delivery Location.

1. Contractor shall transport the AOB Contract Deliverables with the least risk and least disassembly/reassembly practical.
2. Contractor shall use air freight when transporting across and between continents.

## 17.1 Manufacturing Readiness Review

Within the first couple months of the IIV&V stage and before any manufacturing processes begin (long-lead items excluded), Contractor shall host and conduct (on site or remotely) a Manufacturing Readiness Review (MRR).

- (a) The MRR shall determine if the technical effort is on track to complete the system development, meeting project performance requirements within the identified cost and schedule constraints.
- (b) Additional Entrance and Exit Criteria are provided in Appendix B (20.6).



- (c) Contractor shall document their presentation along with unresolved questions and issues. This documentation shall be submitted to the GNAO Project Technical Representative 5 business days in advance of the MRR.
- (d) Contractor shall submit to the GNAO Project Technical Representative a summary of the MRR discussions and a list of action items within 5 business days after the meeting. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and the GNAO team in this summary.

The GNAO team will provide the Contractor with a post-MRR report containing a list of comments for response within 15 business days after the MRR.
- (e) If the MRR is passed, Contractor will also receive a written notice from the GNAO Project Technical Representative and the AURA Contracts Officer to authorize the procurement of all remaining items.

## 17.2 Integration and Testing Readiness Review

During the IIV&V stage, Contractor shall host and conduct an Integration and Testing Readiness Review (ITRR).

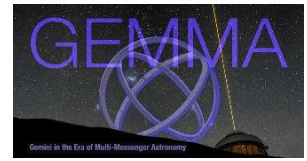
- (a) The ITRR shall ensure that the test articles (hardware/software), test facility, support personnel, and test procedures are ready for testing and data acquisition, reduction, and control.
- (b) The ITRR purpose is to verify that:
  1. Adequate test plans are completed and approved for the system under test,
  2. Identification and coordination of required test resources are completed,
  3. TBD and TBR items are clearly identified with acceptable plans and a schedule for their disposition,
  4. Risks have been identified, credibly assessed, and appropriately mitigated, and residual risk is accepted by project leadership as required.
- (c) Additional Entrance and Exit Criteria are provided in Appendix B (20.7).
- (d) Contractor shall document their presentation along with unresolved questions and issues. This documentation shall be submitted to the GNAO Project Technical Representative 5 business days in advance of the ITRR.
- (e) Contractor shall submit to the GNAO Project Technical Representative a summary of the ITRR discussions and a list of action items within 5 business days after the meeting. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and the GNAO team in this summary. The GNAO team will provide the Contractor with a post-ITRR report containing a list of comments for response within 15 business days after the ITRR.





## 17.3 Factory Acceptance Review

- (a) Contractor shall begin system acceptance testing once the AOB is fully integrated and characterized.
- (b) The Factory Acceptance Test (FAT) plan, shall be completed at the end of the Integration, Implementation, Verification, and Validation stage. The Contractor shall execute the FAT plan and confirm the AOB meets all of the requirements detailed in the updated AOB Specification document [AD-01]
- (c) Contractor shall complete the Onsite Assembly and Installation (OAI) plan and On-site Acceptance Test (OAT) plan for the AOB under development. The OAT plan shall address and verify all items in the compliance matrix.
- (d) Contractor shall create a Pre-Delivery Acceptance Test Report (see Section 19.13) 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.
- (e) The Integration, Implementation, Verification, and Validation Stage shall culminate in a Factory Acceptance Test Review (or IIV&V Acceptance Review) at the Contractor's facility, The FAT Review will focus on the verification and validation of the AOB 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 Project Technical Representative.
- (f) 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 AOB at the Gemini North Telescope facility.
- (g) Contractor shall host and conduct, at their site, a FAT Review (or IIV&V Review). This meeting 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.
- (h) Additional Entrance and Exit criteria are presented in Appendix B (20.8).
- (i) 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 Project Technical Representative.
- (j) The Contractor shall provide the documents listed in the deliverable documentation table provided in Appendix A, Fig.4. Updated PMP and SEMP shall be provided.
- (k) The FAT Review shall be considered complete when all of the tests defined in the FAT Plan, including those repeated at the FAT Review, have been successfully passed, documented, and reviewed by the GNAO Project Technical Representative.



- (l) Contractor shall document their presentation along with unresolved questions and issues. Contractor shall submit agendas and provide all supporting presentation materials at least 5 business days in advance of the FAT Review.
- (m) As per Section 12.5 (j) and (k), Contractor shall submit a Contractor Review Report to the GNAO Project Technical Representative, including a summary of the FAT discussions and a list of action items. The Contractor shall include their responses to items raised by the GNAO Project Technical Representative and the GNAO team in this summary
- (n) Following successful completion of the FAT Review, the AOB shall be shipped to the Gemini Hilo base facility for the Transition to Operation Stage.

## 18 Transition To Operations Stage: Statement of Work

This section of the statement of work describes the Work conducted by the downselect Contractor during the Transition to Operations (TTO) Stage of the project.

- (a) The stage shall begin with a kickoff meeting and conclude with an end-of-stage review as stated in Sections 12.2 and 12.5.
- (b) Contractor shall create the TTO Documentation Set as described in Appendix A, Fig 4.
- (c) Once AURA approves shipment, Contractor shall package the GNAO AOB in a manner that shall protect it from harm during transit in accordance with the specifications contained in [AD-07], and shall then transport the GNAO AOB to the Delivery Location.
- (d) All packing materials must comply with the International Standard for Phytosanitary Measures (ISPM) Publication No. 15, Guidelines for Regulating Wood Packaging Material in International Trade.
- (e) Contractor shall pack the Contract Deliverables into transportation containers and include an appropriate and usable number of:
  1. Shock sensors internal to the transportation containers,
  2. Shock sensors external to the transportation containers, and
  3. Tilt sensors external to the transportation containers.
- (f) Contractor shall insure the GNAO AOB against loss or damage during shipment for the full replacement cost, with AURA and Contractor both named as loss beneficiaries.
- (g) Before the instrument leaves Contractor's facility, Contractor shall fax a copy of the bill of lading, waybill, and insurance documentation, to the AURA Contracts Manager and send the originals by courier service to the Delivery Location. To the extent the bill of lading and waybill do not specify the following information, Contractor shall include it on a separate sheet included with the bill of lading and waybill:

- Weight and dimensions of each package;
- Lifting method to be used with each package, i.e. slings, forklift, or other;



- Estimated date of arrival;
- Employee of Contractor to contact with questions about the shipment.

(h) Before the instrument or any documentation leaves Contractor's facility, Contractor shall ensure that all licenses and documentation for export have been obtained for full compliance with the ITAR, as well as all other United States and other applicable region's laws and regulations controlling the transfer of technology to other nations.

(i) Contractor personnel shall direct AURA-supplied technical personnel in unpacking the instrument and any necessary assembly/configuration according to the Transportation and Telescope Integration Plan (TTIP) (see Section 19.10).

(j) Before beginning facility integration, Contractor shall perform basic fitness tests to verify the GNAO AOB survived transportation to the Delivery Location. Contractor shall compare test results against those obtained in the FAT. Contractor shall perform a subset of acceptance tests before telescope integration. These tests may include additional flexure testing on the instrument test rig. Contractor shall remedy any discovered issues.

(k) Contractor shall perform all the telescope integration tasks, inspections and post-delivery tests described in the TTIP, following the procedures in the ATP, with assistance from AURA. Unless otherwise specified, Contractor shall provide all personnel and equipment necessary to perform the post-delivery tests and inspections.

(l) At the conclusion of the initial round of post-delivery testing, AURA shall review the results of all of the post-delivery tests and inspections specified in the TTIP and ATP. AURA shall then provide Contractor with a written list of all instrument deficiencies that must be corrected. Contractor shall correct all the noted deficiencies and submit new test and inspection results showing that the deficiencies have been corrected.

(m) Once AURA is satisfied that the TTIP has been completed and the Instrument meets all of the AOB Requirements after delivery, and that all other Contract Deliverables, including documentation, meet all contract requirements, it shall give Contractor written notice that the instrument has successfully passed all of the tests and inspections described in the Acceptance Test Plan, and appears to meet all the AOB Requirements. AURA shall then set a date for the end-of-stage review.

## **18.1 Onsite Acceptance Review**

(a) After successful completion of the Transition to Observation (TTO) Stage work, the Contractor shall host and conduct a Final Acceptance Review of the onsite acceptance testing results (OAT).

(b) Technical notes, calculations, measurements, etc., supporting the testing shall be presented and made available to the GNAO Project Technical Representative. Measurements shall be performed, recorded, presented, and provided. Contractor shall archive and make available to the GNAO Project Technical Representative all test results.

(c) Additional Entrance and Exit criteria are presented in Appendix B (20.9).



- (d) At the conclusion of this review, the Contractor shall deliver a written On-site 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.
- (e) The Contractor shall also provide user manuals and other deliverable documentation for the TTO as presented in Appendix A, Fig 4.

## 19 Appendix A: AOB Deliverable Documentation Set

This appendix contains a description and scope for each deliverable document. Fig 4 lists each document and shows the project stages in which each document must be submitted to Gemini for the end-of-stage review assessment. The letter *D* signifies a *draft* version of the document while *CC* means the document goes under change control during that stage.

AOB Deliverable Documentation Set							
Phase	Document ID	Document Filename	Stage				
			CoD	PD	CD	IIV&V	TTO
DESIGN Phase	XXXX-AOB-PMP	Project Management Plan (PMP)	√ CC	√	√	√	√
	XXXX-AOB-SEMP	System Engineering Management Plan (SEMP)	√ CC	√	√	√	√
	XXXX-AOB-SMP	Safety Management Plan (SMP)		√ D	√ CC	√	√
	XXXX-AOB-RD	Requirements Document (RD)	√ D	√ D	√ CC	√	√
	XXXX-AOB-RCM	Requirements Compliance Matrix (RCM)	√ D	√ CC	√	√	√
	XXXX-AOB-FMEA	Failure Modes and Effects Analysis Document (FMEA)	√ D	√ CC	√	√	√
	XXXX-AOB-CoDD	Conceptual Design Document (CoDD)	√ CC				
	XXXX-AOB-EoSr-CoD	CoDS End Stage Report	√ CC				
	XXXX-AOB-ADD	Architecture Design Document (ADD)		√ CC			
	XXXX-AOB-PDD	Preliminary Design Document (PDD)		√ CC			
	XXXX-AOB-IDD	Interface Definition Document (IDD)		√ D	√ CC	√	√
	XXXX-AOB-ATP	Acceptance Test Plan (ATP)		√ D	√ CC	√	√
	XXXX-AOB-EoSr-PD	PDS End Stage Report		√ CC			
	XXXX-AOB-CDD	Critical Design Document (CDD)			√ CC		
	XXXX-AOB-ICD	Interface Control Document (ICD)			√ CC	√	√
	XXXX-AOB-IVP	Integration and Verification Plan		√ D	√ CC	√	√
XXXX-AOB-EoSr-CD	CDS End Stage Report			√ CC			
BUILD Phase	XXXX-AOB-ABR	As-built records				√ CC	√
	XXXX-AOB-SPARE	Recommended Spares List				√ CC	√
	XXXX-AOB-preATR	IIV&V Acceptance Test Report (pre-ATR)				√ CC	√
	XXXX-AOB-S&MM	Service and Maintenance Manual (S&MM)				√ CC	√
	XXXX-AOB-UM	User Manual (UM)				√ CC	√
	XXXX-AOB-TM	Technical Manual (TM)				√ CC	√
	XXXX-AOB-SMM	Software Maintenance Manual (SMM)				√ CC	√
	XXXX-AOB-CVP	Commissioning (deploy) & Validation Plan (CVP)				√ D	√ CC
	XXXX-AOB-TTIP	Transportation and Telescope Integration Plan (TTIP)			√ D	√ CC	√
	XXXX-AOB-EoSr-IIVV	IIV&V End Stage Report				√ CC	
TRANSITION Phase	XXXX-AOB-CVR	Commissioning (Deployment) & Validation Report (CVR)				√ D	√ CC
	XXXX-AOB-postATR	Final Acceptance Test Report (post-ATR)					√ CC
	XXXX-AOB-EoSr-TTO	TTO End Stage Report					√ CC

√ = Required    D = Draft    CC = Change Control    XXXX = Acronym for Contractor name

Fig 4: Deliverable documentation table.



Each document shall be written in English.

Each document should contain a title page containing at least: the document title, document number, author, author's institute, contract number, version number, release date, page number, and total number of pages.

Each page of each document should contain at least the document title, document number, version number, release date, page number, and total number of pages.

Each deliverable document contained within Appendix A should be delivered in source file (e.g. *.docx*, *.mpp*, *.xlsx*, etc.) and in *.pdf*.

Some documents shall either comprise of or be accompanied and supported by, electronic materials of an alternative file format. For example: wiring diagrams, 3D models, OpticStudio (formerly known as ZEMAX) files, Microsoft Project files, etc.

Each deliverable specifies what accompanying/supporting documents are required.

Each document should be written with brevity and only include content which will assist readers in dealing effectively with the information.

The sections below provide additional details for some of the documents listed in Fig. 4.

## **19.1 Project Management Plan [PMP]**

### **19.1.1 Purpose**

The purpose of the Project Management Plan [PMP] is to communicate Contractor's project management approach, methodology, practices, processes, and tools they shall apply through the lifetime of the project. The PMP shall also communicate the specifics related to the creation, monitoring, and control of management elements including budget, schedule, risk, work elements, resources, and communication.

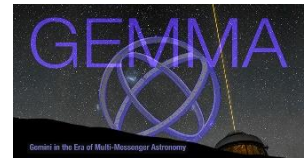
### **19.1.2 Description**

The PMP shall expand on relevant material contained within the proposal to describe how the management team shall manage the project from start to end.

The PMP shall include a description of the project management team's approach and methodology, including any incorporated institutional practices and standards. It should also describe any project management support and training available to the management team by the host institute such as a project management office and any active mentoring arrangements. It shall include details of any other support needed to successfully manage the project such as accounting, contracts, and finance. It shall include details of the project approach to ensure all deliverables, including documentation, are developed meeting requirements and delivered on time.

The PMP shall include a section that describes project management processes and tools covering organizational project resource allocation processes, budget creation and monitoring tools,





schedule tracking and monitoring tools, the process for assigning risk mitigation budget, and schedule contingencies. The section should include what information is provided by each institute to the project and how it is processed by the project and reported to Gemini.

The PMP shall include an organizational structure and a description of how the management team fits into its institutional organizational chart. It shall include project organizational chart(s) displaying the project relationship between institutions and individuals including external stakeholders. It shall describe the roles, responsibilities, and relevant experience of the project's key personnel, including the levels of effort for each. It shall list backup options available for key team personnel.

The PMP shall include a communication plan for the project including details of internal and external meeting and reporting. It shall explain how communication and reporting shall be managed and monitored. It shall describe how Gemini staff will be able to access Contractor documentation during the project.

The PMP shall describe the Work Breakdown Structure (WBS) in enough detail to facilitate reliable costing and tracking throughout the lifetime of the project. Each WBS element shall include the duration, cost, and workforce required. The section should describe how any portions of the work will be subcontracted. The WBS, itself, shall be attached as an appendix.

The PMP shall include a project budget, demonstrating how it is derived from the work packages listed in the WBS. It shall provide enough detail from the WBS along with the corresponding labor hours and charge rates for each task, such that an independent cost analysis may be performed at any point in time. It shall include three-point cost estimates to obtain overall cost margins. This budget section shall describe how costs will be managed, tracked, and controlled during the lifetime of the project. It shall describe how Contractor intends to use the schedule and scope contingency to actively control the budget. An appendix shall contain the details of the budget (the "Cost Breakdown").

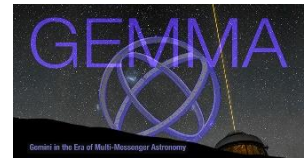
The Cost Breakdown shall contain a list of the expected procurements, describing all major and/or significant components and materials that will need to be purchased. This list shall include the description of the component/material, the estimated quantity, the estimated price with a margin of error, a description of the source of pricing information, the estimated date the procurement will need to be initiated, the estimated vendor's lead time, and the date the item is needed.

The PMP shall describe how the schedule was created. It shall include stage delivery dates with a margin of error and provide an explanation on the schedule structure, schedule reserve and critical path. It shall include a description of the development and delivery schedule for the instrument (through all stages).

It shall demonstrate how the schedule adequately accommodates known risks and likely variations in the plan. It shall clearly identify decision points, especially those related to up-scope and descope options. This section shall describe how the schedule shall be managed, tracked, and controlled during the lifetime of the project. A project Gantt chart shall be attached as an appendix and shall clearly identify all stages of the project, each major work package, dependencies, milestones, long lead items, schedule reserve and shall clearly display the critical path.

The PMP shall describe how risks are identified, categorized, assigned, assessed (for probability and impact), and managed. It shall describe the overall risk management and mitigation approach. It shall describe the major risks identified at the start of the project and include a narrative





description of the research, analysis, or demonstrations that would need to be done to establish the viability of any key or high-risk components. A risk register shall be attached as an appendix. It shall include key risks to schedule, cost, performance, personnel, or any other aspect that would prevent the project from being successful.

Contractor's facilities and subcontractors' facilities must be described. These descriptions will be used during the lifetime of the project. The PMP shall also describe how Contractor shall manage facility resource loading and what backups exist for needed facilities.

### **19.1.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Project Management Approach, Methodology, and Support
- Project Management Processes and Tools
- Project Structure, Roles, and Responsibilities
- Project Communication, Reporting, and Monitoring
- Project Work Breakdown Structure
- Project Budget, Cost Management and Control
- Project Schedule, Schedule Management and Control
- Project Risk Management, Register, and Mitigation Plans
- Facilities

### **19.1.4 Change Control**

This document shall be created during the Conceptual Design Stage and reviewed at the Conceptual Design Review. It shall then be placed under change control and kept up-to-date and resubmitted at every stage review except the Commissioning and Science Verification Review.

## **19.2 System Engineering Management Plan [SEMP]**

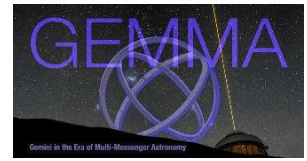
### **19.2.1 Purpose**

The purpose of the System Engineering Management Plan (SEMP) is to communicate the Contractor's system engineering approach, methodology, practices, processes and tools it shall apply to the project during its duration.

### **19.2.2 Description**

The SEMP shall expand on the material contained within the proposal to describe how the management team shall employ systems engineering to manage the technical aspects of the project from start to end.

The SEMP shall include a description of the management team's general approach and methodology to technical management and system engineering, including any incorporated institutional practices and standards. It shall also include the system engineering support, training, and mentoring available to the team by their host institute.



The SEMP shall include a section describing how systems engineering roles and responsibilities are organized within the team. It should also include the system engineering communications methods used within the project.

The SEMP shall include sections that describe the project's systems engineering approach for requirements management, interface management, budget management, information and configuration management, quality management, and verification management. Each section shall describe the process(es) employed, any tools used, the process owners, location and structure of information, and how change control is supported.

These sections should also include what technical information each institute is to provide to the project and how it is processed and reported to Gemini.

The SEMP shall include a requirement management section describing how requirements (science and technical) were structured and created, how they will be flowed down, and how they will be managed, cross referencing the Requirements Document as appropriate.

The SEMP shall include an interface management section on interface definition. It shall describe how project interfaces were created, the current architecture, and how the interfaces shall be maintained and verified.

The SEMP shall include a performance management section describing the performance, error and tolerance budgets including how they were constructed, how contingency was determined, and how they will be maintained throughout the projects. The Performance/Error Budgets shall be attached as an appendix.

The SEMP shall contain an information and configuration management section detailing the configuration management process used for this project including how documents will be numbered, stored, and accessed by partners.

The SEMP shall include a quality management section describing the activities and techniques used to realize quality. These include optimization of science and operational performance through the use of various analysis and trade studies during design, measurement or inspection of completed parts, issue tracking and resolution, and internal and external reviews.

The SEMP shall include a verification management section describing the verification methods that will be used, including details such as planned modeling and simulation, and test events.

The SEMP shall include sections that describe the project's systems engineering activities that occur during each stage of the project.

### **19.2.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- System Engineering Approach and Methodology
- System Engineering Processes
  - Requirements management
  - Interfaces management
  - Budgets management



- Information and configuration management
- Quality management
- Verification management
- Project Stages and Systems Engineering Activities

## 19.2.4 Change Control

This document shall be created during the Conceptual Design Stage and reviewed at the Conceptual Design Review. It shall then be placed under change control and resubmitted at every stage review thereafter with the exception of the Commissioning and Science Verification Review.

## 19.3 Safety Management Plan [SMP]

### 19.3.1 Purpose

The purpose of the Safety Management Plan (SMP) is to communicate the project's approach to keeping personnel and the instrument safe during the project.

### 19.3.2 Description

The SMP shall summarize the aspects of the project that could represent a hazard to personnel, the environment or the instrument. It shall detail safety policy and applicable safety documents, safety requirements for the design process, instrument-specific operational safety issues, areas of risk to the instrument, troubleshooting cautions, and transportation.

The SMP shall be a comprehensive summary with appropriate references to the definitive procedures. It shall identify and mitigate risks associated with all the identified hazards to personnel, the instrument and the facility.

The SMP shall include safety procedures applying to the entire lifespan of GNAO AOB, including construction, integration, commissioning, and operations.

The SMP shall describe any training and certification required for all personnel to perform critical tasks or procedures.

### 19.3.3 Composition (Shall include, but be not limited to, the following sections)

- Introduction
- Institutional Safety Policies and Procedures
- Applying Safety to the Project
- Specific Safety considerations
  - During the Design Phase
  - During the Build Phase
  - During the Telescope Integration and Commissioning Phase



### **19.3.4 Change Control**

This document shall be created during the Conceptual Design Stage and reviewed at the Conceptual Design Review. It shall be placed under change control and resubmitted at every stage review thereafter.

## **19.4 Requirements Document [RD]**

### **19.4.1 Purpose**

The purpose of the Requirements Document (RD) is to communicate the requirements associated with the Contract Deliverables, mostly the GNAO AOB.

### **19.4.2 Description**

The RD shall contain all the requirements pertaining to the deliverables, mostly for the instrument and supporting hardware and software. It shall contain all science, instrument, system, subsystem, and component requirements. Each requirement shall follow the structure communicated in the SEMP and should be either derived from the primary sources (for example: science cases, Gemini requirements, interface control documents) or flow down from other requirements that are in turn derived from the above three primary sources.

Appendix A of the Gemini Instrument Common Requirements document describes a set of recommended data fields and the following fields are required for each requirement:

- A unique identifying number to make it easy to reference
- A running, consecutive version number and corresponding date.
- The source(s) used to derive it, including a brief description of how the requirement was derived from its source along with any assumptions made in the derivation.

Each requirement must be captured such that it is objectively verifiable at some stage in the project. Each requirement must identify the intended method(s) and project stage(s) of verification.

### **19.4.3 Composition (Shall include, but be not limited to, the following sections)**

See Appendix A of the Gemini Instrument Common Requirements document.

### **19.4.4 Change Control**

The RD Science and System level requirements go under change control at the end of the Preliminary Design Stage. The remainder of the requirements go under change control at the end of the Critical Design Stage.

## **19.5 Design Document [DD]**

This section covers the:

- Conceptual Design Document [CoDD]
- Preliminary Design Document [PDD]
- Critical Design Document [CDD]



## 19.5.1 Purpose

The purpose of the Design Document (DD) is to communicate the current design of the GNAO AOB, the Associated Hardware, and the Associated Software.

## 19.5.2 Description

The DD shall expand on the design material contained within the proposal or the design document submitted at the end of the previous stage to provide the current design of the GNAO AOB, Associated Hardware, and Associated Software.

The DD shall begin with an executive summary followed by an introduction before providing a technical overview describing the high level design. Throughout the document relevant material contained in other deliverable documents should be adequately cross-referenced.

The DD shall include a technical overview section and include, at least, the following items:

- A description of the instrument's subassemblies.
- A summary of performed trades, technical budgets and supporting analysis.
- Performance results of any instrument simulations.
- Flexure analysis taking into account both optical and mechanical effects.
- Opto-mechanical error budgets constraining or resulting from the baseline design. Details should be given for particularly difficult or challenging tolerances.
- A summary of existing component designs (hardware or software) to be used in the instrument as a means of reducing risk and/or development time.
- A summary of the technical high-risk items included in a risk register table.
- Remaining up-scope and descope options against the baseline.
- A description providing a comprehensive overview of the entire design of the instrument.
- A description of priorities in balancing science vs. performance trades.
- Science cases cross-referenced to instrument requirements. A summary of the flow down of the science cases cross-referenced to the instrument requirements, as listed in the Requirements Document. The ConOps develops this flow down in more detail, but a general overview and summary of the key science drivers and requirements is desired here.
- A compliance summary matrix comparing the requirements and the current design.

The structure of the remainder of the document should be such that it is easy to follow and links well with information provided in other documents. Whether arranged by work package or by discipline, the design documents shall include the following items:

System design items:

- System budgets
- Technical risks

Optical design items:

- A depiction of the general layout of the optical components.
- A description of optical mounting schemes, including the general approach used to mount and align all optical components.
- A description of key risks associated with the optical design, e.g. long-term stability of optical alignment, manufacturability, coating reliability, expected lifetimes, etc.



- A summary of expected throughput, over the lifetime of the instrument.
- A summary of all optical elements contained in the instrument and coatings that will be used.
- A description of the throughput budgets.
- Detailed surface specifications (material, purity, surface curves, dimensions, scratch/dig, coatings, etc.) for each optical element so that replacements may be obtained if necessary.

Mechanical design items:

- An overview of the instrument's mechanical design.
- An overview of the instrument's subassemblies schematics in the mechanical layout.
- Designs (3D models / drawings) for all subassemblies.
- A description of the design elements that are common to multiple assemblies.
- Outline of instrument integration procedure to verify that there are no significant integration and testing challenges.
- Analysis showing there are no significant instrument handling or space envelope issues with the design as conceived.

Electrical design items:

- An overview of the instrument's electronic systems.
- Estimate of the number of separate control systems the electronics design must support.
- Description of approach to controlling stepper motors and actuators.
- A general layout and wiring scheme for major electronic components.
- A summary of the use of commercial vs. custom boards.
- A description of the detector and controller.

Other items to be included:

- A current design description of the Associated Hardware and Associated Software.

### **19.5.3 Composition (Shall include, but be not limited to, the following sections)**

- Executive Summary
- Introduction
- Technical Overview
- Design details (structured to provide the best read and flow for the current stage)

### **19.5.4 Change Control**

Once submitted, discussed, reviewed, and fully accepted (expected on successful completion of the stage review), the document shall be archived.

## **19.6 End Stage Report(s)**

NOTE: This description covers all the End Stage Reports, one required for each stage, except the last.





### **19.6.1 Purpose**

The purpose of the End Stage Report is to review the progress of the project to date including how the stage performed against the original project and stage plan baseline. It shall recount the major successes and challenges of the stage, suggest future actions based on lessons learned, and include requests related to deviations associated with the next stage.

### **19.6.2 Description**

The End Stage Report shall comment on the validity of the project's driving science cases considering the advances in astronomy during the stage, including the status of synergistic facilities and surveys. If the driving science cases are no longer valid, comment on new science cases that the instrument could still address.

The report shall review both the project and stage objectives and cover how the project has performed to date against its planned targets and tolerances for schedule, cost, quality, scope, and risk. This description shall include a comparison with the start of project baseline and the beginning of stage baseline. It shall include a review of key metrics.

The report shall include a review of team performance, particularly highlighting outstanding individual and team performance for project recognition.

The report shall review the status of stage deliverables and describe any shortfalls. It shall describe major successes and failures of the stage. The report shall contain report lessons learned, a review of what went well, what went badly, how the project may adapt going forwards, and any recommendations for Gemini's consideration.

It shall include the current set of issues and risks affecting the project and should include any requests related to deviations associated with the next stage.

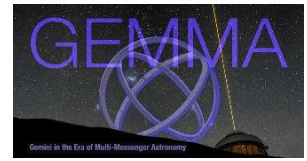
The report shall conclude with a project manager's forecast for the project and the next stage against planned targets and tolerances for time, cost, quality, scope, benefits, and risks.

### **19.6.3 Composition (Shall include, but be not limited to, the following sections)**

- Summary (Summarizing the stage performance)
- Review of the driving Science Cases
- Performance Review of Project and Stage objectives.
- Team Performance Review
- Stage Deliverable Status (major successes and failures)
- Lessons Learned
- Issues and risks
- Forecast

### **19.6.4 Change Control**

Once submitted, discussed, reviewed, and accepted, the document shall be archived.



## **19.7 Interface Definition Documentation [IDD]**

### **19.7.1 Purpose**

The purpose of the Interface Definition Documentation Set (IDD) is to communicate the definition of the existing interfaces at all the layers of the products and sub-products of GNAO Facility and the interfaces to the Observatory. An IDD is also required for contracted products.

### **19.7.2 Description**

The IDD shall document all interfaces between internal hardware or software subsystems including any software systems from third-party vendors.

### **19.7.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Interface Details

### **19.7.4 Change Control**

This document shall be created during the Conceptual Design Stage and reviewed at the Conceptual Design Review. It shall then be placed under change control and resubmitted at every stage review thereafter.

## **19.8 Acceptance Test Plan [ATP]**

### **19.8.1 Purpose**

The purpose of the Acceptance Test Plan (ATP) is to communicate the test plan for the AOB both pre- and post- delivery.

### **19.8.2 Description**

For each top-level instrument and science requirement, the ATP shall contain a verification matrix containing the verification method (e.g. by analysis of the design document, by inspection of the completed hardware or software, or by execution of an acceptance test procedure) and that stage(s) during which (e.g. pre-delivery and/or post-delivery) the test shall occur.

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.

For every requirement, the ATP shall name the person expected to carry out the verification and identify the estimated duration for configuring the instrument or associated test equipment, the duration of performing the verification, and the anticipated duration to perform adequate analysis.



The ATP shall clearly state the success criteria and any test prerequisites, including specific software or hardware needed, for each tested requirement.

A test set-up section should describe any special set-up either involving the instrument (such as being attached to a flexure rig, or within an environmental chamber) or attached to the instrument (such as a calibration source or turbulence injector).

The step-by-step procedure for each verification procedure shall be sufficiently detailed to allow AURA 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 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. These tests are included in the Commissioning and Science Verification Plan.

### **19.8.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Verification Matrix [Test, Requirement, Stage of Verification (pre-delivery, post-delivery)]
- Test
  - Tester
  - Log
  - Estimate Duration (configuration time, test time, analysis, and report time)
  - Success Criteria
  - Prerequisites
  - Safety Issues
  - Test Set Up
  - Test Procedure

### **19.8.4 Change Control**

The ATP shall go under change control when delivered.

## **19.9 Interface Control Documentation [ICD]**

### **19.9.1 Purpose**

The purpose of the collaboratively developed Interface Control Documentation (ICD) is to communicate the implementation of all the AOBs internal and external interfaces that integrate the Facility as described in the IDD.

### **19.9.2 Description**

The ICD shall document all interfaces between internal hardware or software subsystems including any software systems from third-party vendors.



### **19.9.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Interface Details

ICDs may contain drawings and schematics to describe the implementation of mechanical, electrical, optical, etc.

### **19.9.4 Change Control**

This document shall be created during the Conceptual Design Stage and reviewed at the Conceptual Design Review. It shall then be placed under change control and resubmitted at every stage review thereafter.

## **19.10 Transportation and Telescope Integration Plan**

### **19.10.1 Purpose**

The purpose of the Transportation and Telescope Integration Plan is to provide procedures that successfully transport, unpack, integrate, test the instrument in a subcontractor facility and/or at the Gemini Facility, and mount the instrument on the telescope to integrate it into the telescope control system.

The TTIP shall be created by Contractor with input from Gemini.

### **19.10.2 Description**

The TTIP shall contain sections and information that reflects the changes resulting from refocusing the remaining work from Contractor's facility to the Delivery Location.

A section containing context, assumptions and constraints shall provide target dates, facility accessibility, team resources and availability and remaining budget. Changing or new roles and responsibilities of the project team shall be provided along with a communication plan specific to the stage that conforms to Gemini daytime support.

The TTIP shall contain the details of knowledge transfer tasks and define periods in which Gemini staff will be trained in the operation, repair, and maintenance of the instrument, from optical, mechanical, electronics, and software perspectives during the stage.

The TTIP shall include a description of the equipment needed to complete this stage of the project, including both Contractor provided equipment and AURA provided equipment at the Delivery Location to complete tasks contained within this document.

The TTIP shall include checklists related to the step-by-step procedures contained within the plan. These checklists shall be placed in appendices. They shall be followed and completed by team members when performing the procedures and placed into the Transportation and Telescope Integration Report before submission.



The TTIP shall contain a section containing step-by-step instructions describing how to prepare the Contract Deliverables for transportation. This section shall include information on packing the GNAO AOB and Associated Hardware, identifying the sensors to be attached. A packing list shall be included as an appendix. The TTIP shall contain a section containing information on transportation and insurance. The associated checklist shall include items needed both before and during transportation.

The TTIP shall contain information on unpacking and storage. It shall cover inspections, unpacking, reassembly (if required), cabling, and clean room inspection. The TTIP shall include the storage location of spares.

The TTIP shall include a section on the procedures relating to fundamental operations, including connecting services (air supply, glycol, etc.), power up and basic status and alignment checks. It shall include any computer configuration, low-level mechanism tests and monitoring scripts to ensure safety.

The TTIP shall contain a section detailing software integration tasks to enable the software systems to be integrated as much as possible before being mounted on the Instrument Support Structure. The TTIP shall also include a description of the flexure rig characterization process and post-delivery acceptance tests (referencing the ATP) that would be performed before installing the instrument on the Instrument Support Structure (ISS).

The TTIP shall include a procedure to move the instrument from the instrument test room to the dome floor and a procedure to mount the instrument to the ISS. It shall contain all procedures and testing prior to obtaining first light on the instrument. These tests shall include monitoring the effects of vibration and testing optical alignments using GCAL or other telescope subsystems.

### **19.10.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Context, assumptions, and constraints
- Knowledge Transfer
- Equipment
- Packing and Preparation
- Transportation and Insurance
- Unpacking and Storage
- Fundamental Operation and Survivability Tests
- Software Integration
- Flexure Rig Characterization
- ISS Installation
- Post Delivery Acceptance Testing

### **19.10.4 Change Control**

Once submitted, the plan shall go under change control until the Transportation and Telescope Integration stage is completed, at which point it shall be archived.



## **19.11 As-built Records**

### **19.11.1 Purpose**

The purpose of the As-built Records is to provide Gemini with all the specifications, 3D models, 2D manufacturing drawings, wiring diagrams, and software code to successfully refabricate and acquire the components of the GNAO AOB such that it could be duplicated.

A main document should be provided explaining how record documentation is structured.

### **19.11.2 Description**

The As-built Records shall include an electronic copy of the following items:

- 3D CAD model of the entire instrument,
- 2D manufacturing drawings (also provided as a hardcopy),
- Parts List (also provided as a hardcopy),
- Electronic schematics (also provided as a hardcopy),
- Wiring Diagrams (also provided as a hardcopy),
- Software source code,
- Procurement Specifications and quotations for purchased components, including those not selected,
- Items required for assembling components (bonding materials, glues, etc.)

The As-built Records shall represent the as-built instrument and NOT the as-designed instrument.

### **19.11.3 Composition (Shall include, but be not limited to, the following sections)**

Multiple files. The main document should contain (at least):

- Introduction
- Methodology
- Structure of records (including file names and document codes)

### **19.11.4 Change Control**

The As-built records go under change control when delivered.

## **19.12 Recommended Spares List**

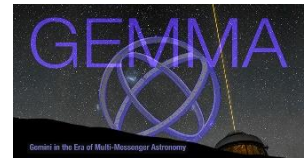
### **19.12.1 Purpose**

The purpose of the Recommended Spares List is to provide Gemini with a list of spare GNAO AOB hardware components Contractor believes are important for Gemini to obtain. It shall include a list of spares that shall be delivered with the GNAO AOB as part of the Associated Hardware.

### **19.12.2 Description**

The Recommended Spares List shall contain a list of recommended instrument components. The Recommended Spares List should consider a number of factors including component reliability (factoring any mean-time-to-failure statistics), obsolescence (our ability to purchase the





component in the future), lead-time (how long it will take to procure a replacement) and impact (how the instrument performance would be affected were the item to fail).

The document shall include links to the original specifications and quotation from the As-built Records.

The Recommended Spares List shall also describe any spares that will be provided with the instrument.

### **19.12.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Methodology
- Spares provided with the instrument (include table)
- Recommended Spares (include table including the following)
  - Component/item
  - Reliability Score
  - Availability Score
  - Impact Score
  - Overall Ranking
  - Cost
  - Supplier
  - Link to specification and quotation
  - Notes

### **19.12.4 Change Control**

The Recommended Spares List shall be delivered to Gemini at the end of the Build Phase.

## **19.13 IIV&V Acceptance Test Report [pre-ATR]**

### **19.13.1 Purpose**

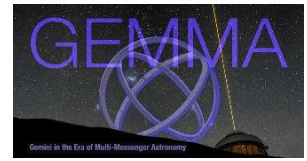
The purpose of the Pre-Delivery Acceptance Test Report (pre-ATR) is to document the results of the requirement verifications performed on the GNAO AOB before it has been delivered to the Delivery Location.

### **19.13.2 Description**

The basis of the pre-ATR is the Acceptance Test Plan (ATP).

The pre-ATR shall report on all the requirements marked in the ATP verification matrix as needing verification prior to delivery to the Delivery Location.

The pre-ATR shall retain the structure of the ATP, removing test procedures not requiring pre-delivery verification. A test results section shall be added for each test and shall contain the results,



conclusion, and a clear PASS/FAIL assessment as to whether the verification demonstrates the requirements were met. Any deviations from the test procedure contained in the change controlled version of the ATP shall be noted and explained.

### **19.13.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Verification Matrix [Test, Requirement]
- Test
  - Tester
  - Log
  - Estimate Duration (configuration time, test time, analysis and report time)
  - Success Criteria
  - Prerequisites
  - Safety Issues
  - Test Setup
  - Test Procedure
  - Test Result

### **19.13.4 Change Control**

Once submitted, discussed, reviewed, and fully accepted (expected on successful completion of the stage review), the document shall be archived.

## **19.14 Service and Maintenance Manual [S&MM]**

### **19.14.1 Purpose**

The purpose of the Service and Maintenance Manual is to provide Gemini with the information necessary to service and maintain the GNAO AOB.

### **19.14.2 Description**

The S&MM shall include a list of inspection and maintenance procedures developed during the project. The S&MM shall describe each procedure, including its purpose, the duration required to perform it, and the recommended frequency of performance.

The S&MM shall reference specific as-built drawings as required for component identification and specifications. It shall reference the Technical Manual (see Section A.14) for procedures that are described there and shall reference the pre-delivery acceptance test report for results pertaining to testing as required.



### **19.14.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Safety
- Required Facilities and Equipment
- Regular inspection procedures
- Regular maintenance procedures
- Engineering Troubleshooting Guide

### **19.14.4 Change Control**

The S&MM shall be under change control when delivered.

## **19.15 User Manual [UM]**

### **19.15.1 Purpose**

The purpose of the User Manual (UM) is to provide a Gemini Instrument Scientist and Gemini Instrument Engineer with an understanding of the GNAO AOB and its operation. It shall provide information on the GNAO AOB's configuration, modes of operation, user calibration procedures, and instrument performance characteristics.

### **19.15.2 Description**

The UM shall contain all information necessary to enable a Gemini Instrument Scientist who is familiar with the Gemini telescopes, but not necessarily familiar with the instrument, to understand the operation of the instrument.

The UM shall begin with a technical overview of the instrument, written for someone familiar with astronomical instrumentation, but not an instrument engineer or builder. This section shall include a description of the mechanisms in the instrument, the optical path, and the detector and controller type and general capabilities.

The UM shall be delivered before the instrument is integrated at the Delivery Location with the Gemini's Observatory Control Software; hence it shall also describe how to use the instrument in the laboratory. Any safety issues associated with operation shall be clearly stated or referenced.

The UM shall contain a description of all functionality available to the user on any user-level graphical user interfaces. It shall communicate the meaning of all warnings and alarms and explain how to appropriately respond to them.

The UM shall include any user-controlled calibrations that are performed during day-time instrumentation preparation and night time observing. It shall also include procedures for taking calibration data such as flats, arcs, etc.

The UM shall contain an overview of the different operational modes and how to execute them in the instrument software.



The UM shall cross-reference material in the Concept of Operations Document and Technical Manual when appropriate.

### **19.15.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- The instrument design and configuration
- Operating the instrument as a user
- Safety Issues
- Modes of operation
- Calibration procedures
- The instrument performance characteristics

### **19.15.4 Change Control**

The UM shall go under change control when delivered.

## **19.16 Technical Manual [TM]**

### **19.16.1 Purpose**

The purpose of the Technical Manual (TM) is to provide Gemini with the necessary technical information to assemble, align, internally calibrate, cable, and place the GNAO AOB into an operational state and also provide a technical understanding of the design and structure of the GNAO AOB.

### **19.16.2 Description**

The TM shall provide a technical description of the instrument and explanations of its working. Material from design documentation shall be updated (to reflect the as-built instrument) and placed into the Technical Manual.

The TM shall describe the step-by-step assembly and disassembly procedures referring to Associated Hardware as needed. It should include a step-by-step alignment procedure identifying any challenging steps or known difficulties.

The TM shall include internal instrument calibration procedures and the population of any look-up tables referring to any Associated Software if external software routines are needed to complete tasks.

The cabling procedure should be provided, highlighting any steps that require special attention for safety. Warm up/cool down procedures and power up/power down procedures should also be provided.

By referencing the as-built records, the technical manual should allow the reader to build and prepare a clone of the instrument.



### **19.16.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
  - Technical description of the instrument and subsystems
- Safety
- Required Facilities and Equipment
- Assembly/Disassembly procedure
- Alignment procedure
- Internal mechanism calibration procedure
- Cabling procedure
- Warm-up/Cool-down procedure
- Power up/power down procedure

### **19.16.4 Change Control**

The TM shall go under change control when delivered.

## **19.17 Software Maintenance Manual [SMM]**

### **19.17.1 Purpose**

The purpose of the Software Maintenance Manual (SMM) is to provide Gemini with a description of the GNAO Instrument software at a level of detail that a programmer familiar with the Gemini software environment, but not initially familiar with the instrument software, can maintain it properly.

### **19.17.2 Description**

The SMM shall include detailed written descriptions of all software systems and subsystems at a high level, describing purpose, organization, and interaction with other software systems and subsystems.

The SMM shall include any systems analyses, data flow diagrams, data dictionaries, structure charts, and specifications developed during the software design process reflecting as-built condition.

The SMM shall also include listings of all software delivered as part of the system, including firmware in all ROMS, and PROMS on any custom or semi-custom designed electronics boards, etc.

All software source code modules shall include a standard header documenting the module contents. Each module shall contain a sufficient number and quality of comments explaining the purpose and function of each few lines of code so that a programmer unfamiliar with the software can understand it.



### **19.17.3 Composition (Shall include, but be not limited to, the following sections)**

The composition should include the items contained within the description and shall be structured in the manual in a way which makes the most sense.

#### **19.17.4 Change Control**

The SMM shall go under change control when delivered.

## **19.18 Commissioning (Deploy) & Validation Plan [CVP]**

### **19.18.1 Purpose**

The purpose of the Commissioning and Science Verification Plan (CSVP) is to communicate the plan and procedures needed to systematically characterize the performance of the instrument in all of its modes and verify any remaining concept of operations requirements and science requirements. The validation is done by executing the Commissioning Plan to ensure that the stakeholder expectations have been met.

### **19.18.2 Description**

The CSVP describes the set of on-sky observations and tests that shall be performed to measure all aspects of instrument performance that will be necessary or helpful for planning science observations using the instrument.

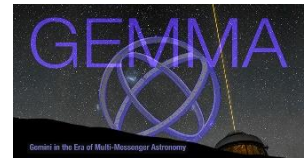
The CVSP shall contain estimates of the time and resources (both supplied by Contractor and its associated Subcontractors and by AURA) required to perform each procedure and an analysis of the total time and resources necessary to fully perform the plan.

The CVSP shall include commissioning tasks associated with the data reduction software.

### **19.18.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Overview (containing a summary table)
- Compliance Matrix (associated with remaining concept of operations and science requirement)
- Test (For each test)
  - Description
  - Prerequisites
  - Observing Condition
  - Contractor Lead
  - Gemini Lead
  - On-sky time required
  - Post observation time required (to analyze data and create report)
  - Step-by-step Observing Procedure
  - Results (blank for the plan, completed for the report)





## 19.18.4 Change Control

The CSVP shall go under change control when delivered. If situations arise that cause a real-time change in the test during execution, Contractors shall update the CSVP accordingly.

## 19.19 Final Acceptance Test Report [post-ATR]

### 19.19.1 Purpose

The purpose of the Final Acceptance Test Report (post-ATR) is to communicate the results for the requirement verifications performed on the GNAO AOB after the instrument has been delivered to the Delivery Location.

### 19.19.2 Description

The basis of the post-ATR is the Acceptance Test Plan (ATP). The post-ATR shall report on all the requirements marked in the ATP verification matrix as needing verification after delivery to the Delivery Location.

The post-ATR shall retain the structure of the ATP, removing test procedures not requiring post-delivery verification. A test results section shall be added for each test and shall contain the results, conclusion, and a clear PASS/FAIL assessment as to whether the verification demonstrates the requirements were met. Any deviations from the test procedure contained in the change control version of the ATP shall be noted and explained.

### 19.19.3 Composition (Shall include, but be not limited to, the following sections)

- Introduction
- Verification Matrix [Test, Requirement]
- Test
  - Tester
  - Log
  - Estimate Duration (configuration time, test time, analysis, and report time)
  - Success Criteria
  - Prerequisites
  - Safety Issues
  - Test Set Up
  - Test Procedure
  - Test Result

### 19.19.4 Change Control

Once submitted, discussed, reviewed and fully accepted (expected on successful completion of the stage review), the document shall be archived.



## **19.20 GNAO AOB End Project Report**

### **19.20.1 Purpose**

The purpose of the GNAO AOB End Project Report is to review how the project performed against its baseline. It shall also contain lessons learned and details of ongoing risks, and potential future enhancements and upgrades.

### **19.20.2 Description**

The GNAO AOB End Project Report shall compare the actual delivered specification against the requirements, the actual completion date and schedule against the Completion Date and baseline schedule, and the actual cost of the project against the baseline stage budgets, building on the information contained within the last stage report.

It shall also contain a number of lessons learned during the final stage of the project in addition to summarizing the major lessons learned over the entire project.

Any tasks that were not completed or requirements that were waived that require further work should be identified and detailed to provide AURA enough information to continue working on those items, if desired.

Ongoing risks should be identified and the latest version of the risk register should accompany the report.

Potential future enhancements should be presented with cost and schedule estimates.

### **19.20.3 Composition (Shall include, but be not limited to, the following sections)**

- Introduction
- Performance Review
- Lessons Learned
- Unfinished Work
- Ongoing Risks (accompanied with Risk Register)
- Potential Future Enhancements and Upgrades

### **19.20.4 Change Control**

Once submitted, reviewed, and accepted the document shall be archived.



## 20 Appendix B: AOB Reviews Entrance and Exit Criteria

This appendix contains entrance and exit criteria for each review.

### 20.1 System Requirement Review: Entrance and Exit Criteria

#### 20.1.1 Entrance Criteria:

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- or a timely closure plan exists for those items remaining open.
- A preliminary SRR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the SRR.
- Stakeholders have been identified and stakeholder expectations have been defined and are ready to be baselined after review comments are incorporated.
- High level requirement stakeholder signoff prior to SRR.
- Preliminary Verification and Validation method identified for each requirement.
- Technical system requirement-related risks identified and technically assessed.
- Interfaces with external systems are identified.
- Preliminary MOPs and TPM and other key driving requirements identified.

#### 20.1.2 Exit Criteria:

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- The functional and performance requirements defined for the system are responsive to the stakeholder needs and parent requirements, reflect the system's intended operational use, and represent capabilities likely to be achieved within the scope of the project.
- The maturity of the requirements definition and associated supporting materials is sufficient to begin the Conceptual Design Stage.
- System Interfaces with external entities have been identified.
- Preliminary approaches have been determined for how requirements will be verified and validated.
- System requirement-related risks have been identified and technically assessed, and viable mitigation strategies have been identified.
- Lessons learned by the Contractor from other projects and programs have been identified and addressed.
- Functional Baseline established, including functional, interoperability, and interface requirements.



## 20.2 Conceptual Design Review: Entrance and Exit Criteria

### 20.2.1 Entrance Criteria:

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary CoDR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the CoDR.
- Programmatic products are ready for review at the maturity levels stated in the governing program/project management guidance:
  1. Project goals and objectives.
  2. Risk register containing top technical, cost, schedule, and safety risks with developed associated risk management and mitigation strategies and options.
  3. Preliminary engineering development assessment and procurement plans to achieve what needs to be accomplished in the next phase.
  4. Initial risk-informed cost and schedule estimates for implementation.
- A preliminary SEMP (or equivalent project documentation), including technical plans.
- Updated and released concept of operations.
- The concept has been developed to a sufficient level of detail to demonstrate a technically feasible solution (including software) to the project needs and is ready to be baselined after review comments are incorporated.
- Alternative concepts have been analyzed and are ready to be reviewed, including preliminary descope options.
- Preliminary requirements allocation to the next lower level system has been performed.
- Preliminary approach to verification and validation identified for the selected concept(s).
- Key Measures of Performance, technical budgets and technical performance metrics are defined.
- A conceptual PBS has been initiated.
- Initial FMEA draft, including identification of critical functions and requirement for failure detection/failure isolation provisions.

### 20.2.2 Exit Criteria:

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- Project objectives are clearly defined and stated and are unambiguous and internally consistent.
- The selected concept(s) satisfactorily meets the stakeholder expectations.
- Preliminary requirements flowdown complete.
- Risk and mitigation strategies have been identified and are acceptable based on technical risk assessments.
- The concept evaluation criteria to be used in candidate systems evaluation have been identified and prioritized.
- The project is feasible. A concept has been identified that is technically and logistically feasible. A rough cost estimate is within an acceptable cost range.
- Technical planning is sufficient to proceed to the next phase and includes planning for hardware, software, human systems, and data deliverables.



- Alternative concepts have adequately considered the use of existing assets or products that could satisfy the project or parts of the project.
- Lessons learned from other projects and programs have been identified and addressed.

## **20.3 Architecture Design Review: Entrance and Exit Criteria**

### **20.3.1 Entrance Criteria:**

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary ADR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the ADR.
- Supporting analyses, functional/timing descriptions, and allocations of functions to architecture elements ready for review.
- Requirements flowed down sufficiently to support architecture decisions.
- Defined architecture, including major tradeoffs and options ready to be baselined after review comments are incorporated.
- Preliminary system interface definitions.
- Approval and status of technical performance related to leading indicators, margins, TPMs, and resolution of the previous review discrepancies addressing effectiveness of technical achievement and communicating the overall risk to the project.

### **20.3.2 Exit Criteria:**

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- All technical requirements are allocated to the architectural elements.
- The proposed system architecture is credible and responsive to program requirements and constraints.
- The architecture tradeoffs are completed, and those planned for the Preliminary Design Stage adequately address the defined design solution.
- Lessons learned from other projects and programs have been identified and addressed.

## **20.4 Preliminary Design Review: Entrance and Exit Criteria**

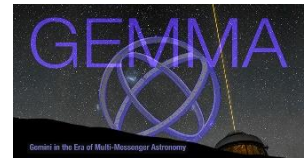
### **20.4.1 Entrance Criteria:**

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary PDR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the PDR.



- Programmatic products are ready for review at the maturity levels stated in the governing project management guidelines:
  1. Updated risk assessment and mitigation, with all major design risks eliminated or reduced to an acceptable level.
  2. Life-Cycle Cost and Integrated Master Schedule (IMS) that are ready to be baselined after review comments are incorporated.
  3. Procurement plan established. Long lead time items have been identified and accounted for.
  4. A complete stage plan for the Critical Design Stage.
- Systems Engineering products are ready for review at the maturity levels stated in the governing project management guidelines:
  1. Initial draft Sustainment Plan, including Service and Maintenance Schedule.
  2. An updated SEMP (or equivalent project documentation), including technical plans.
- Updated and released concept of operations.
- All major design trade options shall be resolved or, if not, an adequate plan exists for timely resolution.
- All technical budgets and tolerances shall be established and documented.
- A preliminary design that can be shown to meet all technical requirements and performance measures or has waivers.
- The software design shall be detailed as follows:
  1. 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.
  2. The associated hardware and physical layout of the software components shall be included.
  3. Software design document that describes the proposed solution at a level of detail to adequately explain how the system will operate under typical required situations.
  4. A preliminary list of software configuration items.
  5. 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.
  6. 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.
  7. A list of software milestones, releases, and schedule points for Gemini collaborative testing at each milestone (at least once every four months).
  8. 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.
- Schematic details of the system's 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, that are ready to be baselined after review comments are incorporated.
- Baselined system requirements complete.





- Subsystem design specifications (hardware and software), with supporting trade-off analyses and data, as required, that are ready to be baselined after review comments are incorporated.
- An outline of the Factory Acceptance Test (FAT) plan, On-site Assembly and Installation (OAI) Plan, and Site Acceptance Test (SAT) plan for each system implementation in addition to a draft version of the Acceptance Test Plan (ATP).
- Compliance matrix ready to be baselined.
- Interfaces shall be defined in the Interface Definition Document (IDD) and draft ICDs provided.
- Preliminary technical performance related to margins, TPMs, and status of associated technical risks.
- Conceptual PBS that was demonstrated at CoDR has been progressed to a more detailed version.
- Updated FMEA(s) and FMECA(s) including system response to failure detection/failure isolation provisions.
- Draft Safety Management Plan.
- Initial reliability analyses and assessments.
- Applicable design standards that have been identified and incorporated.
- If applicable, plans to respond to regulatory requirements (e.g., Environmental Impact Statement), that are ready to be baselined after review comments are incorporated.
- Preliminary engineering drawing set.

## 20.4.2 Exit Criteria:

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- The following Project Management products are in the stated status:
  1. The program/project cost and schedule are credible and within program/project constraints
  2. The project risks are understood and have been credibly assessed, and plans, a process, and resources exist to effectively manage them
  3. Procurement and supply chain risk management execution is complementary with the technical development schedule. Long lead time items approved for procurement.
- The concept of operations is technically sound and reflected in the design.
- System requirements - including project success criteria, TPMs, and any sponsor imposed constraints - are agreed upon, finalized, stated clearly, and consistent with the preliminary design.
- The flow down of verifiable requirements is complete and proper, or, if not, an adequate plan exists for timely resolution of open items. Requirements are traceable to parent technical requirements and to project goals and objectives.
- The preliminary design is expected to meet the requirements at an acceptable level of risk.
- Adequate technical and programmatic margins and resources exist to complete the development within budget, schedule, and known risks.
- Heritage designs have been suitably assessed for applicability and appropriateness and adequate planning exists for the development, insertion, or deployment of any enabling new technology.
- Technical trade studies are mostly complete to sufficient detail and remaining trade studies are identified, plans exist for their closure, and potential impacts are understood.



- Appropriate modeling and analytical results are available and have been considered in the design.
- Definition of the system interfaces (both external entities and between internal elements) is consistent with the overall technical maturity.
- Manufacturability has been adequately considered in design.
- Lessons learned from other projects have been identified and addressed.
- Allocated requirements baseline established.

## 20.5 Critical Design Review: Entrance and Exit Criteria

### 20.5.1 Entrance Criteria:

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary CDR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the CDR.
- Programmatic products are ready for review at the maturity levels stated in the governing project management guidelines:
  1. Updated risk assessment and mitigation with all major design risks eliminated or reduced to an acceptable level.
  2. For Subsystem: A complete Integration Plan for Implementation, Integration, Verification, and Validation phase.
  3. For System: A draft Integration Plan for Implementation, Integration, Verification, and Validation phase.
  4. Products requiring MRR are identified and the plan for completion is well-defined.
- Initial draft Sustainment Plan, including Service and Maintenance Schedule.
- All technical budgets and tolerances shall be current and documented
- Technical design work products (as applicable) for hardware, software, and human system elements have been made available to the cognizant participants prior to the review:
  1. A baselined detailed design that can be shown to meet all technical requirements and performance measures or has waivers.
  2. Product build-to specifications along with supporting trade-off analyses and data that are ready to be baselined after review comments are incorporated. For products that will undergo MRR detailed drawings will be in draft form.
  3. Fabrication, assembly, integration, and test plans and procedures are being developed and are ready to be baselined after review comments are incorporated.
  4. Technical data package (e.g., integrated schematics, spares provisioning list, interface control documents, engineering analyses, and specifications) ready to be baselined after review comments are incorporated.
- A set of software documentation that describes the design of the software system and demonstrates proper execution of the required functions. The information shall include:
  1. An overview of the software architecture
  2. Description of all major software components.
  3. Description of instrument's status and commands.
  4. Description of configuration file purpose and format.
  5. Description of development platform and tools.
  6. Description of processing design choices.
  7. A final dictionary of command and status items.



- 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
- 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 4 months.
- A final design of the computing hardware, networking, and any extra hardware needed to interface the computing system to external hardware.
- Updated system requirements.
- A draft Factory Acceptance Test (FAT) plan, Onsite Assembly and Installation (OAI) plan, and Onsite Acceptance Test (OAT) plan for each system implementation along with Acceptance Test Plan(s) (ATP) that are ready to be baselined after review comments are incorporated.
- A complete set of requirements with verification method ready for baseline.
- A build set of Internal System Interface Documents. All interfaces between internal and external hardware or software subsystems shall be finalized and documented.
- Analysis required to show design meets Technical Performance Metrics.
- PBS progressed to the final version.
- Updated detailed FMEA, including assessment of individual component failure conditions. Initial draft of software detailed FMEA if applicable.
- Updated Safety Management Plan, with major hazards identified, and controls/mitigation plans defined.
- Updated reliability analyses and assessments.
- Draft spares list with major components identified.
- Design for required supporting hardware such as Ground Support Equipment and any other related auxiliary hardware at the same level of maturity as system design.

## 20.5.2 Exit Criteria:

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- The following Project Management products are in the stated status:
  1. The program/project cost and schedule estimates are credible and within program/project constraints.
  2. Risks to safety and project success are understood and credibly assessed and plans and resources exist to effectively manage them.
  3. Procurement risk management execution is complementary with the technical development schedule.
  4. Detailed phase plan is credible and within program constraints.
- The CONOPS has matured, is at a CDR level of detail, and has been considered in test planning.
- The detailed design meets the entrance criteria and is shown to meet the requirements via respective analyses or appropriate design documentation. Adequate technical and programmatic margins (e.g., mass, power, memory) and resources exist to complete the development within budget, schedule, and known risks.
- Any required new technology has been developed to an adequate state of readiness, or backup options exist and are supported to make them viable alternatives.
- Modeling and simulations have been developed and tested per plan.



- Interface control documents are sufficiently mature to proceed with fabrication, assembly, integration, and test, and plans are in place to manage any open items.
- The product verification and product validation requirements and plans are complete. The testing approach is comprehensive, and the planning for system assembly, integration, test, and telescope operations is sufficient to progress into the next phase.
- Safety Management Plan adequately addresses safety in system and operational designs, and any applicable products (e.g., Failure Modes and Effects Analysis) meet requirements, are at the appropriate maturity level for this phase of the program/project life-cycle, and indicate that the program/project safety/reliability residual risks will be at an acceptable level.
- Manufacturability has been adequately considered in design.
- Lessons learned from other projects have been identified and addressed.
- Technical product baseline, including requirements, established and placed under change control.

## 20.6 Manufacturing Readiness Review: Entrance and Exit Criteria

### 20.6.1 Entrance Criteria:

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary MRR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the MRR.
- Programmatic products are ready for review at the maturity levels stated in the governing project management guidelines:
  1. Updated risk assessment and mitigation with all major manufacturer risks eliminated or reduced to an acceptable level.
  2. Updated costs and schedules.
- All identified production engineering problems and nonconformances encountered during the design phase are resolved.
- The build-to documentation needed to support production is available, including:
  1. Product build-to specifications are complete and ready to be re-baselined and released for manufacture.
  2. Technical data packages (e.g., integrated schematics, spares provisioning list, interface control documents, engineering analyses, and specifications) are complete and ready to be re-baselined.
- Fabrication, assembly, and integration plans are complete and ready to be re-baselined.
- The production-enabling products are ready.
- Resources are available, have been allocated, and are ready to support end product production.
- The bill of materials is available and critical parts identified.
- Delivery schedules are available.
- In-process and end-item inspections and tests have been identified and planned.



## 20.6.2 Exit Criteria:

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- The program/project cost and schedule estimates are credible and within project constraints.
- High confidence exists that the system requirements will be met in the final production configuration.
- Adequate resources are in place to support production, including required standard and specialized tools and facilities.
- Production engineering and planning are sufficiently mature for cost-effective production.
- Production processes and methods are consistent with quality requirements and compliant with occupational health and medical, safety, environmental, and energy conservation regulations.
- Design-for-manufacturing considerations have been incorporated to ensure ease and efficiency of production and assembly.
- Lessons learned from other projects have been identified and addressed.
- Drawings are approved/certified.
- Technical product baseline re-established.

## 20.7 Integration and Testing Readiness Review: Entrance and Exit Criteria

### 20.7.1 Entrance Criteria:

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary ITRR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the ITRR.
- Programmatic products are ready for review at the maturity levels stated in the governing project management guidelines:
  1. Updated Integrated Master Schedule (IMS)
  2. Updated risk register with Verification test risks identified and mitigation plans in place.
  3. Personnel resources, including quality assurance personnel, required have been identified and committed.
  4. Components are on schedule to be available for the Verification Test.
- The objectives of the testing have been clearly defined and documented.
- Approved Verification Plans, test procedures, test environment, and configuration of the test item(s) that support test objectives are available.
- All test interfaces have been placed under configuration control or have been defined in accordance with an agreed-to plan, and version description document(s) for both test and support systems have been made available to ITRR participants prior to the review.
- All known system discrepancies, including known lab anomalies, have been identified and dispositioned in accordance with an agreed-upon plan, with mitigation plans in place as necessary.
- Updated Safety Management Plan to include test, with major hazards identified, and controls/mitigation plans defined.





- All required test resources including facilities, test articles, test instrumentation, and other test-enabling products—have been identified and are available to support required tests.
- As-built hardware and software documentation defining the configuration of the item under test are released and under configuration control.
- Support has the required level of expertise.

## 20.7.2 Exit Criteria:

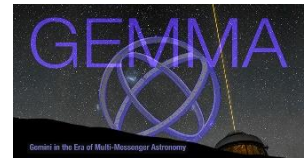
- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- Verification Risks have been identified, credibly assessed, appropriately mitigated, and accepted by project leadership.
- The objectives of the testing have been clearly defined and documented, and the review of all the test plans, as well as the procedures, environment, and configuration of the test item, provides a reasonable expectation that the objectives will be met.
- Test personnel have received appropriate training in test operation and health and safety procedures.
- Adequate identification and coordination of required test resources are completed.
- Lessons learned from other projects have been identified and addressed.

## 20.8 Factory Acceptance Test Review: Entrance and Exit Criteria

### 20.8.1 Entrance Criteria

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary FAT agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the FAT.
- Programmatic products are ready for review at the maturity levels stated in the governing project management guidelines:
  1. Updated risk assessment and mitigation.
  2. Personnel resources, including quality assurance personnel, required have been identified and committed.
  3. Components are on schedule to be available for the Factory Acceptance Test.
- Completed Sustainment Plan, including Service and Maintenance Schedule.
- Results of any preceding FATs conducted at the major suppliers.
- Product verification and validation results from sub-components.
- Documentation that the delivered system complies with the established acceptance criteria.
- A final Factory Acceptance Test (FAT) plan, Onsite Assembly and Installation (OAI) plan, and Onsite Acceptance Test (OAT) plan for each system implementation along with Acceptance Test Plan(s) (ATP) that are ready to be baselined after review comments are incorporated.
- A pre-defined subset of the Factory Acceptance Tests will be repeated during the FAT review.





- Updated detailed FMEA, including assessment of individual component failure conditions. Updated draft of software detailed FMEA if applicable.
- Updated Safety Management Plan, with major hazards identified, and controls/mitigation plans defined.
- Operations documentation (e.g., handbook, procedures) has been written, verified, and approved.
- Baselined as-built hardware and software documentation.
- Required safety, shipping, and handling procedures documented.
- Technical Product Baseline change control record available.

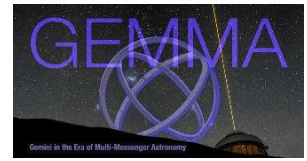
## 20.8.2 Exit Criteria:

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- Risks are identified and mitigated to acceptable levels.
- Required preceding Factory Acceptance Tests and analyses are complete, have successfully passed, have been successfully documented, indicate that the system will perform properly in the expected operational environment, and have been reviewed and approved.
- Lessons learned from other projects have been identified and addressed.
- System meets the established acceptance criteria per FAT plan.
- Results reflecting Factory Acceptance Testing performed have been recorded, documented, and provided.
- Acceptance data package is complete and reflects the delivered system.

## 20.9 Onsite Acceptance Test: Entrance and Exit Criteria

### 20.9.1 Entrance Criteria

- The project has successfully completed the previously planned life-cycle reviews and responses have been made to all outstanding open technical issues, or a timely closure plan exists for those items remaining open.
- A preliminary OAT agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the OAT.
- Programmatic products are ready for review at the maturity levels stated in the governing project management guidelines:
  1. Updated risk assessment and mitigation.
  2. Personnel resources, including quality assurance personnel, required have been identified and committed.
  3. Components are on schedule to be available for On-Site Acceptance Test.
- All planned on-site testing has been completed per On-Site Acceptance Plan.
- All operational supporting and enabling products (e.g., facilities, equipment, documents, software tools, databases) that are necessary for nominal and contingency operations have been tested and delivered/installed at the site(s) necessary to support operations.
- FAT V&V results ready for review.
- A pre-defined subset of the On-Site Acceptance Tests will be repeated during the OAT review.



- Test failures and anomalies from verification and validation testing have been resolved, and the results/mitigations/work-arounds have been incorporated into supporting and enabling operational products.
- Updated as-built hardware and software documentation.
- Users/operators have been trained on the correct operation of the system.
- Technical Product Baseline change control record available.
- Preliminary certification for on-telescope use.

## 20.9.2 Exit Criteria

- Responses have been made to all outstanding open technical issues or a plan for resolution exists for those items remaining open.
- All anomalies have been closed and waivers accepted.
- All applicable lessons learned for organizational improvement and systems operations have been captured.
- Systems hardware, software, personnel, tools, supporting infrastructure, and procedures are in place to support operations.
- Results reflecting On-Site Acceptance Testing performed, recorded, documented, and provided.
- The system, including all enabling products, is determined to be ready to be placed in an operational status.
- Final as-built baseline established.



## 21 Appendix C: Acronyms and Abbreviations

A list of abbreviations and acronyms used in this document can be found in the GNAO Acronym List Document [AD-15].

Acronym	Meaning
CPFF	Cost-Plus Fixed Fee
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes Effects and Criticality Analysis
HBF	Hilo Base Facility
ITAR	International Traffic in Arms Regulations
KPI	Key Performance Index
MOP	Measure of Performance
RFA	Review For Action
RID	Review Item Discrepancy
TTIP	Transportation and Telescope Integration Plan