GNAO AOB
Questions/Answers Tracker
(Progressive)

GNAO-AOB-QA-001

February 23st, 2023

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GNAO Management Team

Document Acceptance and Release Notice

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Change Record

Vers.	Date	Description	Change Request	Owner Name
0.1	2022-10-04	Initial draft	N/A	C. Blain
1.0	2022-10-10	Released for approval	GEM-439	C. Blain
1.1	2022-10-14	Updated draft with addition of questions ID 69-76	N/A	C. Blain
2.0	2022-10-27	Released for approval	GEM-443	C. Blain
3.0	2022-11-03	Released for approval	GEM-444	C. Blain
4.0	2022-12-15	Released for approval	GEM-455	C. Blain
5.0	2023-01-31	Released for approval	GEM-462	C. Blain
6.0	2023-02-23	Released for approval	GEM-467	C. Blain

ID	Question	Answer
14 22-23 27 29-31 54	Additional information regarding the upcoming SRR	The main goal of the SRR is for the GNAO team to ensure that the AOB teams have a proper understanding of the requirements. The GNAO team will participate in the review as observers. GNAO team members attending in person will be Manuel, Gaetano, Celia, and tentatively Stephen and William. Each AOB team should expect to have 3 or 4 members of the GNAO team traveling on site. The exact number (3 or 4) will vary on location and availability Stephen/William at the review date, and will be provided in the coming weeks. Other members of the GNAO teams (from the SE team) will attend the meeting remotely. As per the SOW, the SRR is a contractor held review. The contractors are expected to define the agenda, conduct and chair the review. The contractors are responsible for deciding the format of the review and how much time is needed to conduct the review. The contractors are free to bring in an external review board (on site or remote) if they desire, but this cost could not be passed onto the contract. The contractors should let the GNAO team (the stakeholder in this case) know at which date they will be able to provide the stakeholder sign-off. With the sign-off, the GNAO team will review the proposed requirements and only approve them if they are in compliance and properly derived from the set of requirements provided in the SOW. Entrance and Exit criteria for the SRR can be found in the SOW in Appendix B page 76.

5	What is the weight for the evaluation criteria presented in the KOM slides?	During the KOM, the evaluation criteria were classified under 5 categories: - Phase A Programmatic performance - Phase A Technical performance - Phase B Programmatic plan - Phase B Technical plan - Phase B Contract maturity The first 4 categories will be provided to the Conceptual Design (downselect) Evaluation Committee. Each of the four criteria will have an equal weight of 25%. The evaluation committee will provide their assessment and recommendations to an internal selection committee. The selection committee will be appointed nearer the time. The AURA Central Administration Service (CAS) will evaluate the maturity of the Phase B contract and provide their assessment and recommendations to the internal selection committee. The selection committee will consider both the evaluation committee's recommendations and CAS's recommendations before making a final decision, shortly after the review.
15	System Specification document: please clarify what is meant by "Inspection [PDR]"	Inspection definition (as per NASA SE Handbook): "The visual examination of a realized end product. Inspection is generally used to verify physical design features or specific manufacturer identification [...]. Inspection can include inspection of drawings, documents, or other records." For example, for REQ-L3-AOB-425 in the L3 Specification document (with a verification method specified as "Inspection [PDR]"), the requirement would be verified by inspection by reading the Transportation and Handling Plan document and procedures provided by the contractor at PDR and confirming that the proposed transport and handling equipment comply with the "Instrument to Facility handling Equipment Interface Control Document" requirement.
17	Could you provide a detailed description of the "Custom handler" (fig2 & fig3 from the 23_IDD 1.15.2.1_1.15.2.2 - GNAO AOB to RTC Interface Definition Document v1.0.pdf)	Please read the RTC related documents on the AOB webpage and let the GNAO team know if more clarification is needed.
18	Please provide a description of the engineering tools available to validate the interfaces before the final RTC is available.	The GNAO team plans to develop an Interface Simulator ("RTC_IS") which will implement the same interfaces as the RTC. RTC_IS functionality beyond the interfaces is still TBD, and will be discussed with the contractor during the preliminary design phase.
28	Could you clarify what is meant by "TBC requirements contained in the appendix of [AD-01] have been identified and assessed."	TBC requirements are requirements which need to be confirmed by the AOB teams, these requirements are either: (i) identified, but are not defined yet. (ii) not identified yet.

32	(Document source: L3 System Specification) Why does the NGS unit contain an NGS focus controller? Can GNAO provide derived numbers for GEMS regarding the NGS focus controller?	The NGS focus controller is here to control the mechanism that moves the NGS WFS path in the Z axis, to accommodate its focus with respect to the science instrument. If the AOB was designed for GIRMOS only, this would not be needed. But to make GNAO a facility instrument, a requirement needs to be added for the NGS focus. The current tolerance range for NGS2 works ±2mm.
35	The requirement numbering in the export file (CSV) provided is different from the numbering in the L3 Subsystem Specification Document. Is there a specific reason for this? Which numbering should be used?	The CVS file has been exported from DOORS, which auto-assigns unique requirement IDs. For the AOB and AOS, the GNAO team used an existing template that forced the numbering to begin at ~300. It is not possible to deliberately match the word document numbering exactly in DOORS because each entry is unique and cannot be repeated. The DOORS export file is provided only as a Reference document to alleviate the effort of the AOB teams to import the AOB specifications in their requirements database. For now, the AOB teams should use the ID numbering based on the Applicable documents released at the time of the RfP, i.e. "2_GNAO-AOS-SPE-002-GNAO-AOB-Subsystem-Specification-Document-SSD-v2.0.pdf" Later on, once all requirements are baselined, the generic numbering scheme in the word document specification will need to be replaced to match the DOORS IDs.
36	What is the experience with the new GeMS WFS?	NGS2 is performing as expected, increasing significantly the sky coverage for GeMS. The only drawback is the use of P1 as the SFS, which is not optimum. This is why we are asking the SFS to be part of the AOB.
37	Are there information or lessons learned available from other recent (>2014) GeMS updates?	Please read the 2 GeMS papers listed on the AOB webpage.
38	What is currently the need for the on-site operator at GeMS?	Since March 2022, Gemini South does not operate GeMS on-site anymore. GeMS operations have been fully transitioned to the base. Currently, they still require more staff than the normal 2-person night observing crew, with 4 people total needed. Gemini is working to reduce this to 3 in the short term then down to 2 in the longer term.
39	What is the required number of LGSF? Most of the documentation mentions four LGS, but in some locations, the number mentioned is five, similarly to GeMS.	As per the L3 System Requirement document, from requirement ID [REQ-L3-AOB-13], GNAO should have 4 LGS.
40	The described atmospheric model in the document "13_GNAO-SYS-SIM-012" has currently 7 layers. Is this sufficient?	GNAO used the same model as the TMT study for NFIRAOS. We believe that this is sufficient for our facility.
42	Is there a wish to change the GNAO-AOB to a different conjugate layer height in the future, once the adaptive secondary mirror is operational?	No.
43	(Reference document 1 from ISS to GNAO "GNAO-AOB ICD, 1.5.3/1.15.2.1") Are vibration levels induced by the telescope and ISS already available? If not, when will they become available?	The Gemini team working on the vibration analysis for GN is planning to release a report after the next run at the telescope, scheduled for early February 2023. The AOB teams should expect to receive additional information on this in March.

44	Vibration levels: 12 milli-arcsecond tip/tilt errors due to telescope vibrations are specified in REQ-L3-AOB-3. This is relatively low and could be compensated without separate TTM. Is 12mili-arcsecond realistic or should we account for larger tip/tilt errors?	12mas TT vibrations are only for the vibrations inducing image motion. We do not prefer a specific solution between (i) a TT mirror coupled with DM, (ii) one DM doing TT compensation or (iii) some other set up. Whichever option chosen must provide enough stroke to correct for all aberrations.
45	Do you want a truth sensor? It is not in the requirements.	It is not a requirement. The choice is left to the AOB teams.
46	Can we rely on certain science instrument information for NCPA (dynamic) calibration?	Please see GIRMOS documents provided on the AOB webpage.
47	Is there a need for built-in turbulence screens (static or rather dynamic)? Is there a preference for a single DM versus DM+TT combination? or use of a SLM?	Not in the requirements. The choice is left to the AOB teams.
48	(Document source:GNAO-SYS-SIM-002) What is the four-OAP design mentioned in this document?	During the previous scope of GNAO, when the facility was aiming at doing MCAO, we performed an internal conceptual design and 2 optical models were studied. One was based on a modified Offner relay and one on a double pair of off-axis parabola called 4-OAP.
57	(Document source: Concept of Operation) Will the M2 be repaired before the installation of GNAO, if not, what is the impact of the M2 print-through? Is it taken along in the requirements?	GN's M2 will be replaced with a new M2 before GNAO comes online. There is currently an AURA procurement to purchase a new M2. The vendor was selected and we expect the new M2 will be installed and commissioned by the end of 2024.
58	The text on the SFS loop mentions that the slow focus control will be done by either an additional NGS or part of the light from one of the TT NGS. Is this already fixed or can we choose?	The choice for the SFS star is left to the AOB teams. No preferred choice but we do request the SFS to be in the AOB.
69	(from the Conops document) "The LTAO mode may be used with a reconstructor optimized on-axis (optimum Strehl for observations on-axis requiring very narrow fields) or a reconstructor optimized over the field (for a reduced but more uniform SR over slightly wider fields)". Does this mean that the AOB teams get to choose?	The AOB teams do not need to choose. Both options will be made available in the RTC and the System Controller.
70	Does the AOB need to compute the controids or does it just deliver images (pixel-outputs)?	The RTC receives the raw pixels from the WFSs and all the centroids calculations are done within the RTC. There will be an interface between the RTC and the WFSs to transfer the data in the proper format
71	Laser Guide Star LUT: Are the units already defined? What is the minimal accuracy needed? Is that the accuracy needed to be within the range of the focusing sensor?	The units are not defined. This is up to the AOB teams and based on the chosen design. There is a requirement on the range for the altitude, but the rest is dependent on the flowdown of the chosen design.
74	Start-up sequence: what is meant with point 4.: "Calibrate zero point of LGS WFS LUT by adjusting the DM to LGSWFS registration"?	This means estimating the order 0 (the constant) of the LUT. Based on the conditions, this parameter can evolve. This is just a matter of defining the working point.
75	Acquisition sequence: Is the laser pointing camera mentioned as part of the LGSF?	Yes, the Laser Pointing Camera (LPC) is a component of the LGSF.

76	Plate scale/image size (from ICD document): The incoming beam from the telescope to the AOB is f/16.24, the fov is 120 arcsec, the plate scale is 1.610 arcsec/mm. The outgoing beam from the AOB to the science instrument is f32.5, the FOV is 120 arcsec, the plate scale is TBD arcsec/mm. Is it assumed that the image size is doubled (or the plate scale halved)? The confusion seems to come from one image in the ICD which shows the optical path being bent away and bent back, and the plate scale for the light coming back from the AOB has the same plate scale as the input focus of the AOB.	The assumption that the plate scale is halved is correct. GNAO left the value at TBD (in IDD 1.15.2.1 to 1.6) for the final design value.
87	Clarification of the requirement REQ-AOB-L3-4 from the AOB L3 specification document "2_GNAO-AOS-SPE-002 GNAO AOB Subsystem Specification Document (SSD) v2.0.pdf", please see page 23. Specifically, clarification of the last bullet point in the "Note" section: "Wavefront Error (WFE RMS) < 100 nm (goal < 65nm)"	The total WFE after NCPA correction at the focal plane of the imager shall be less than 100 nm RMS. The value of <100 nm RMS pertains to the total WFE, not just the imager. It is up to the vendor to determine the individual WFE contribution of a potential imager.
109	What format should be used to present the requirements (spreadsheet, model, etc..)?	The AOB teams are free to decide which format is best to present the requirement (document type, number of documents, etc...) and shall follow instructions for deliverable documentation presented in the SOW v3.0 Section 19.
110	Does Gemini have any plans for having capability for future upgrade of the AOB (e.g., new DMs, conjugate etc)?	Additional capability for future upgrades is not in the scope of the AOB SOW. The teams are free to propose something.
111	Where will the RTC be located?	The RTC could be installed in the Gemini North summit computer room or directly in the electronic cabinet of the AOB. The final decision shall be taken in the Preliminary Design Stage and shall be reflected in the ICD.
112	Will the down-time requirement be per mode or overall?	Requirement REQ-L3-AOB-73 refers to the total downtime. The 2% is aggregate.
113	Do you have a definition of what you expect for the KPI or is it up to the teams to provide what they think is appropriate?	It is up to the AOB teams to provide what they think is appropriate.
114	The position of the LGS constellation needs to be defined. Do the AOB teams have total freedom? Or are there some constraints? For example, the 4 LGSs could be on a square versus the 4 LGSs could be on a triangle asterism, with one LGS at the center?	The position of the LGS constellation is up to the AOB teams. It is requested that the constellation shape be a square.
115	Teams are asked to provide a way to calibrate the optical distortion. To what level do we need to characterize these distorsion? Depending on the characterization level, different methods could be proposed.	The AOB teams are requested to provide the means to measure and calibrate the distortions to reach a scientific astrometric requirement, as presented in science case documents.

116	REQ-L3-AOB-32 states the need to provide a way to align the HI WFS with the DM. Why is this a requirement? If a design was proposed allowing to make the system stable enough (so the registration stays within an acceptable range with respect to the performance), would this requirement still be applicable? Would it still be a requirement to provide adjustment to this registration?	This requirement was included because the AOB is not temperature controlled and there are currently no known systems stable enough to keep the registration within an acceptable range. If a contractor can propose a design solution allowing the system to be stable enough (and prove by analysis that this requirement is not required), a waiver to remove this requirement can be requested.
117	Regarding the science instrument: The AOB teams need to provide final performance in the science instrument focal plane. However, currently, nothing is known about the science instrument performance. Will the AOB teams get this information at some point? For now, should they use placeholders in their error budgets?	For now, please use placeholders in the error budget. When available, details about the science instrument's expected performance will be provided to the AOB teams.
118	As part of the documents deliverable, a calibration alignment procedure must be provided. Does Gemini also ask to receive a beginning of the night procedure? Is it something the AOB teams can propose?	Yes, the AOB teams can propose procedures for the beginning of the night.
119	ADC: REQ-L3-AOB-121 refers to the accuracy of the ADC. REQ-L3-AOB-122 refers to the wobble. What is the difference between these 2 requirements?	The accuracy refers to the rotational accuracy, or how accurately one can position the plates. The wobble refers to the slope/motion in the bearing (if the bearing is misaligned for exemple). The wobble would be traced using Zemax, evaluating the design sensitivity to the prism's wobble.
120	REQ-L3-AOB-8 states that the system shall be able to operate at up to a seeing of 1.2 arcsec. Is it the seeing at zenith? (then the system would also need to operate up to 60 deg, which would result in a total seeing of > 1.2 arcsec)? Or does the 1.2 arcsec correspond to the maximum seeing at the maximum zenith angle?	This requirement refers to the maximum seeing at the maximum angle.
121	REQ-L3-AOB-90 refers to the number of HI WF modes. Does this infer the number of corrected HI WF modes?	Yes, this requirement refers to the number of corrected HI WF modes.
122	Can you confirm that the calibration sources that need to be provided are only for the AO system (They do not need to be able to calibrate anything related to the science instrument).	Please see REQ-L3-AOB-46: "The AOB shall provide the means to calibrate static optical distortion at the instrument focal plane and the Wavefront Sensor focal planes." Please see also REQ-L3-AOB-48: "The AOB shall provide the means to calibrate non-common path aberrations (NCPA)." The calibration sources shall provide the ability to calibrate both the AO system and the science instrument.

123	Will GNAO provide simulators (or the final systems) for the RTC and SyCo before the AOB teams have to conduct the FAT? Will the final RTC be integrated before or after the FAT?	The GNAO team plans to develop a SyCo Interface Simulator ("SyCo_IS") which will implement the same interfaces as the SyCo. SyCo_IS functionality beyond the interfaces is still TBD, and will be discussed with the contractor during the preliminary design phase. The final RTC will be integrated several months before the AOB FAT. The goal is for the AOB team to have it at the start of their IIVV phase.
124	Environmental conditions: For the FAT, is it left to the AOB teams to define under which environmental conditions the AOB system should be tested under?	Yes, the AOB teams are responsible for defining under which environmental conditions the AOB FAT should be performed at their facilities. The environmental conditions shall emulate all conditions under which the AOB will operate, according to the AOB Specification document and ICDs.

SRR Questions

125	The requirements for the image distortion are listed in IDD 1.15.2.1/1.6 (GNAO AOB to A&G Science Fold Mirror Interface Definition Document). However, we could not find any tracing to higher level systems or science requirements. We suspect the absolute number of 0.5% has been tightened with respect to CANOPUS, but we do not know why. Also the required stability of 0.2% seems quite large with respect to the absolute number. As the absolute distortion requirement is one of the drivers for the optical system, we were wondering if you could explain the rationale behind it?	The distortion values in IDD 1.15.2.1/1.6 come from GIRMOS documentation: - 0.5% comes from absolute pointing budget, i.e. acquisition - 0.2% comes from relative pointing budget, i.e. re-acquisition after a dithering offset Rationale behind the absolute distortion requirement in budget: Distortion and plates-scale variations due to changes in optics alignment. (TBC, with just 1 DM, GNAO cannot introduce or correct plate scale or distortion variations.) Related science requirements are [GIRMOS-SCI-011] and [REQ-L0-SCI-007].
126	[REQ-L3-AOB-9] Zenith Angle: " The AOB shall meet all performance specifications up to a 50 degree zenith angle, and shall be operational up to a 60 degree zenith angle" For which turbulence profile does the requirement specify to maintain operation for >50 degrees? Is it for the 50% percentile?	The performance requirements are specified for median conditions. Median conditions are defined as 0.56 arcsec seeing in V-band at Maunakea, corresponding to the 50-percentile of the Maunakea turbulence profile.

127	The cut-off wavelength ([REQ-L3-AOB-24] and REQ-L3-AOB-39]) is 830nm, which is quite low. Is there really a need for this low or can the AOB teams access higher? We understand it is used for the MOAO truth sensor, but what are the constraints?	The vendors should keep all options open (i.e. in terms of detector selection) until the Phase B down-select. After the down-select, the GNAO team and AOB team will initiate discussions with the GIRMOS team and conduct trade studies to help further answer this question.
128	The need for (and the details of) an astrometric calibration mask ([REQ-L3-AOB-126], [REQ-L3-AOB-46] and [REQ-L3-AOB-47]) is very much dependent on the expected GIRMOS optical specification. Please provide further information on the requirement.	This information is not yet available from GIRMOS. More details will be available after the CoDR. The GNAO team does not consider this information as a driving requirement for the conceptual design (pinhole pattern and size).
129	Night time operation: Target of opportunity observing sequence is not defined. What is the AOB starting state?	It can be assumed that GNAO is ready for use (i.e. powered up and initialized) during scheduled observing time. See also QA ID #159.
130	How much is the expected NCPA to compensate for outside of the AOB ([REQ-L3-AOB-127] and [REQ-L3-AOB-128])?	Please see answer provided for Question ID #87 above.
131	We need to better understand the speed requirements of the ADC, i.e. what is the update frequency, as we may need to implement tracking mechanisms. This also includes the SFS and impacts of non-sidereal. Please provide more information on tracking with other instruments.	For the conceptual design stage, the AOB teams only need to consider deployment in/out of the field and rotation of the ADC. The tracking responsibility is internal to the GNAO team. The ADC location and rotation angle will be provided by GNAO to the AOB. The HW selection for the ADC elements, ADC mechanism and control will be discussed during the PDS.
132	[REQ-L3-AOB-25] Non-Sidereal Guide Objects: "The AOB shall have the capability of sensing the low-order wavefront using Natural Guide Objects moving at non-sidereal rates." Is this requirement assumed to hold for TT and slow-focus? What are the limitations on the non-sidereal rates? 45 or 450 arcsec/hour? Are there different performance requirements for non-sidereal tracking? Or are they the same as for sidereal tracking?	Non-sidereal requirement pertains to both TT and slow-focus objects moving at non-sidereal rates. [REQ-L3-AOB-26] specifies non-sidereal rates up to 450 arcseconds/hour. [REQ-L3-AOB-27] specifies that the AOB must be able to track multiple NGOs moving at different rates. Requirement [REQ-L1-SYS-25], listed in the Reference document GNAO_SYS_SPE_002 document "GNAO System Specification Document (SSD)" constrain a typo. It should be 450 arcsec/hrs instead of 45 arcsec/hrs. Typo will be fixed in the next released version of the GNAO_SYS_SPE_002. As a reminder, the information contained in the L3 document "GNAO-**AOS**-SPE-002" superseded the information contained in the L1 document "GNAO_**SYS**_SPE_002". Performance requirements are the same for sidereal and non-sidereal tracking.

133	[REQ-AOR-L3-46]: The need to calibrate distortion is specified without accuracy. In [REQ-L3-AOB-126], it is requested that the vendor derives this accuracy. Shouldn't it be driven by science and provided by Gemini to the vendor?	This requirement is to be derived by the AOB teams. See also QA ID #115.
134	[REQ-AOR-L3-62]: Is the source intensity control mandatory? Does this apply to both LGS and NGS calibration sources? What is the range of intensity that the sources shall cover?	Yes, the source intensity control is mandatory to simulate faint and bright sources for both the NGS and LGS (this could be necessary for Phase Diversity for example, or to emulate poor vs good sodium return nights) The intensity range will depend on the source used and should be derived by the AOB teams.
135	[REQ-L3-AOB-87] and [REQ-L3- AOB-88]: For a given configuration (GLAO or LTAO), is the LGS asterism as seen from GNAO entrance focal plane kept fixed in position by the LGSF? When the Cassegrain rotator is rotated to maintain the science field fixed, is the LGS asterism derotated so that the LGS are always at the same position on the sky?	As per the AOB system, the LGS asterism will be fixed in the field. The rotation correction will be handled by the LGSF.
136	Which version of EPICS is to be used for the telescope and when is this to be implemented ([REQ-L3-AOB-70])?	The current assumption is that it will be EPICS 7. Of course, it is not possible to garanty how EPICS will evolve while the AOB is under development, so the final version supported by Gemini will not be known until closer to delivery.
137	The high stability mode for the DM will have some impact on the RTC ([REQ-L3-AOB-71]). Please check if high stability mode is desired and impact with the RTC team.	There is no need for high stability mode as natural seeing mode will have larger WFE than expected for creep. All other AO modes will run in closed-loop and don't need the high stability feature.
138	Please provide further clarity around the purpose of [REQ-L3-AOB-59] in regards to remotely enable and disable?	The DM and TTM controllers must have the capability of applying the received actuator positions or ignoring them.
139	What are the thresholds and averaging periods of the off-loading process to the secondary mirror. What is the magnitude of the range of M2 motion available for use on AOB?	There is no direct answer to this question. There are no simple "averaging periods" and "thresholds" involved because the tip-tilt guiding is a continuous process involving multiple servo loops and a PID filter within the SCS. Roughly, the M2 tip/tilt system has a bandwidth of about 5 Hz up to a few arcseconds on-sky, and receives updates from our guiders at 50 to 100 Hz, but interacting with it requires more detail than this, especially with both natural and laser guide stars involved. The off-loading process to the secondary mirror includes corrections from non-AO WFS too. In all cases, the maximum frame rate for offload corrections to the secondary is 200 Hz.

		For tip/tilt, the maximum magnitude of these corrections is roughly 8'' at the focal plane (in TCS coordinates) or about 4 times larger at M2 (32''). In focus the maximum correction limit is 200-300 um at M2. Since Altair has a much faster sample rate @ 1 kHz, the offload corrections are downsampled to average every 5 corrections. This matches the 200Hz limit of the autoguider.
140	Documentation standards: Can STEP files be provided?	Yes, it is ok to provide STEP files, with accompanying pdf drawings.
141	Env.2.8 - Storage Environment Shock: The instrument shall not be damaged by exposure to shocks of peak acceleration of 10g on all axes. Time duration of the shock pulse will need to be defined	Similar discussions happened for GIRMOS. Unfortunately, Gemini is currently not able to provide a timescale.
142	Env.2.9 Storage Environment Seismic Base Acceleration: The instrument shall not be damaged by exposure to shocks of peak acceleration of 0.4g @ 0.5Hz to 100Hz in any axis. Why is a range of frequencies specified? Is a sweep sine expected to be considered?	Env.2.9 rationale: “Acceleration projected when an earthquake occurs and instrument is in storage.” The frequency range is what is expected from earthquakes. A sine sweep test shall not be considered.
143	For the list of TBD requirements: Who is responsible to derive them?	The AOB teams are doing the conceptual design, they should derive all the TBDs driven by their designs. GNAO should derive any TBDs in our specification (L3). However, as there are TBDs in L3 spec which depend on the design choices, the AOB teams should derive those TBDs in the L3 specification document.
144	Does the RTC require/allow multicasting ([REQ-L3-AOB-71])?	The RTC does not require multicasting but can allow it at a potential loss of performance (which can be quantified by the RTC team).
145	What should we consider to be the range of focus adjustment of the NGS2 to accommodate GIRMOS or other instruments ([REQ-L3-AOB-68] and/or [REQ-L3-AOB-69])?	This is a missing requirement. The final value for the range of focus is not critical for the conceptual design phase. This requirement will be added to the specification document after the CoDR. In the meantime, the AOB teams should plan to provide a way to remotely adjust focus by ±2mm (equivalent F/16 focal plane)
146	What is the accuracy of the AO fold mirror feed ([REQ-L3-AOB-68] and/or [REQ-L3-AOB-69]), i.e. tolerances and possible misalignments?	The focus tolerance is ±1 mm for the AOB input beam from the AO fold mirror and also for the output beam towards the science fold mirror (please see section 5.1 of IDD 1.15.2.1 to 1.6).

147	In [REQ-L3-AOB-9] what is the definition of "operational"?	Operational means that it can be operated safely up to that elevation. All performance requirements do not have to be met but nothing can be damaged by operating at this elevation.
148	The vibration specification in the ISS ICD (ISS.1.10) from [REQ-L3-AOB-69] is listed as "to be confirmed" and is expressed as a force in N over a frequency range. Please provide this specification or an explanation of the likely range and it would be useful if it was expressed in a more common unit.	The intent of this requirement was to make sure instruments with cryocoolers do not create/transmit vibrations to the telescope. At the CoDS level, the AOB teams will not have a structural design in place that would be influenced by this requirement. Request has been made to Gemini Operations to have more information regarding vibration. [REQ-L3-AOB-69] will need to be considered at PDS and CDS for structural design. Please see also QA ID# 151.
149	[REQ-L3-AOB-104] Low-order Wavefront Sample Accuracy: “Sample accuracy requirement to be derived by vendor.” Assuming this requirement refers to the timing accuracy in reading out the low-order WFS. Is that correct?	Sample accuracy referred to centroiding accuracy, not timing accuracy. This is applicable to both [REQ-L3-AOB-95] and [REQ-L3-AOB-104]. Timing accuracy is included in the jitter requirement.
150	[REQ-L3-AOB-68] “Pupil distortion absolute and relative” What is the intent? Minimize thermal leaks in GIRMOS? Ensure DMs co-registration between AOB and GIRMOS?	The intent is primarily ensuring DM co-registration (cf. section 5.3 in IDD 1.15.2.1 to 1.6), but minimizing thermal leak is also relevant.
151	GNAO to define the vibration use case and power spectra.	Providing this data is out of the scope of the GNAO team. Request has been passed to Gemini Operations management. As a reminder, what’s currently available has been shared on the AOB webpage (see [AI ID 11] or https://staff.gemini.edu/~astephens/alopeke/vibration/) Also, from document IDD 1.15.2.1 to 1.6 in Section 5: “Residual GNAO vibration image jitter <=12 mas” For the Alopekee data provided, please note that the fold mirror vibrating within Alopeke is affecting its images, therefore the image motion it sees doesn't necessarily represent the overall vibrations of the ISS and A&G. In general, data regarding vibration available from Gemini should be considered with reservation. Additional data taken on GN and a closing report will be available once the Gemini vibration team is able to access GN. The exact date is still unknown and will depend on the schedule of the M1 repair. The GNAO will provide updated

		information as they become available. Currently, the timeline for the telescope to be back online is early to mid-April.
152	Is there a restriction beyond the emissivity requirement on transmitting the science path through the WFS dichroic? In GEMS for example the science path is transmitted. Is there a preference that can be communicated or some perhaps new requirements that might be communicated?	No, the design choice is up to the vendor.
153	Can we find out what Gemini does in active optics to control linear astigmatism (rotation of M2 about coma neutral point) and telescope focal plane tilt? What range should we expect from the telescope?	The telescope's linear astigmatism is controlled with the M1 active optics system. The linear astigmatism can be measured and corrected with 2 peripheral wavefront sensors (PWFS1 and PWFS2) in the A&G, with the GMOS on instrument wavefront sensor (OIWFS), or with Altair. PWFS1, PWFS2, and the OIWFS are all 2x2 Shack-Hartmann lenslet arrays that also control focus and tip/tilt guiding. Coma is controlled through the open loop M1/M2 look-up table. Coma is corrected by moving the M2 laterally in X or Y position. Due to the Ritchey-Chretien design, the telescope is coma insensitive. This creates an effect where coma from small amounts of tilt can be corrected for by moving the M2 laterally. This coma correction will unfortunately result in binodal astigmatism. Please see the SPIE paper posted on the AOB webpage “Collimating the Gemini telescopes using a peripheral wavefront” detailing how M2 tilt is determined using the PWFS2, and how we were able to correct for it. Using the method described in the paper, we can achieve a defocus at a 6 arcminute radius of ±5 microns.
154	What is the intent or motivation for [REQ-L3-AOB-117] on tip-tilt clear aperture?	This requirement was extracted from GeMS requirements and is not necessarily applicable to GNAO. The AOB teams can ask for a waiver to remove this requirement if they estimate it is not applicable to their design.
155	[REQ-L3-AOB-6] Wide Field Mode Sensitivity [REQ-L3-AOB-7] Narrow Field Mode Sensitivity How does AURA see the derivation and verification of the requirement in light of this complementarity?	The parameters listed in [REQ-L3-AOB-5/6/7] were written in a way that we believe contain the necessary information to calculate the sensitivity of an imager at the focal plane of such an instrument. The detector can be assumed to be an H4RG (as listed in [REQ-L3-AOB-5]), the focal plane wavefront errors (including everything such as the AOB, the imager, etc.) are also listed to be <100 nm RMS; here we also refer the reader to QA response 87 for more information. The pixel scale of the detector is also given. These parameters, along with the AOB performance, are enough to characterize both WFM and NFM sensitivity within the given parameter range of the requirements [REQ-L3-AOB-5/6/7].

156	[REQ-L3-AOB-68] “Spherical aberration, Astigmatism, Coma, WFE, Residual high-order NCPA” What is the intent of these specifications? Are they defined in closed-loop? Do they assume NCPA correction or not?	There is a typo in the documentation. Spherical aberration, astigmatism, coma are part of residual WFE and NCPA. There is no need to distinguish them.
157	[REQ-L3-AOB-68] “Residual high-order NCPA” What terms are considered “high-order”?	We consider “high-order” all modes other than tip and tilt.
158	[REQ-L3-AOB-66] Remote field viewing “The AOB shall provide the capability of remotely viewing the Technical Field of View seen by the Low Order wavefront sensors.“ What are the requirements on e.g. resolution, wavelengths and frame rate?	Resolution, frame rate, and wavelength aspects are important but not driving. The requirement is that it must be adequate to support NGS acquisition. We need to be able to see the guide star so we can center on them.
159	[REQ-L3-AOB-10] “The AOB shall, once powered up and initialized, be capable of achieving a given device configuration within 60 seconds of being commanded, regardless of the starting state”. What does “device configuration” mean exactly?	The intent of this requirement is that the AOB be ready to support the next observation (devices in position, WFSs configured, etc) within 60 seconds of the end of the last observation (or powerup and initialization), regardless of where things were when the configuration was requested.
160	The management of NCPAs would need to be tightened up at Phase B’s KOM and discussion will need to include the AOB team, the GIRMOS team, the RTC team, and the SyCo team	Agreed.
161	Is there a design reference science mission? It would help to know if some science cases will be done more often than others.	For GIRMOS, the expectation is to spend roughly: - ~ 90% or more of the time using GLAO, - ~ 5% of the time using LTAO for Globular Clusters, - ~ 2% of the time for ToO with imager. Additional information can be obtained looking at conference proceedings from Sivanandam et al. (2018, 2020) and Chapman et al. (2018, 2019, 2022). The GIRMOS Science case document has been released on the AOB webpage. An updated version of the GNAO Science case will also be released to the webpage in the coming weeks. Both documents will provide additional information on the workhorse modes for GIRMOS and cardinal cases for GNAO.
162	Could the AOB teams discuss with the GNAO Instrument Scientist to see what type of constellations could be optimum for the science?	Such discussion would most likely result in a solution discussion with the teams. This is not possible during Phase A and would have to be postponed to Phase B.

163	Does Gemini have a preference between Python or Matlab?	GNAO has a very strong preference for Python, for operational support reasons. Note: the use of Python is already mentioned in the Specification documentation and in the SyCo documentation.
164	What is the maximum frame rate for NGS control? Is the NGS frame rate in any way coupled to or limited by the LGS frame rate?	The maximum frame rate for NGS is 1 kHz. It is currently anticipated that the NGS frame rate is a fraction of the LGS frame rate. This information needs to be confirmed by the RTC developer. (please see additional detail below in question ID 164b)
165	Field Curvature: Is the goal to replicate telescope field curvature or aim for planar focal plane?	Please see the description in IDD 1.15.2.1 to 1.6 in Section 5.1: “The GNAO focal plane field curvature has a > 2m radius of curvature” (please see additional detail below in question ID 165b)
166	Who’s responsible for the network switch? It seems that it should be selected by RTC experts. Is an NGS/LGS synchronization required by the RTC?	The assumption is that the AOB vendor is responsible for all electronics in the AOB, including the network switches. The RTC requires NGS/LGS synchronization, so high order processing will not be delayed. Discussion between the GNAO, AOB and RTC teams will be possible in Phase B to reach an agreement on the selected switches. Please see also QA ID #144
167	Seismic requirement for instrument in storage (from 1.9 to 5.0 document in Env2.9): The requirement is only for storage but another one should be added for when the system is in operation.	For the instrument in operation, this is covered by requirement Env2.10 in the same document. The title of Env 2.10 is confusing and should not specify instrument storage only. Request was sent to the Gemini Development Group to update this document. *Note: Env 2.10 (current): The instrument shall not be damaged by exposure to shocks of peak acceleration of 2.0g @ 0.5Hz to 100Hz in any axis.* *Rationale: Acceleration projected when earthquake occurs and instrument* ***is mounted on ISS****.*
168	Scattered light: Could you clarify the illumination scenario to consider?	Examples of illumination scenarios (in open shutter) could be: - dome light - out of field source reflection into the detector - status light from other instruments - GCAL
169	Temperature operation: - Is -15degC really desired? (For the LLT requirement, it was changed to -10degC).	GIRMOS updated the requirement on temperature range. The new range is from -10degC to +10degC based on the LLT requirement. The AOB teams could request a waiver for

	- Does Gemini close the dome below a certain dome temperature?	the GNAO operating temperature requirement to be adjusted. Gemini closes the dome if temperature drops below -8degC.
170	In 1.9 to 2.7, the doc has a weird unit for orientation. The requirement states ±1 G in x and ±1 G in Y. Should it just be±1 G for all orientation?	GNAO will never be mounted on the ISS bottom port. It will only be mounted on the AO port (port 4). GNAO confirming it wil see ±1G in all orientations.
171	[REQ-L3-AOB-83]: Typo correction: the wrong reference document is referenced in the requirement text.	Typo correction: the correct document that should have been referenced in [REQ-L3-AOB-83] is ICD 1.9 to 2.7 “Science Instruments to Facility Handling Equipment” [REQ-L3-AOB-83] should read: “The AOB shall comply with all transport and handling requirements defined in the 1.9 to 2.7 Science Instruments to Facility Handling Equipment”.
172	What does the RTC team plan to do in simulation for AO components?	If the selected components are in agreement with what is currently being used in the RTC template (interface GigE vision and ethernet) then it should be transparent and the RTC team will just customize it to all the spec of the components. If other solutions are chosen, then some interface work will be required. This will need to be discussed between GNAO, the RTC team and the AOB team at a later time.
173	ISS to AOB: Should the ISS interface mockup be delivered prior to FAT. Would it be provided by Gemini?	Gemini will not provide an ISS mockup but could make one available at GN Hilo Base Facility (HBF) which is equipped with the Telescope Flexure Rig and with one ISS faceplate. This is out of the GNAO team scope and would need to be requested by the AOB teams as part of the on site integration plan.
174	Do the AOB teams need to provide performance modeling for ETC?	Performance modeling for ETC is not required for the CoD Phase.
175	Can the GNAO team provide feedback on when RTC FAT will happen?	We expect to have the RTC FAT by April 2025.

176	Does Gemini have data to look at flexure and gravity effects on GEMS? Is it sensitive or not?	Gemini has a set of raw engineering data available that have been recently acquired (January 2023) https://archive.gemini.edu/searchform/GSAOI/not_site_monitoring/NotFail/cols=CTOWBEQ/includeengineering/GS-ENG20230117-5 https://archive.gemini.edu/searchform/GSAOI/not_site_monitoring/NotFail/cols=CTOWBEQ/includeengineering/GS-ENG20230117-6 No analysis has been performed yet to comment on sensitivity.
177	Is there a need for pupil clocking control to keep the GNAO DM actuator grid aligned with the GIRMOS DM actuator grid?	This would be a constraint on the GIRMOS development team, not the AOB teams. This should be discussed during Phase B with the GIRMOS team.
178	Will GNAO be allowed to offload more modes to M1?	The TCS has a fixed structure for receiving Zernike modes which defines the number that can be sent (Z2 to Z20), adding more would require modifications to the TCS. See ICD 1.14.8/1.1.11 for details.
179	[REQ-L3-AOB-112] Deformable Mirror Position Resolution “DM position resolution requirement to be derived by vendor” Assumed to be the DM actuator resolution (not the DM position on the bench)	Assumption is correct.
180	[REQ-AOB-L3-10]: “AOB shall, once powered up and initialized, be capable of achieving a given device configuration within 60 seconds of being commanded, regardless of the starting state.” Is there a requirement missing on the time required to power up/initiate? Maybe a “desirable” requirement to keep in mind the time should be minimized.	There is no operational requirement that can be tied to a constraint on the maximum time to power up/initiate. The only constraint comes from the requirement on the instrument downtime: “The instrument downtime due to faults shall be 2% or less of scheduled time on the telescope.” (please see complete requirement in document INST-REQ-0001 in Section 4.4.2)

164 b	Additional feedback on question ID 164: What is the maximum frame rate for NGS control? Is the NGS frame rate in any way coupled to or limited by the LGS frame rate?	The answer provided in 164 was confirmed by the RTC developer team. The RTC System shall allow the NGS processing loop rate to be varied at any time, independently of the LGS processing loop rate. However, the NGS rate will always be such that it is a sub-multiple of the LGS rate.

		During phase B, the AOB team will be able to discuss directly with the RTC developer.
165 b	Additional feedback on question ID 165: Section 5.1 of the AOB to A&G IDD states that the field curvature for GNAO is > 2m. Is there a preferred value to target?	The AOB to A&G IDD indicates that the field curvature at the output of GNAO should be similar to the field curvature at the input to GNAO (close to 2m). The goal is to have a similar field (and pupil) with or without GNAO, so that current instruments can also be used behind GNAO. The AOB teams should consider the preferred value for GNAO's output beam field curvature to be 2m.

181	The residual dispersion specified in the IDD 1.15.2.1_1.6 v1.0 document is set to <= 4.8 mas at 50° from the Zenith. Is this value to be achieved on the full science waveband or over individual science filters wavebands? What is the main driver/rationale for this requirement?	The origin of this value is the GIRMOS-GNAO pointing budget, which includes a calculation of the atmospheric refraction and the resulting dispersion with an assumption of an ADC with 2.5% residual dispersion. The value of 4.8mas assumes: - YJ band (because of the strongest refraction) - zenith angle 60 deg (not 50)
183	Can you clarify what is meant by "Flux accuracy" and "Flux precision" in the AOB to A&G IDD?	The intent was to specify AOB contribution to photometric accuracy measurements (temporal and spatial flux stability). For the moment these values can be ignored.
184	When mounted on the ISS, the AOB shall not cause an out of balance in excess of 500 Nm with respect to the telescope elevation axis, in any orientation of the telescope or rotator. Does this depend on other instruments mounted on the ISS?	All the instruments mounted at the ISS, including the AOB, shall meet this interface requirement to keep: - the elevation axis of the telescope at operational specs - the Cass Rotator/telescope balanced. This is dependent on the instruments suite at the ISS. However, as long as each instrument individually meets this requirement, a specific or determined instrument does not need to know the instrument suite mounted on the ISS at a given time.