

DRAFT

**Next Generation Adaptive Optics Preliminary Design
Compliance Matrix**

KECK ADAPTIVE OPTICS NOTE 772

Christopher Neyman
May 24, 2010

ABSTRACT

This note contains a discussion of the compliance verification process for the Next Generation Adaptive Optics (NGAO) system at the end of its preliminary design. A matrix denoting the level of compliance for each of the major NGAO subsystems was completed by that subsystem's design lead. Summary statistics are compiled in this document. Full compliance matrices are left in an excel spreadsheet as an appendix to this document.

Revision History

Revision	Date	Author (s)	Reason for revision / remarks
1.0	May 24, 2010	C. Neyman	Initial release

1. Introduction and Methodology

During the completion of the preliminary design of the major subsystems, the lead of that subsystem was requested to complete a compliance matrix to document the compliance of each subsystem design with the system level and functional level requirements. Each lead was presented with an excel spread sheet listing the requirements short name, unique ID, and description as they appeared within the NGAO requirements database. The leads were asked to choose from a fixed number of possible selections for each requirement's compliance level. For fully compliant requirements, they were asked to list a KAON, or other documentation that would provide details that support the finding of full compliance. In addition, the engineers were asked to comment on non compliant or partially compliant requirements. The possible choices for each requirement were limited to the following:

- Yes
- No
- Partial
- Determine if compliant by PDR
- DD
- Goal Only
- N/A



While the choices Yes and No are self evident, the other selections require some explanation:

Determine if compliant by PDR: not known now if the design is compliant or not but expect that determination can be made with additional analysis or design work to be completed by the date of the preliminary design review.

Partial: the design is compliant to part of the requirement, but not all of it. (Note: If this uncovers a combined requirement that should be separated into two, the systems engineering team can follow up with the subsystem lead, to e.g. split the requirement or otherwise handle the situation.)

DD: compliance will not be determined until further analysis or design occurs in the Detailed Design phase of the project.

Goal Only: the requirement only states a system goal. We will remain cognizant of this goal, but do not intend to test or report compliance (this should be rare).

N/A: not applicable, as this subsystem plays no part in determining compliance with the requirement.

After initial submissions of the compliance matrices by the engineers, they were reviewed by the NGAO systems engineering team. This process found several requirements that were not clearly stated, inconsistent, or out of date. These requirements were submitted for review and when appropriate revision. The submissions were also used to clear up any misunderstandings of the process and the meaning of requirements by the engineers. As the preliminary design approached, any compliance matrix entries that were still set to "Determine if compliant by preliminary design review" were changed to DD: determine compliance during the detailed design phase.

The main subsystems for NGAO are as follows and a subsystem compliance matrix was developed for each of these subsystems:

- AO Enclosures
- AO Bench (& main optics)
- LGS WFS
- NGS WFS
- LOWFS
- Acquisition Camera
- Alignment, Calibration, & Diagnostics
- RTC
- LGS Facility
- Controls
- Science Tools

The systems engineering team used the submitted compliance matrices to develop summary compliance matrices. There are eleven summary matrices that delineate the compliance of each subsystem with its unique functional requirements. Since the AO system has a level of functional requirements that apply to all the subsystems that are part of the full AO system, a single compliance matrix was compiled for these "Overall AO" requirements. It includes the eight systems in the list above from AO Enclosures down to RTC. In addition, the systems team compiled a single system level compliance matrix. It summarizes how the eleven subsystems comply with the system requirements. The systems requirements are those specifications that cover the full NGAO system and are independent of any particular architecture choice. These finalized matrices proved problematic to format from excel to fit inside this document and have been left as excel spreadsheet included as an appendix to this KAON.



2. Summary Statistics

In addition to the summary compliance matrices, the systems engineering team compiled the following summary tables of each finalized matrix.

2.1. System Requirements All Subsystems

The system level requirements matrix (see appendix spreadsheet) shows the compliance level of each of eleven subsystems against all 102 system requirements. This is a total of 1122 compliance selections, in many cases the requirement is not applicable to that subsystem and is denoted N/A. In the remaining cases, the design has not reached sufficient maturity to make a determination of compliance and the compliance is denoted DD. The total of each selection are shown in the table below.

The one requirement not in compliance (denoted “No” in table below) is related to the mass limited requirement for systems that are mounted inside the secondary mirror support structure. The LGS Facility design team commented, “The mass of the components will exceed that in the spec. However, there is an existing 700 pound counterweight that will be removed to offset any weight increase by the components in the secondary.” This issue will be addressed during the detailed design.

The two requirements listed as partially compliant involve documentation requirements. It is not expected at preliminary design review to be able to satisfy the requirement for all final documentation. The other systems all listed this as being verified only at detailed design or during delivery of the subsystem.

Two of the three requirements listed as “Goal” are all related to failure testing of the software. Software methodology cannot guarantee compliance during the design phases, the possibility exists of unknown bugs that may not be found until the code is written and tested. Software unlike hardware cannot test many identical units to determine a statistical mean time between failure. The NGAO control software will be verified to the extent possible during full scale development of software. The last requirement that is listed as “Goal” involves the requirement to simulate the telescope functions with the AO control software. The software design team commented that they are not currently tracking this as a design feature of controls system, but it could be added during the detailed design phase.

	N/A	DD	Yes	No	Partial	Goal
Compliance of 11 subsystems for all 102 System Requirements	568	378	170	1	2	3
% excluding N/A		68.23%	30.69%	0.18%	0.36%	0.54%
% including N/A	50.62%	33.69%	15.15%	0.09%	0.18%	0.27%



2.2. Overall AO Functional Requirements AO Subsystems

The Overall AO requirements matrix (see appendix spreadsheet) shows the compliance level of each of eight AO subsystems against all thirty Overall AO functional requirements. This is a total of 240 total compliance selections, in many cases the requirement is not applicable to that subsystem and is denoted N/A.

The one requirement listed at partial involves not blocking the Keck telescope pupil. The design team of the NGS WFS notes that: “The sensors low order 5x5 mode will sometimes lose light (during extreme nutation).” The one requirement listed as a “Goal Only” by the NGS WFS design team involves the non-operational conditions (temperature, humidity, etc.) in the observatory dome environment; no reason was given for the noncompliance. Both issues will be addressed during the detailed design phase.

	N/A	DD	Yes	No	Partial	Goal
Compliance of 8 major subsystem for all 30 Overall AO functional Requirements	102	80	56	0	1	1
% excluding N/A		57.97%	40.58%	0.00%	0.72%	0.72%

2.3. Functional Requirements Individual Subsystems

The individual requirements matrices (see appendix spreadsheet) show the compliance level of each of eleven subsystems against their own unique subsystem functional requirements. See table below for summary of each subsystems compliance.

Subsystem Specific Functional Requirements	DD	Yes	No	Partial	Goal
AO Enclosure	12	18	0	0	0
AO Bench	21	47	0	2	0
LGS WFS	11	24	1	0	0
NGS WFS	10	12	1	0	0
LOWFS	5	11	0	0	0
Acquisition Camera	6	8	0	0	0
Alignment, Calibration, & Diagnostics	5	11	0	7	0
RTC	2	39	0	0	0
LGS Facility	26	103	1	1	0
Controls	8	48	1	0	0
Science Operations Tools	8	38	0	3	0

The next sections discuss issues of non compliance for each subsystem.

2.3.1. AO Enclosures

Design is compliant to the level that it can be verified at preliminary design.



2.3.2. AO Bench

The two requirements that are listed as partially compliant are related to Lateral Color of the wide field and narrow field relays respectively. The specifications are not met for all bands. This issue will be followed up on during the detailed design phase.

2.3.3. LGS WFS

The one requirement listed as not compliant (No) is related to the Patrolling Asterism LGS WFS. The requirement specifies an operating dynamical range of at least plus/minus 1.4 arc seconds (on-sky). The design has plus/minus 0.86 arc seconds. This issue will be followed up on during the detailed design phase.

2.3.4. NGS WFS

The one requirement listed as not compliant (No) appears to be an error in the original draft of the requirement or the interpretation of the requirement by the NGS WFS design team. This item has been noted in the Contour requirements database and will be addressed during the final parts of the preliminary design phase (June 2010).

2.3.5. LOWFS

Design is compliant to the level that it can be verified at preliminary design.

2.3.6. Acquisition Camera

Design is compliant to the level that it can be verified at preliminary design.

2.3.7. Alignment, Calibration, and Diagnostics

Requirements that are listed as partially compliant can be organized into two groups. These are related to four requirements for an atmospheric simulation capability that are only partially supported by the calibration unit design. At present this deficiency is acceptable, but will be revisited during the detailed design phase. The other partially compliant requirements (three in total) are related to the formal statement of the requirements on calibration source brightness in terms of the final SNR at the science instrument. The calibration unit design team believes that the specifications can be met, but no formal verification has been documented. Therefore, they are listed as partially compliant. The issues of required calibration source brightness will be revisited during the detailed design phase.

2.3.8. RTC

Design is compliant to the level that it can be verified at preliminary design.

2.3.9. LGS Facility

The one requirement listed as No, is related to the strength of material for items mounted on or above the telescope. This issue will be addressed during the detailed design phase. The requirement denoted as partial involves the power required in the enclosure housing the laser units mounted to the elevation ring. The design was modified to require less power in this location, so the current enclosure design provides for less power than stated in the formal requirement. This issue will be addressed during the detailed design phase.

2.3.10. Controls

The one requirement denoted in the table as not compliant (i.e. No) is a result of the formal statement of the requirement. The software team will support all functionality listed in the requirement but it will not be done by a distributed control system on a single "command processor" as stated in the requirement. If the KCSF/EPICS framework is considered the "command processor" then the software team feels their design is compliant. This issue will be addressed during the detailed design phase.



2.3.11. Science Operations Tools:

The requirements that are listed in partial compliance are related to the need to more completely specify the design, functionality, and operations that are part of the controls design or the science tools design. Some confusion on the exact scope of each resulted in controls requirements being assigned to the Sci. Ops. Tools. Likely these requirements should be split between the two systems. This issue will be addressed during the detailed design phase.