NGAO Functional Requirements

Key	Name	Sect	Cat	Priority	WBS	Description	Rationale	Traceability	Status	Version	Verification	Originator	Last Modified
FR-32	First stage relay	Overall	Functional	Essential	1.2.4	The NGAO AO system shall have a main relay that contains a deformable mirror at an optical conjugate to the telescope pupil	The telescope pupil (limiting aperture) is the primary mirror. We define this as the "ground layer" or 0km conjugate. The first stage DM is intended to correct to moderate order over a wide field of view to feed multiple deployable near-IR IFU and the LOWFS. System architecture decision by design team.	Title: NGAO System Architecture Definition KAON 499 Version: 1.2 Section: 10 System Architecture 5: The "Cascaded Relay" page 19 Date: August 28, 2007 File: KAON_499_v1.2.pdf	Draft	1.0	Inspection	Chris Neyman	Mar 5, 2009 1:00 PM
FR-34	LOWFS optical interface	Overall	Functional	Essential	1.2.4	The first relay shall provide a wide field output as an interface for up to 3 NGS low order wavefront sensors (LOWFS).	A wide field interface is needed so that a large natural guide stars can be selected resulting in high sky coverage	KAON 499 "NGAO System Architecture Definition"	Draft	1.0	Inspection	Chris Neyman	Mar 5, 2009 1:01 PM
FR-35	Deployable Integral field spectrograph interface	Overall	Functional	Essential	1.2.4	The wide field output from the main relay shall direct light into the optical inputs of multiple deployable integral field spectrographs.	A wide field interface is needed for this required science instrument	KAON 499 "NGAO System Architecture Definition", Science Instrument requirements	Draft	1.0	Inspection	Chris Neyman	Mar 5, 2009 1:01 PM
FR-37	Acquisition Camera Interface	Overall	Functional	Essential	1.2.4	There shall be an optical pickoff to direct light to the acquisition camera between the output of the first stage relay and the input to the LOWFS assembly.	This sensor is needed to aid in the acquisition of (1) the 3 NGS for tip tilt tracking, (2) science objects and (3) LGS	KAON 567: NGS and LGS Acquisition Subsystems for NGAO: Initial Requirements and Conceptual Design.	Draft	1.0	Inspection	Chris Neyman	Mar 5, 2009 1:01 PM
FR-40	First relay field of view	Optical	Performance	Essential	1.2.4	The first stage of the optical relay shall pass a circular unvignetted field of view of 150 arc seconds diameter, without vignetting beams coming from point sources at 80 km altitude. (These fields are referenced to the sky).	This field of view is established by considering the system requirements for wavefront error and sky coverage, while folding in the availability of natural stars for low-order wavefront sensing and assuming the architectural design decision to place the LOWFS downstream of the first relay. Adopts 50th percentile seeing conditions of Mauna Kea ridge model. This requirement is intended to include all anticipated altitudes without vignetting rays from any part of the telescope pupil	See KAON 504 "NGAO Performance vs. Technical Field of View for LOWFS Guide Stars", wavefront error budget spread sheet v1.26 Science Case: Architecture_reqments_summary_v7.xls (row sky coverage)	Draft	1.0	Test	Chris Neyman	Mar 5, 2009 1:02 PM
FR-42	Static optical quality of first relay	Optical	Performance	Essential	1.2.4	The static optical quality of the first AO relay shall be as high as possible over the entire field of view of the AO system. Uncorrectable static aberrations of the AO relay shall be no more than 30nm, including chromatic focal shift.		This requirement is derived from the Performance Budget, Wavefront Error and Encircled Energy spreadsheet. It meets the static aberration requirements of all science cases	Draft	1.0	Test	Chris Neyman, Don Gavel	Mar 5, 2009 1:07 PM
FR-46	Curvature of output focal	Optical	Performance	Essential	1.2.4	The focal plane curvature at the output of the first relay shall	TBD	TBD	Draft	1.0	Demonstration	Chris Neyman,	Mar 5, 2009 1:03 PM

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	plane, first relay					be sufficient to implement deployable integral field spectrograph and low order wave front sensor object selection mechanisms.						Don Gavel	
FR-56	Pupil image size internal to the first relay	Optical	Performance	Essential	1.2.4	The pupil image size within the first relay shall be 100 mm	This pupil size is driven by the choice of deformable mirror for the first relay. The requirement is to accommodate a DM having 21 actuators across the diameter of the pupil and we are assuming that the actuator pitch is 5mm.	KAON 499 "NGAO System Architecture Definition"	Draft	1.0	Test	Chris Neyman, Don Gavel	Mar 5, 2009 1:04 PM
FR-58	Output pupil distortion, first relay	Optical	Performance	Essential	1.2.4	The allowable pupil distortions shall be less than 0.1 %	Requirement is based on tenth of a subaperture registration error and 64 subapertures across the pupil.	Standard rule of thumb for AO systems (Chris Neyman engineering decision)	Draft	1.0	Test	Chris Neyman, Don Gavel	Mar 5, 2009 1:05 PM
FR-1490	Lateral color, first relay	Optical	Performance	Essential	1.2.4	Lateral color shall be no more than 30 milli arc sec (TBD) for the first relay.	Cause a minimal effect on the centroiding accuracy for NIR tip/tilt stars. Assumption is that an ADC can correct for this.	Wavefront error budgets	Draft	1.0	Test	Don Gavel & Renate Kupke	Mar 5, 2009 1:06 PM
FR-1495	Field distortion, first relay	Optical	Functional	Essential	1.2.4	The optical distortion across the field at the output of the first relay shall be correctable by calibration of the AO system.	To first order, an astrometric grid can be established with internal fiducial, sufficient to establish position accuracy for accurate placement of tip/tilt star pickoffs with the aid of the acquisition camera	TBD	Draft	1.0	Demonstration	Don Gavel	Mar 5, 2009 1:02 PM
FR-1497	Transmission, first relay	Optical	Performance	Essential	1.2.4	The optical transmission of the first relay shall be as follows: 1. Transmission in the wavelength range XXXnm to YYYnm [IR Science wavebands] will be TBD %. 2. Transmission in the wavelength range XXXnm to YYYnm [Visible Science wavebands] will be TBD % 3. Transmission at the sodium D2 line (~589nm) will be TBD % 4. Transmission in the wavelength range XXXnm to YYYnm [NGS wfs sensing bands] will be TBD %		Wavefront error budget (tip/tilt stars), wavefront error budget (laser guide stars), Background and Transmission budgets- KAON 501 (science light)	Draft	1.0	Test	Chris Neyman, Don Gavel	Mar 5, 2009 1:03 PM
FR-1499	Output focal ratio, first relay	Optical	Functional	Essential	1.2.4	The output focal ratio of the first relay shall be made compatible with the input to the second relay, the inputs to the LOWFS, and the inputs to the dIFS units.	The two relays have to work together	KAON 499 "NGAO System Architecture Definition"	Draft	1.0	Demonstration	Chris Neyman, Don Gavel	Mar 5, 2009 1:03 PM
FR-1502	Exit pupil location, first relay	Optical	Functional	Essential	1.2.4	The output of the first relay shall be a telecentric beam (pupil at infinity).	The pupil location was chosen to simplify the design of the LGS WFS and LOWFS pick-off mechanisms and wavefront sensors. A telecentric system does not require tilt with field to keep the chief ray constant on entering the wavefront sensor. There are also no pupil scale changes with conjugate distance for the LGS WFS.	Engineering decision of AO relay design team (see System Design Manual)	Draft	1.0	Demonstration	Don Gavel	Mar 5, 2009 1:04 PM
FR-1505	Telescope pupil image grid	Optical	Performance	Essential	1.2.4	The pupil grid distortion at the output of the first relay shall	Assumption is that "push matrix" calibration will be able to	Wavefront Error Budgets, and design study for AO relay (see	Draft	1.0	Test	Chris Neyman,	Mar 5, 2009 1:05 PM

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	distortion, first relay					be less than 0.5% .	measure this distortion sufficiently to compensate for it in the RTC to a level of ~0.1 subaperture, which is required for closed loop stability	System Design Manual)				Don Gavel	
FR-1507	Telescope pupil image aberrations, first relay	Optical	Performance	Essential	1.2.4	The pupil aberration at the woofer mirror in the first relay shall be less than 10% of a subaperture on the DM.	The telescope will map to the woofer mirror with a point spread function whose width depends on the field being corrected, in this case 150 arc seconds. This point spread function blurs the correction applied to the DM, causing an effective Anisoplanatic error.	Wavefront Error Budgets. This needs an analysis given formulas in B. Bauman "Anisoplanatism in adaptive optics systems due to pupil aberrations" SPIE 5903 (2005)	Draft	1.0	Test	Renate Kupke	Mar 5, 2009 1:06 PM
FR-1510	Telescope pupil image tilt, first relay	Overall	Performance	Essential	1.2.4	The pupil tilt at the woofer mirror in the first relay shall be less than 25 mm at the edge of the 100 mm DM.	There will be a large tilt of the pupil at the plane of the woofer, due to the nature of producing the pupil with an off-axis parabola. This tilt will act like an uncertainty in the conjugate height being corrected. The uncertainty in conjugate height = (magnification)^2 x (edge displacement). Magnification = 100 (10 m -> 100 mm). A 25 mm tilt will cause 250 m conjugate height variability	Anisoplanatic error in wavefront error budgets.	Draft	1.0	Test	Renate Kupke	Mar 5, 2009 1:05 PM