GEMINI
OBSERVATORY

MCAO Adaptive Optics Module Initial Alignment Plan

MCAO Preliminary Design Review Material

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The Adaptive Optics Module is aligned in at least three phases. The first phase will be to align the individual elements into the multi-element component assemblies. This includes the source simulator, the NGS diagnostic wave front sensor, the zoom corrector, the LGS wave front sensor, and the NGS field patrol unit. The two elements of the rotating beam splitter must be individually aligned while in the NGS path. The two ADC's have optical tolerances that are loose enough that simply machining the mechanical parts to tolerances obtainable with normal machining operations is adequate to ensure proper alignment of the optics. The second phase will be the alignment of all of the optics to the optical table. The third and final phase is the alignment of the optical table to the telescope. The alignment plans are subject to review, and revisal by the affected contractors.

1. Multi-element Components. The individual components will be aligned either at the contractor's optics lab or in the Gemini, Hilo optics lab depending on the contractual agreements.

    1.1. NGS Source Simulator

        1.1.1. Components

            1.1.1.1. Fiber Heads. Prior to mounting the Source Simulator onto the AO bench, the sources must be placed in the proper pattern and aligned so that they are diverging at f/16.

        1.1.2. Datums

            1.1.2.1. The central ray.

        1.1.3. Fixtures/equipment

            1.1.3.1. Source mounts.

            1.1.3.2.Target cards. Cards with the constellation patterns printed on it and at a scale that is expected at a specified distance.

        1.1.4. Procedure.

            1.1.4.1. Place the source simulator in a secure mount.

            1.1.4.2. Place the target card at the specified distance from the fiber heads.

            1.1.4.3. Align the central beam to coincide with the central target.

            1.1.4.4. Align the other beams with their corresponding targets.

            1.1.4.5. Align the central beam to coincide with the central target.

    1.2. LGS Source Simulator

        1.2.1. Components

            1.2.1.1. Diodes. Prior to mounting the Source Simulator onto the AO bench, the five sources must be placed in the proper pattern and aligned so that they are diverging at f/16.

        1.2.2. Datums

1.2.2.1. The central ray.

1.2.3. Fixtures/equipment

1.2.3.1. Source mounts.

1.2.3.2.Target cards. Cards with the constellation patterns printed on it and at a scale that is expected at a specified distance.

1.2.4. Procedure.

1.2.4.1. Place the source simulator in a secure mount.

1.2.4.2. Place the target card at the specified distance from the fiber heads.

1.2.4.3. Align the central beam to coincide with the central target.

1.2.4.4. Align the other beams with their corresponding targets.

1.2.4.5. Align the central beam to coincide with the central target.

1.3. DM0 Mask

1.3.1. Components

1.3.1.1.Mask

1.3.2. Datums TBD

1.3.3. Fixtures/equipment: None

1.3.4. Procedure. The tolerances for the DM0 mask is sufficiently lenient that the mask can be placed using calipers and micrometers.

1.4. NGS Diagnostic Wave Front Sensor

1.4.1. Components

1.4.1.1. Large Doublet

1.4.1.2. Small Doublet

1.4.1.3. Deanamorphoser

1.4.1.4. Shack Hartman Lenslet Array

1.4.1.5. CCD Detector

1.4.1.6. Video Camera

1.4.2. Datums

1.4.2.1.Machined inner diameters of tube for radial alignment of the lenses.

1.4.2.2.Machined axial datum surfaces for axial and tip/tilt alignments of the lenses.

1.4.3. Fixtures/equipment

1.4.4. Procedure. Tolerances may be loose enough to require mechanical alignment only of the lenses into their cells. Detailed procedures will be determined by the contractor.

1.5. NGS Field Patrol Unit

1.5.1. Components TBD

1.5.2. Datums TBD

1.5.3. Fixtures/equipment TBD

1.5.4. Procedure. TBD

1.6. Zoom Corrector

1.6.1. Components

1.6.1.1.Corrector #1

1.6.1.2.Corrector #2

1.6.1.3.Corrector #3

1.6.1.4.Corrector #4

1.6.2. Datums

1.6.2.1.Machined outer diameter of outer tube for radial alignment of unit.

1.6.2.2.Machined axial datum surface on outer tube for axial alignment of unit.

1.6.2.3. Machined flats or index marks on outer tubes for Z-rotational alignment of unit.

1.6.2.4. Machined internal diameters for radial registration lenses to tube.

1.6.2.5. Machined axial datum surfaces for axial registration of lenses to tube.

1.6.2.6. Index mark on Corrector #4 for Z-rotational alignment of Corrector #4 to tube.

1.6.3. Fixtures/equipment TBD

1.6.4. Procedure. Tolerances may be loose enough to require mechanical alignment only of the lenses into their cells. Detailed procedures will be determined by the contractor.

1.7. LGS Wave Front Sensor

1.7.1. Components

1.7.1.1. Tilt Window. The tolerances for the tilt window are loose enough that optical alignment is not required.

1.7.1.2. Hyperboloid

1.7.1.3. Tip/tilt mirror

1.7.1.4. Deanamorphoser

1.7.1.5. Source flip mirror

1.7.1.6. Shack Hartman Lenslet Array

1.7.1.7. Relay Field Lens

1.7.1.8. Cylindrical Lens #1

1.7.1.9. Cylindrical Lens #2

1.7.1.10. Cylindrical Lens #3

1.7.1.11. Focus Doublet #1

1.7.1.12. Focus Doublet #2

1.7.1.13. CCD

1.7.2. Datums TBD

1.7.3. Fixtures/equipment TBD

1.7.4. Procedure. Detailed procedures will be determined by the contractor.

1.8. Beam Splitter Changer

1.8.1. Components

1.8.1.1.Changer Mechanism

1.8.1.2. Splitter #1

1.8.1.3. Splitter #2

1.8.2. Datums TBD

1.8.3. Fixtures/equipment

1.8.3.1. Dummy window

1.8.3.2. Calipers, Gauge pins, etc.

1.8.4. Procedure.

1.8.4.1. A dummy window is securely placed into the splitter #1 cell. The tolerances for the window are sufficiently lenient that the prisms can be placed using calipers, gauge pins, etc.

1.8.4.2.Splitter #1 is placed and aligned during the optical bench alignment.

1.8.4.3..Splitter #2 is also placed and aligned during the optical bench alignment.

1.9. Science ADC

1.9.1. Components

1.9.1.1. ADC Mechanism

1.9.1.2. Prism #1

1.9.1.3. Prism #2

1.9.2. Datums

1.9.2.1. Cell Surfaces

1.9.2.2. Prism surfaces

1.9.2.3. Index marks on cells

1.9.2.4.Index marks on prisms

1.9.3. Fixtures/equipment

1.9.3.1.Calipers, gauge pins, etc

1.9.4. Procedure.

1.9.4.1. The tolerances for the ADC are sufficiently lenient that the prisms can be placed using calipers, gauge pins, etc.

1.9.4.2. Visually align the index marks on the cells with the index marks on the prisms.

1.10. NGS ADC

1.10.1. Components

1.10.1.1. ADC Mechanism

1.10.1.2. Prism #1

1.10.1.3. Prism #2

1.10.2. Datums

1.10.2.1. Cell Surfaces

1.10.2.2. Prism surfaces

1.10.2.3. Index marks on cells

1.10.2.4. Index marks on prisms

1.10.3. Fixtures/equipment

1.10.3.1. Calipers, gauge pins, etc

1.10.4. Procedure.

1.10.4.1. The tolerances for the ADC are sufficiently lenient that the prisms can be placed using calipers, gauge pins, etc.

1.10.4.2. Visually align the index marks on the cells with the index marks on the prisms.

2. Optical Table Alignment The optical table will be aligned either at the contractor's optics lab or in the Gemini, Hilo optics lab depending on the contractual agreements.

2.1. Science Path

2.1.1. Components

2.1.1.1. First Fold

2.1.1.2. OAP1

2.1.1.3. DM2

2.1.1.4. DM1

2.1.1.5. DM0

2.1.1.6. Tip/tilt Mirror

2.1.1.7. Beam Splitter #1. Although the beam splitters are in the science (transmitted) path, they have very little effect on the science path alignment. The beam splitters will be aligned with the NGS (reflected) path. The beam splitter with the dummy window should be installed at this time but no alignment is necessary yet.

2.1.1.8. Fold #2

2.1.1.9. OAP2

2.1.1.10. NGS Diagnostic WFS

2.1.2. Datums

2.1.2.1. Cross-hair targets at input and output beams and in the plane of the mounting pads.

2.1.2.2. Set up. The AO bench will be mounted in a support fixture that will hold it cantilevered in the vertical position. This is the same position that it will see when mounted on the telescope and the telescope is pointed toward zenith. Aligning the optics in this position will null out flexure in this orientation.

2.1.3. Fixtures/equipment

2.1.3.1. Support fixture.

2.1.3.2. Alignment fixture. The alignment fixture is designed to hold two alignment telescopes, one in the input beam and the other in the output beam. The fixture is mounted on the support fixture. The alignment fixture should be designed so that a laser can be substituted for either AT.

2.1.3.3. Three cross-hair targets.

2.1.3.4. Two alignment telescopes.

2.1.3.5. Temporary flat mirrors in lieu of DM's for initial alignment.

2.1.3.6. Temporary flat mirrors in lieu of OAPs.

2.1.3.7. Dummy window in lieu of beam splitter

2.1.3.8. Mobile target on XY stage set to the height of the beam from the optical table.

2.1.3.9. Two theodolites.

2.1.4. Procedure. By itself, the science path has only two powered elements – OAP1 and OAP2. The two OAPs are temporarily replaced with flats to facilitate the initial alignment. Since the ADC has almost no effect on the alignment of the rest of the science path, it is left out of the beam until the end of the alignment process whereupon it is aligned with respect to the optical axis. Because the beam splitter does not transmit in the visible range, it is replaced with a dummy window so that the alignment process can be done with visible light instruments.

2.1.4.1.Install the AO module into the support structure so that it is in the same vertical position that it would be if it were on the telescope at zenith.

2.1.4.2.Install the alignment fixture.

2.1.4.3. Install the cross-hair targets in the alignment fixture.

2.1.4.4. Using the theodolites, establish the datum at the three cross-hair targets.

2.1.4.5. Using the theodolites, place the target at the OAP1 location.

2.1.4.6. Remove the cross-hair targets and install the AT's

2.1.4.7. Place and align fold mirror #1 by sighting on the target with the AT off of fold mirror #1.

2.1.4.8. Using the theodolites, place the target at the DM2 position.

2.1.4.9. Place and align OAP1 dummy flat mirror by sighting on the target with the AT off of OAP1 flat.

2.1.4.10. Using the theodolites, place the target at the DM1 location.

2.1.4.11. Place and align the dummy DM2 flat by sighting on the target with the AT off of DM2.

2.1.4.12. Using the theodolites, place the target at the DM0 location.

2.1.4.13. Place and align the dummy DM1 flat by sighting on the target with the AT off of DM1.

2.1.4.14. Using the theodolites, place the target at the tip/tilt mirror location.

2.1.4.15. Place and align the dummy DM0 flat by sighting on the target with the AT off of DM0.

2.1.4.16. Using the theodolites, place and roughly align the beam splitter #1.

2.1.4.17. Install a flat black card in the reflected beam of the beam splitter. This is to reduce confusion about which path the AT is sighting on.

2.1.4.18. Align the ADC to .06º. Using the AT, rotate the ADC unit until the return is off by 3.6 arc minutes.

2.1.4.19. Put the ADC in out-of-beam position.

2.1.4.20. Using the theodolites, place the target at the fold mirror #2 location.

2.1.4.21. The tip/tilt mirror should be placed at it's nominal mid range position. Place and align the tip-tilt mirror by sighting on the target with the AT, through the beam splitter, and off of the tip-tilt mirror.

2.1.4.22. Install the AT in the output port.

2.1.4.23. Place and align dummy OAP2flat mirror by sighting on the target with the AT off of OAP2 flat.

2.1.4.24. Place and align fold #2 by sighting on the other AT through the entire system

2.1.4.25. Install the NGS diagnostic WFS.

2.1.4.26. Turn on reticle of autocollimator

2.1.4.27. Move the NGS diagnostic WFS CCD into the beam.

2.1.4.28. When the retro reflection is aligned, mark the position as the central position.

2.1.4.29. Replace the dummy OAP flats with the real off-axis parabolas.

2.1.4.30. Align the two OAP's.

2.1.4.31. Replace DM2 dummy flat with the real DM2.

2.1.4.32. By observing with the diagnostic WFS, establish the null mode for DM2.

2.1.4.33. Replace DM2 dummy flat with the real DM1.

2.1.4.34. By observing with the diagnostic WFS, and nulling DM2, establish the null mode for DM1.

2.1.4.35. Replace DM2 dummy flat with the real DM0.

2.1.4.36. By observing with the diagnostic WFS and nulling DM2 and DM1, establish the null mode for DM0.

2.2. NGS Path

2.2.1. Components

2.2.1.1.Source Simulator.

2.2.1.2. Beam Splitter #1 Each of the two beam splitters must be aligned individually. The rotator is driven to the first position and the beam splitter mechanism is aligned with the optical path. Then the mechanism is driven to the second position and the second beam splitter is aligned by adjusting it in its cell.

2.2.1.3. OAP3

2.2.1.4. Fold #3

2.2.1.5. Beam Splitter #2

2.2.1.6. NGS ADC

2.2.1.7. Fold #4

2.2.1.8. Field Lens

2.2.1.9. Field Patrol Unit

2.2.2. Datums.

2.2.2.1. Cross hair targets in the input and output beams and in the plane of the mounting pads. These are the same datums as used for the science path.

2.2.3. Fixtures/equipment

2.2.3.1. Support fixture.

2.2.3.2. Alignment fixture. The alignment fixture is designed to hold two alignment telescopes, one in the input beam and the other in the output beam. The fixture is mounted on the support fixture. The alignment fixture should be designed so that a laser can be substituted for either AT.

2.2.3.3. Cross-hair target.

2.2.3.4. Alignment telescope.

2.2.3.5. Temporary flat mirrors in lieu of DM's for initial alignment.

2.2.3.6. Temporary flat mirrors in lieu of OAPs.

2.2.3.7. Mobile target on XY stage set to the height of the beam from the optical table.

2.2.3.8. Two theodolites.

2.2.4. Procedure

2.2.4.1. Using the theodolites, place the mobile target at the OAP3 position.

2.2.4.2. Replace the dummy beam splitter window with the real beam splitters (2).

2.2.4.3. Remove the flat black card from the reflected beam of beam splitter #1 and place it in the transmitted beam directly after the beam splitter.

2.2.4.4. With the beam splitter rotator rotated to the first position, align the beam splitter mechanism with respect to the bench by sighting on the target off the beam splitter through the AT.

2.2.4.5. With the beam splitter rotator rotated to the second position, align the beam splitter with respect to the rotator by sighting on the target off the beam splitter through the AT.

2.2.4.6. Using the theodolites, place the mobile target at the fold mirror #3 position.

2.2.4.7. Place and align OAP3 dummy flat mirror by sighting on the target with the AT off of OAP3 flat.

2.2.4.8. Using the theodolites, place the mobile target at the BS#2 position.

2.2.4.9. Place and align fold mirror #3 by sighting on the target through the AT and off of fold mirror #3.

2.2.4.10. Using the theodolites, place and roughly align beam splitter #2.

2.2.4.11. Install a flat black card in the reflected beam of the beam splitter. This is to reduce confusion about which path the AT is sighting on.

2.2.4.12. Using the theodolites, place and roughly align the NGS ADC.

2.2.4.13. Align ADC by observing retro reflection of the front surface with the autocollimator.

2.2.4.14. Null the ADC.

2.2.4.15. Using the theodolites, place the mobile target at the field lens position.

2.2.4.16. Place and align fold #4 by sighting on the target with the AT .

2.2.4.17. Place and align the field lens by sighting on the lens with the AT.

2.2.4.18. Place and align field patrol unit.

2.3. LGS Path

2.3.1. Components

2.3.1.1.Zoom Corrector

2.3.1.2.LGS Wave Front Sensor

2.3.2. Datums

2.3.2.1.Cross hair targets in the input and output beams and in the plane of the mounting pads. These are the same datums as used for the science path.

2.3.3. Fixtures/equipment

2.3.4. Procedure

2.3.4.1.Using the theodolites, place the mobile target at the zoom corrector #1 position.

2.3.4.2.Remove the flat black card from the reflected beam of beam splitter #2 and place it in the transmitted beam directly after the beam splitter.

2.3.4.3.Align the beam splitter #2 by sighting on the target off the beam splitter through the AT.

2.3.4.4.Using the theodolites, place and align the zoom corrector by sighting on targets on the tube.

2.3.4.5.Using the theodolites, place and roughly align the LGS WFS.

2.3.4.6.TBD

3. Instrument to Telescope Alignment

3.1. Components

3.1.1. Instrument Support Structure

3.1.2. AO Optical Bench

3.2. Datums

3.2.1. Cross Hairs on the telescope

3.2.2. Surface of ISS

3.3. Fixtures/equipment

3.3.1. Two alignment telescopes (AT's)

3.3.2. Alignment telescope mount (dwg # 83-GP-0000-1010)

3.4. Procedure

3.4.1. Mount AT on the ISS science port opposite the AO Module.

3.4.2. Mount the second AT on the AO port opposite the AO module.

3.4.3. Remove the AO fold mirror and install the science fold mirror.

3.4.4. Sighting off the science fold mirror, align the lower AT with the cross hairs on the telescope.

3.4.5. Remove science fold mirror and install AO fold mirror.

3.4.6. Sighting off the AO fold mirror, align the upper AT with the cross hairs on the telescope.

3.4.7. Put the DM's into their nominal, flat, mid-range position. This is the configuration to which the AO module was initially aligned.

3.4.8. With the lower AT, align the AO module by sighting on the upper AT through the AO module. Modify alignments as necessary by changing shims on the AO module mounting pads.

3.4.9. Verify alignment by using the upper AT, sighting on the lower AT through the AO module.

3.4.10. As a second verification, install the AO fold mirror. Using the lower AT, sight on the telescope cross hairs through the AO module.