Procedure to Remove the 2.5m Primary Mirror (M1)

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Cautionary Notes

- **This operation requires 5 people.**
- **If the telescope runs away at any time, engage an e-stop button immediately.**
- **The following weather conditions must be met:**
  - No threat of precipitation
  - Sustained wind speed < 35 MPH for 15 minutes
  - Wind gusts for instrument changes < 25 MPH
  - Dew point depression: >= 4°F or 2°C
  - Dust count < 10,000 units
  - Check for condensation regularly when the dew point depression is less than 8°F or 6°C. Close the enclosure if condensation is found on rails, building skin, or the top of the doghouse.
  - Do not push the dust limit and the dew point limit at the same time. If the dust counts are near the stated limit, it is best to have a dew point depression of > 18°F or 20°C.
- Safety wear (recommended): rubber-soled shoes, hard hat.
- Only people trained by observatory staff may execute this procedure.

Equipment Required

M1 Crate; Location: stored at American Storage in Alamogordo; Appearance: yellow

M1 Lifting Spider; Location: stored at American Storage in Alamogordo; Appearance: green

M1 Hard Covers; Location: 3.5m enclosure ground level; Appearance: white

M1 Guide Rods; Location: 3.5m enclosure observing level; Appearance: threaded rod approx 5'

M1 Support Pedestals (with foam pads); Location: 3.5m enclosure ground level; Appearance: black steel with white foam pads on top.

Eight pieces of 4x6 wood, 6 feet long; Location: Garage

Support Platform (or extension ladder if platform not available).

Work Light for the person in the center of M1.

Flashlights; (4) rubber-coated

Common Corrector Crate; Location: stored at American Storage in Alamogordo; Appearance: black

Common Corrector Cover (with bolts and Delrin washers); Location: stored in the common corrector crate

Hydraset; Location: 3.5m enclosure ground level; Appearance: black on rollers

Astigmatism Corrector Tools; Location: storage trailer on site; Appearance: L-shaped tool and rod puller.

Braided Rope; Location: 2.5m enclosure storage cabinets; Appearance: 50 feet of 1/2"

Protection Tubes for Axial Actuator Quills; Location: storage trailer on site

Rigging straps; Location: 2.5m enclosure storage cabinets; Appearance: variety of sizes

Plastic guide strips; Location: 2.5m enclosure storage cabinets; Appearance: 3/16" x 2" x 4' white vinyl

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Initial State of Telescope

- All instruments removed (excluding the spectrographs) and safely stowed.
- Spectrograph corrector removed and safely stowed.
- Wind baffle removed.
- M2 mirror removed and safely stowed.
- Secondary truss removed.
- Telescope pinned at zenith and turnbuckle to wind baffle.

Procedure

Note: stow all items mentioned in procedure in the plug plate lab.

1. Set up barriers to control personnel traffic.

2. Determine lead person and review procedure with crew before commencing

3. Remove hardware around the front circumference of M1:

    a. Remove the witness samples and aperture stop/earthquake ring. The aperture stop is in four pieces and requires a 5/32" Allen wrench. Be careful not to touch the fronts of the witness samples.

    b. Remove top earthquake bumpers. This requires a 1/8" Allen wrench.

    c. Set one hard cover on the south third of M1.

    d. Rig the support platform across the south side of the PSS (above the portion of the mirror protected by the hard cover.)

4. Remove the M1 light baffle:

    a. Rig the M1 light baffle to the overhead crane using an 8ft. strap.

    b. Position somebody wearing a non-scratchy hat or cap and carrying a work light up inside the center hole of M1 (standing on the floor). Be very careful not to touch the common corrector. This same person does all the detaching mentioned in the next steps and attaches the lifting spider.

    c. Rotate the rotator until the light baffle bolts are visible by looking through access holes in the common corrector mount.

    d. Unscrew the M1 light baffle mounting bolts. These are captive bolts; leave them captured for now.

    e. Using the crane, hoist the M1 light baffle out and over the WB frame and stow.

5. Install the remaining M1 hard covers.

6. Remove the common corrector:

    a. Using the crane and 3 point rigging, hoist the common corrector cover onto the common corrector.

    b. Attach the corrector cover to the common corrector using the bolts and Delrin washers.

    c. Detach the common corrector from its mounting ring.

    d. Using the crane, hoist the common corrector out of the telescope and crate it.

    e. Retrieve the brass spacer washers that go between the common corrector and its mounting ring. (At some point these spacers may be permanently attached.)

f. Stow the crated common corrector.

g. Remove the support platform from the PSS.

7. Remove the common corrector mounting ring (black cylinder in center of M1):

    a. Rig the common corrector mounting ring to the crane using an 8 ft. strap through holes on the ring.

    b. Detach the common corrector mounting ring from the rotator.

    c. Using the crane, hoist the common corrector mounting ring out of the telescope and stow in the plug-plate lab.

    d. Remove the captive bolts that held the M1 light baffle.

8. Attach the M1 lifting spider:

    a. Rig the M1 lifting spider to the crane with a Hydraset.

    b. Adjust the Hydraset so it is nearly fully compressed (piston within body).

    c. Using the crane, hoist the M1 lifting spider into the center of M1 and attach to the M1 lifting fixture.

9. Remove actuators and gauges:

    a. Home M1 actuators A, B, C, and D (see the Galil Mirror Controller manual for instructions).

    b. Turn off the support system air.

    c. Disconnect astigmatism actuator air.

    d. Remove the transverse vertical actuator (actuator D).

    e. Remove the transverse vertical Mitutoyo linear gauge (Y axis gauge), and remove the three small black screws on inner plate. Do not remove the main plate or detach the gauge from the inner plate or else “absolute” position will be lost.

    f. Detach the lateral links at the mirror.

    g. Remove the two lateral Mitutoyo linear gauge hard points (the blocks the gauges touch), using a 0.050" allen key. **Note:** the gauges themselves cannot be removed with the mirror in.

10. Remove the astigmatism corrector actuators and rods:

a. Turn the rotator as needed to expose access panels for the various astigmatism corrector actuators. Rotator positions for removing astigmatism actuators: 2°, 28°, 72°,

   95°, 115°, 158°, 182°.

b. Use the L-shaped tool to pry each rod loose at the actuator end.

c. Detach the actuator from the PSS (squeeze to release).

d. Use the rod puller to detach the rod at the mirror end.

11. Turn the rotator to 0 degrees.

12. Position the three M1 support pedestals, setting them on pairs of 4x6s to distribute the weight on the floor.

13. Detach the lifting fixture (inside M1) from the PSS.

14. Position four people with rubber-coated flashlights and plastic guide strips on the PSS to watch the mirror as it comes up.

15. Have each person place guide strip between the PSS and M1. Move it around to check for obstructions, and then hold it upright while M1 is raised.

16. Position one person inside the M1 central hole. This person controls the crane and watches the under side of the mirror.

    Note: all lifting is done using the crane, not the Hydraset. The Hydraset acts as a force gauge, shock absorber, and safe way to set the mirror back down on the PSS (should that prove necessary).

17. Using the crane, raise the lifting fixture just enough to free it.

18. Hydraset

    a. Raise the lifting fixture a few inches and extend the Hydraset piston.

    b. Assign one of the four people on the PSS to watch the Hydraset force gauge. **When lifting the mirror, watch the Hydraset at all times. It should read approximately 2250 lbs when the mirror is raised.**

19. Install the mirror guide rods.

20. Using the crane, raise the lifting fixture, until it contacts the mirror. **IMPORTANT: make sure the fixture is seated correctly on the glass, and there is nothing between the lifting fixture and the glass. Any error could destroy the mirror.**

21. Raise M1 about a foot.

22. Detach all 4 thermometer cable connectors.

23. Raise M1 slowly. Be especially vigilant as the bottom of the mirror reaches the tops of the vent tubes, as the vent tubes have shoulders.

24. When M1 has cleared the PSS, remove the guide rods.

25. When M1 is high enough to clear the wind baffle support frame and flat field lamps, attach two tag lines around its circumference. Give one rope to somebody at the west end of the PSS and the other rope to somebody on the floor at the east end of the telescope.

26. Hoist the mirror over the wind baffle support frame and lower onto the M1 support pedestals.

27. Inspect the mirror.

28. Place protective tubes over the axial actuator quills.

29. Remove the extension rods from the three axial Mitutoyo linear gauges.

30. If you are going to leave the mirror on the pedestals for any length of time, keep 1200 lbs of force on the crane hook.

31. Crate M1:

    a. Place the open M1 crate on the back of the pickup truck.

    b. Back the truck up to the west edge of the concrete apron.

    c. Raise the mirror off the M1 support pedestals.

    d. Use the enclosure and crane to move M1 into its crate.

32. Roll the secondary baffle back into the enclosure; note that it fits best sideways.

Document History

2001-08-10 first public release R. Owen.

2001-08-16 F. Leger, R. Owen: corrected M1 guide rods.

2001-08-29 R. Owen: misc. edits.

2001-08-29 web page created; format edits by GVD.

2001-09-05 web update GVD.

2001-09-05 R. Owen: restore list formatting and improve HTML conformance.

2001-10-03 R. Owen: minor improvements based on recent M1 removal.

2004-06-24 SDSS Engineering Staff: minor improvements based on last M1 removal.

2004-06-25 Download to web site; archived old procedure: GVD