

Procedure to Remove the 2.5m Secondary Mirror (M2)

Prepared by Russ Owen, French Leger, and Larry Carey

Reviewed by Mark Klaene

Maintained by Gretchen Van Doren

Last modified on 2004-06-24 at 10:10

- [Cautionary Notes](#)
 - [Equipment Required](#)
 - [Initial State of Telescope](#)
 - [Procedure](#)
 - [Document History](#)
-

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: $\geq 4^{\circ}\text{F}$ 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 $> 18^{\circ}\text{F}$ or 20°C .
 - Safety wear (recommended): rubber-soled shoes, hard hat.
 - Only people trained by observatory staff may execute this procedure.
-

Equipment Required

M2 Crate; Location: stored at American Storage in Alamogordo; Appearance: yellow

M2 Belly Band; Location: inside M2 crate; Appearance: polished metal circular band.

M2 Spreader Bar for crane with down-straps attached; Location: 3.5m enclosure ground level; Appearance: green.

Force Gauge for crane (500 lb.); Location: 3.5m enclosure; Appearance: black

Hydraulic Damper for crane; Location: 2.5m storage cabinets.

Ladders; Location: 2.5m enclosure; Appearance: 4 ft. step.

Plastic Sheeting; Location: Garage; Appearance: 1/4"

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

Initial State of Telescope

- All instruments removed (excluding the spectrographs) and safely stowed.
 - Spectrograph corrector removed and safely stowed.
 - [Wind baffle removed](#) and wind baffle support frame secured (tied down and supported with jackscrews).
-

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 the M2 light baffle:
 - a. Remove all four M2 light baffle side plates; be careful of the delicate 1/4-turn quick-release screws.
 - b. Rig the M2 light baffle to the overhead crane with 8 ft. straps (400 lb capacity min), and take up some weight.
 - c. Station one person on each side of the mirror to control the light baffle.
 - d. Loosen the M2 light baffle and adjust the crane to just take up the weight.
 - e. Unscrew the light baffle and remove it.
 - f. Stow the light baffle.
4. Rig the overhead crane with (in order from the hook): hydraulic damper, 500 lb. force gauge and M2 spreader bar.
5. Install the M2 belly band:
 - a. Place the belly band around the M2 with the latches **on top**. Off-centered trunnions to be positioned toward the front plate of mirror. Hook the latches but **do not close them** yet.

- b. Connect the spreader bar to the trunnions on the belly band.
 - c. Take up 90-100 lb. of force on the crane hook.
 - d. Put a light weight level on the spreader bar and level the spreader bar by sliding the belly band around the mirror.
 - e. Close the belly band latches.
6. Prepare M2 for removal:
 - a. Turn off 24V to Galil
 - b. Detach all wires coming from the mirror and piezos and make sure they are untangled and can easily be removed with the mirror.
 - c. Tape thermometer cables to the back of the mirror with aluminum tape.
 - d. Remove the Heidenhain encoders and flexures. The flexures are very fragile. If they are bent, discard them.
 - e. Tape the Mitutoyo linear gauges fully retracted. Place a small piece of tape, ends facing each other, to prevent adhesive from touching the Mitutoyo actuator.
7. Lay the big sheet of plastic on the floor of the enclosure, under M2 and up against the lip of the enclosure.
8. Lay the lid of the M2 crate, foam side up, on sheet of plastic under M2.
9. Take up the weight of M2: approximately 270 lb. on the force gauge.
10. Find at least two Allen wrenches to fit the set screws that hold the axial actuator flexure to the actuator (at least one should be L-shaped) and a wrench to fit the screws holding the anti-rotation link.
11. Position one person, wearing a face mask, in front of the mirror, pushing it east with gloved hands against the outer edge of belly ban to hold it in place. Position two people behind the mirror to detach the axial actuators. Have a fourth person ready to take parts and tools.
12. Detach the axial actuator flexures at the actuator end by loosening (but not removing) four set screws per actuator.
13. Remove the anti-rotation link (detach at both ends and stow). **Warning: the axial flexures are very vulnerable with the anti-rotation link removed. Do not allow the mirror to rotate or tip.**
14. Position two people in front of the mirror, one at either side, to keep the mirror vertical. Position one person behind the mirror to feed cables and make sure the actuator flexures

don't hang up on anything. Have a fourth person control the crane. The combined weight of the spreader bar, belly band, and mirror is approximately 280-290 lbs. 275 lbs. is the true weight number.

15. Move the hoist west to gently pull the mirror off its center rod. Be sure to hold the mirror vertical (it will try to swing) and watch that nothing hangs up in back of the mirror.
16. Verify that all cables are detached and that the actuator flexures are clear of the M2 cage.
17. Keeping the mirror vertical, lower it to a few inches above the lid of the mirror crate.
18. **Double check the belly band latches.**
19. Rotate the mirror face-side down (90 deg.). **Note: the rivets on the belly band may hang up on the lifting fixture.**
20. Rotate the mirror about its vertical axis until the trunnions are at the corners of the crate lid.
21. Lower the mirror into the crate lid.
22. Remove the whiffles. Stuff Kimwipes into mirror holes to keep screws from falling inside and have a grabber ready. Stow the whiffles (with attached axial actuator flexures and all fasteners).
23. Lay two strips of plastic outside the enclosure, as skids for the M2 crate lid.
24. Slide the crate lid out from under the truss.
25. Place the main body of the crate on top of the crate lid, being careful to align the holes in the foam with the mounting pads glued to the back of the mirror.
26. Close the crate latches.
27. Double check the latches. Sometimes they look latched but the hook has not properly engaged in the slot.
28. **Do not rely on the M2 crate latches to support the weight of the mirror.** Both the crate lid and the crate body have handles. Only lift by the lower set of handles!

Document History

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

2001-08-16 F. Leger, R. Owen.

2001-08-28 edits M. Klaene: add gloves, sheeting, actuator positioning.

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

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

2001-09-05 web updates GVD.

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

2001-10-03 R. Owen: minor improvements based on recent M2 removal.

2004-06-21 SDSS Engineering Staff: minor improvements based on last M2 removal.

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