COATLI

Technical Manual

Fernando Ángeles, Rosa L. Becerra-Godínez, Oscar Chapa,
Salvador Cuevas Cardona, Alejandro S. Farah,
Jorge Fuentes-Fernández, Rosalía Langarica Lebre, Fernando Quirós,
Carlos G. Román-Zúñiga, Carlos G. Tejada, and Alan M. Watson

Instituto de Astronomía
Universidad Nacional Autónoma de México

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Contents

Chapter 1

Introduction

This is the technical manual for the COATLI installation, telescope, and instrument and the DDOTI prototype telescope and instrument.

It has two aims. The first is to provide clear instructions to the OAN/SPM technical staff supporting routine operations. The second is to to aid COATLI and DDOTI team members and OAN/SPM technical staff perform preventative and corrective maintenance of the equipment.

For an overview of the COATLI and DDOTI projects, we recommend our 2016 SPIE papers:

- "COATLI: an all-sky robotic optical imager with 0.3 arcsec image quality", Watson et al. 2016, Proc. SPIE, 9908, 99085O-2
- "DDOTI: the deca-degree optical transient imager", Watson et al. 2016, Proc. SPIE, 9910, 99100G-1

Chapter 2

Safety

In this manual, safety instructions and observations are highlighted by boxes, like this:

> *Do not eat rat poison.*

2.1 Feedback

If you encounter a dangerous situation that is specific to COATLI and is not covered by the rules below or if you have comments or suggestions on the existing rules, please inform the PI of COATLI (Alan Watson) and the Secretario Técnico of the OAN.

2.2 Priorities

> *The safety priorities at the COATLI installation, from highest to lowest, are:*
>
> 1. *Personnel Safety.*
> 2. *Equipment Safety.*
> 3. *Observing and Data Preservation.*

The highest priority is personnel safety: avoiding death and injury to personnel.

The second highest priority equipment safety: avoiding damage or loss of equipment.

The lowest priority is observing and data preservation: they must proceed in a way that does not put personnel or equipment at unnecessary risk.

2.3 Personnel Safety

The COATLI installation is potentially one of the most dangerous installations at the OAN/SPM. Personnel safety is more important than equipment or observation. The following rules are designed to maintain personnel safety and must be followed at all times.

> *You must not work alone on the open platform or on the balconies.*

At least one other person must be present either on the platform or at ground level.

> *If you wish to work alone on the platform, you must close the enclosure. However, someone else must be present when your ascend or descend the tower.*

You can have someone close the enclosure manually after you have entered or you can close remotely using the iPod Touch. Remember that you must have a radio on hand.

> *You must use a safety harness, line, and helmet whenever you are on the platform or balconies or ascend the tower. Attach your line to one of the fasteners, to the balcony rail, or to something equivalently strong.*

The main platform is about 5 meters above the walkways. A fall from this height can easily kill.

Safety harnesses, lines, and helmets are stored in the shed.

The line can be attached to a various points: the eyes in the platform floor installed specifically for this purpose, the balcony safety rails, and other parts of the platform or tower structure.

The helmet will protect you from collisions with the telescopes, if you fall, and from falling objects.

> *You must use a safety helmet if you are working under the platform or balconies.*

The main platform is about 5 meters above the walkways. An impact from an object falling from this height can easily kill.

Safety helmets are stored on the shed.

> *If you wish to ascend to the platform or balconies, you must put the enclosure in local mode.*

In remote mode the enclosure can close without warning.

> *You may only be on the platform or balconies if it is strictly necessary.*

The platform and balconies are not a vantage points. You must only be on them to work on equipment.

You may only be on the platform or balconies at night if you need to close the enclosure manually or are testing or commissioning equipment on the sky.

You must not perform maintenance at night.

If there is a failure at night, you must not ascend to the platform to fix it. Instead, you must abandon the night's observations and attempt to close the enclosure from the shed.

You may only ascend to the platform at night if you need to close the enclosure manually.

You may only be on the platform or balconies in poor conditions if you need to close the enclosure manually.

Poor conditions include high wind, snow, and rain.

You must not perform maintenance in poor conditions.

You may only climb the platform in poor conditions if you need to close the enclosure manually.

Do not walk on the elevated areas at the ends of the platform.

These areas are not load-bearing. If you walk on them, you will likely fall.

You must have a radio on hand when working on COATLI.

A radio will allow you to summon help in an emergency.

You must physically disconnect mains power before working on an electronics boxes A and C–F.

Note that boxes A and C have two mains connectors, one for regulated power and one for unregulated power. Boxes D–F have only one mains connector, for regulated power.

Using the switch is not enough; it is present to allow the equipment to be rebooted. Besides, the unregulated power to boxes A and C is not switched.

Be extremely careful when working inside the controller, covers, and secondary cabinets as they use 220 VAC.

2.4 Equipment Safety

Only open the enclosure when conditions are benign.

For the time being, conditions are not benign if:

1. It is raining or snowing.
2. The humidity is 85% or higher and rising or previously reached 90% and has not yet fallen below 80%.

3. The wind average speed has not been 30 km/h or greater at any moment in the previous 30 minutes.
4. Any other circumstance in which, in the judgement of observatory technical staff, it is not safe to open.

These rules are implement in the COATLI weather server. If you check the COATLI web page, there is a summary line for the weather that says “may be open”, conditions are benign and you may open. If it does not, conditions are not benign and you must not open.

Note that the rules for opening the other telescopes specify a wind limit of 45 km/h. The limit for COATLI is currently lower until we have greater confidence in its reliability and performance in high winds.

> *Before opening the enclosure, check on the webcams that the telescope are not pointed to towards the sun.*

This is especially important for the Celestron telescope as it does not have a cover. In the home position, the telescopes are pointed to the north pole.

> *The enclosure controller should normally be switched on at all times in order to keep the electromagnetic lock activated.*

If the lock is not activated, the wind can open the roof a few centimeters and allow the ingress of rain or snow.

> *In case of fire, there is an extinguisher in the shed.*

If you do fight a fire, remember that personnel safety is more important than equipment safety.

Chapter 3

Operations

TODO: Opening windows on Mac.

TODO: Configure web page at 1.5-meter.

COATLI is in a phase of *remote commisioning*. In this phase, team members will operate and monitor the telescope remotely with limited support from the observatory staff. The telescope will not yet operate unattended.

3.1 Participants

By "observatory staff" we refer to the telescope operators, resident astronomers, and maintenance technicians. The actually division of responsibilities will be decided by the Secretario Técnico of the observatory.

By "team members" we refer to members of the COATLI and DDOTI technical teams.

3.2 Opening and Curfew

Initially, it will be possible to open COATLI only at the start of the night: from half an hour before sunset until a curfew at 21:30 PST/PDT. This ensures that if technical assistance is required, the observatory staff will not be called upon too late.

3.3 Communications

Communication between the observatory staff and the team members will take place primarily through the RATIR/COATLI operations Skype chat (formerly used for RATIR operations).

3.4 Operating Procedure

The operating procedure is:

- Most afternoons (the exception being extremely inclement weather), a member of the observatory staff checks the 1.5-meter telescope in situ and reports in the operations chat.

  After this, they will check the COATLI webcams on the COATLI web interface for any obvious problem. The address of the COATLI interface is:

  http://coatli.astrossp.unam.mx/

  The web interface is protected by passwords. The `operator15` and `operator21` accounts are configured with the same passwords for the RATIR web interface. If in doubt, ask on the Skype chat.

  If necessary, the observatory staff member will carry out an on-site inspection of COATLI. For example, after a snowfall, it might not be obvious from the webcams whether snow remains on the roof of the enclosure. In addition to safety, the idea here is to gain experience in which situations can be detected in the webcams and which need a physical inspection.

  They will then report the results of this inspection in the chat, indicating clearly if the remote observer has permission to open or not and whether any anomalies are visible.

- If permission is given and weather conditions permit, a team member may subsequently open COATLI no earlier than half an hour before sunset. The team member will report opening in the Skype chat.

- While COATLI is open, the team member will monitor the telescope and the Skype chat near constantly (i.e., breaks of up to 10 minutes are permitted but not longer).

- The team member will close COATLI if:

  1. It is raining or snowing.
  2. The humidity is 85% or higher and rising or previously reached 90% and has not yet fallen below 80%.
  3. The wind average speed has not been 30 km/h or greater at any moment in the previous 30 minutes.
  4. Requested by the observatory staff.

  Note that the rules for opening the other telescopes specify a wind limit of 45 km/h. The limit for COATLI is currently lower until we have greater confidence in its reliability and performance in high winds.

- The team member will begin to close COATLI for the night no later than the curfew time of 21:30 PST/PDT. The team member will report that they are beginning to close in the Skype chat. Once the telescope is closed, the team member will carry out a visual inspection using the webcams and report the results in the Skype chat.
- If at the curfew the remote team member has not begun to close (for example, because of a network interruption), the observatory staff should first remind the team member that the telescope needs to be closed. If there is no response within 10 minutes, the observatory staff member should close according to the procedure below.
- During the evening, requests by team members for technical assistance from the observatory staff are limited to whatever is necessary to close COATLI and return it to a safe state. Once technical assistance is requested, COATLI must be closed and may not open again until the next day.
- Requests for technical assistance beyond that needed to close COATLI and return it to a safe state must be directed to the Secretario Técnico of the observatory.

3.5 Local Closing

If it becomes necessary to close (for weather reasons, if requested by the observatory staff, or at the curfew) and the team member is unable to close for some reason, the observatory staff will have to close locally.

The procedure for closing COATLI locally is:

- Obtain the key to the shed.

  The key is stored in the lid of the toolbox in the COATLI equipment cabinet in the ground floor of the 84-cm telescope building.
- Go to the shed.

  You will close COATLI using the web interface on the Mac and the controllers for the mount, covers, and enclosure.
- Check you have windows for the web interface, the VNC to the PC, and Skype on the Mac. See Figure 3.1.
  - If the web interface is not running, select "Open Web Interface" from the script menu in menu bar in the upper right. See Figure 3.2.
  - If the Skype is not running, select "Open Skype" from the script menu in menu bar in the upper right. See Figure 3.2.
  - If the VNC to the PC is not running, select "Open VNC to PC" from the script menu in menu bar in the upper right. See Figure 3.2.

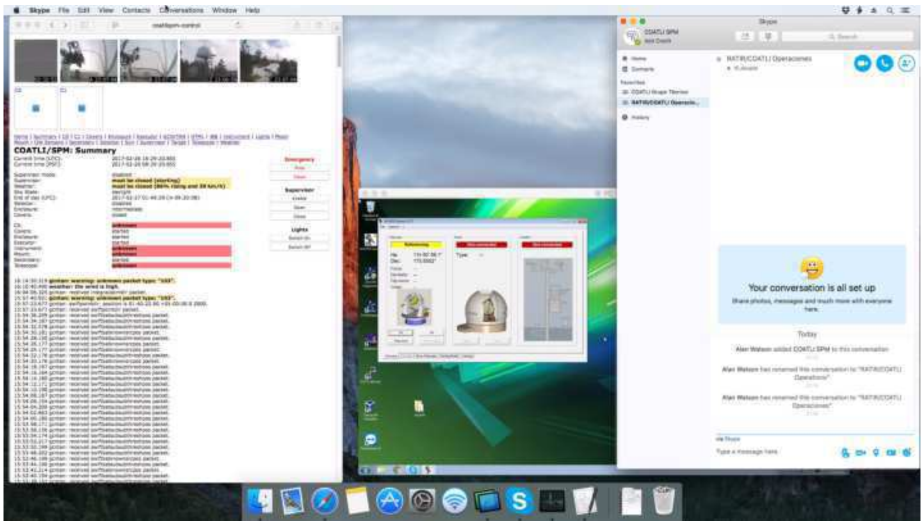

Figure 3.1: The windows on the Mac. To the left, the web interface in Safari. To the right, Skype. In the middle, AsTelOS Express running in a VNC to the PC.

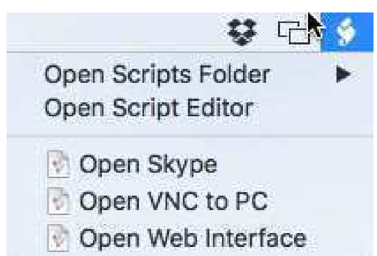

Figure 3.2: The script menu, in the upper right, can open useful windows on the Mac.

    - If AsTelOS Express is not running in the PC, double click on the shortcut on the PC's desktop.

- Switch on the enclosure lights.
    - In the web interface, click on the "Switch On" button in the Lights section.
    - There is currently only one light and it takes a few seconds to warm up.
    - Check that you can see the light in the webcams. If you cannot, report this in the Skype chat.

- Attempt to move the mount to its home position.
    - On the Control Mac, open the window with the VNC to the PC. The AsTelOS Express program should be running on the PC. If it is not, start it by double clicking on the icon on the desk top.
    - If the AsTelOS Express window shows an error, like the one shown in Figure 3.3, click on the "Clear Errors" button to attempt to clear it.
    - If there is no error or if the error is cleared, the AsTelOS Express window should appear like the one shown in Figure 3.4. Now move the mount to the home position by clicking on the "Home Position" button.
    - If you cannot clear the error or if AsTelOS Express gives an error after you attempt to move to the home position, reboot the mount controller in the rack by first switching it off using the large black power switch in the lower right of the front panel and then using the same switch to switch it back on. Report this on the Skype chat and proceed.

- Attempt to close the covers.
    - Move the mode selector on the covers controller to "LOCAL".
    - Press the close button until the LCD display indicates that the covers are closed.
    - Move the mode selector back to "REMOTE".

- Close the enclosure.
    - Move the mode selector on the enclosure controller to "LOCAL".
    - If the error button is illuminated, clear the error. For details, see §8.3.
    - Press the close button until it switches off.
    - Move the mode selector back to "REMOTE".
    - Check the enclosure has closed using the web cams. If it has not, report this in the Skype chat.
    - If you are unable to close locally – for example if you are unable to clear an error, if there is a power failure, or if one of the motors has failed – close manually following the instruction in §8.4.3.

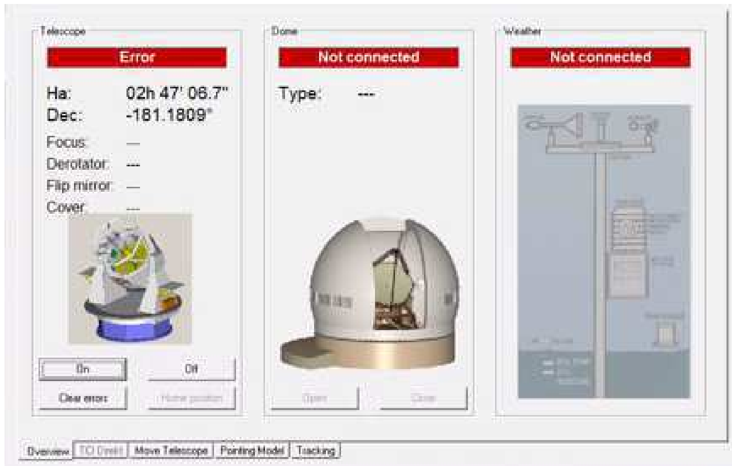

Figure 3.3: The AsTelOS Express window showing an error. This can normally be clared by pressing the “Clear Error” button.

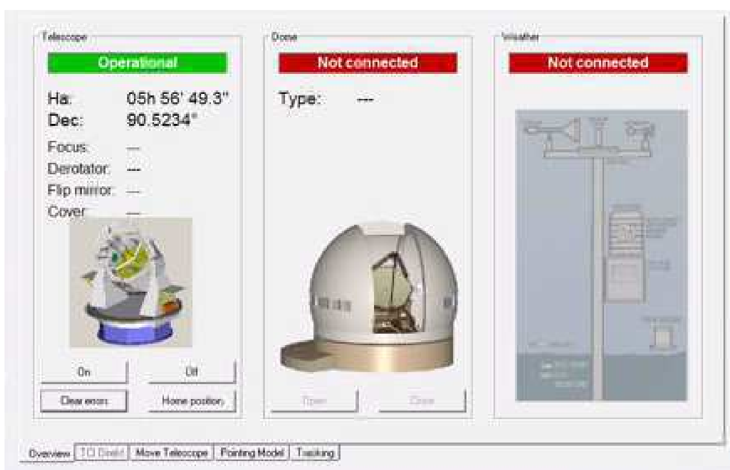

Figure 3.4: The AsTelOS Express window not showing an error. You can now move the mount to the home position by pressing the “Home Position” button.

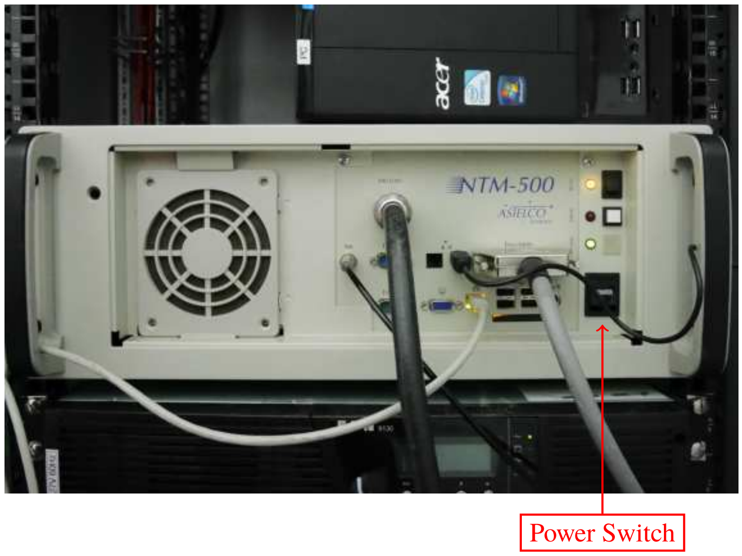

Figure 3.5: The mount controller in the rack. This is rebooted using the large black power switch in the lower right.

- Use the webcams to check that the mount is in the home position, the covers are closed, and the enclosure is closed. If not, report this in the Skype chat.

  The home position is pointed to the north pole with the 50-cm telescope above the mount. For reference, webcam images of the mount in the home position with the covers and enclosure shown are shown in Figure 3.7.

- Switch off the enclosure lights.

  – In the web interface, click on the "Switch Off" button in the Lights section.
  – Check that you can no longer see the light in the webcams. If you cannot, report this in the Skype chat.

- Leave the shed, closing and locking the door.

- Return the key.

  The key is stored in the lid of the toolbox in the COATLI equipment cabinet in the ground floor of the 84-cm telescope building.

Figure 3.6: Image from webcam A showing the mount in the home position with the covers and enclosure closed.

Figure 3.7: Image from webcam B showing the mount in the home position with the covers and enclosure closed.

Chapter 4

Electrical Power

This chapter describes the electrical power system in the COATLI installation. The electrical grounding system is described in Chapter 5.

Figure 4.1 shows a schematic of the electrical power system. The sections below describe each part in detail.

TODO: Schematic of the shed.

TODO: Schematic of the platform.

TODO: Schematic of the telescope.

TODO: Mount controller.

4.1 External Mains Supply

The OAN electricity supply is 220 V 60 Hz three-phase.

The COATLI installation is connected to the OAN electricity supply via a spur to circuit box in the 84-cm telescope building. This spur carries two phases (L1 and L2) and neutral (N). The phases are protected by 80 A breakers. The circuit box and the breakers are shown in Figure 4.2.

4.2 Circuits

Figure figure:circuit-box shows the circuit box in the shed. The master breaker is 80 A. The electricity supply is divided between the circuits listed in Table 4.1, each with their own breaker.

The 220 V circuits are generated between the two phases (L1 and L2). As a consequence, the 220 V circuits are live-live-ground, with 220 V between the two lives but each live 127 V above ground. (This is in contrast to a European-style live-neutral-ground 240 V circuit, with 240 V between live and neutral and with neutral nominally at the ground level.)

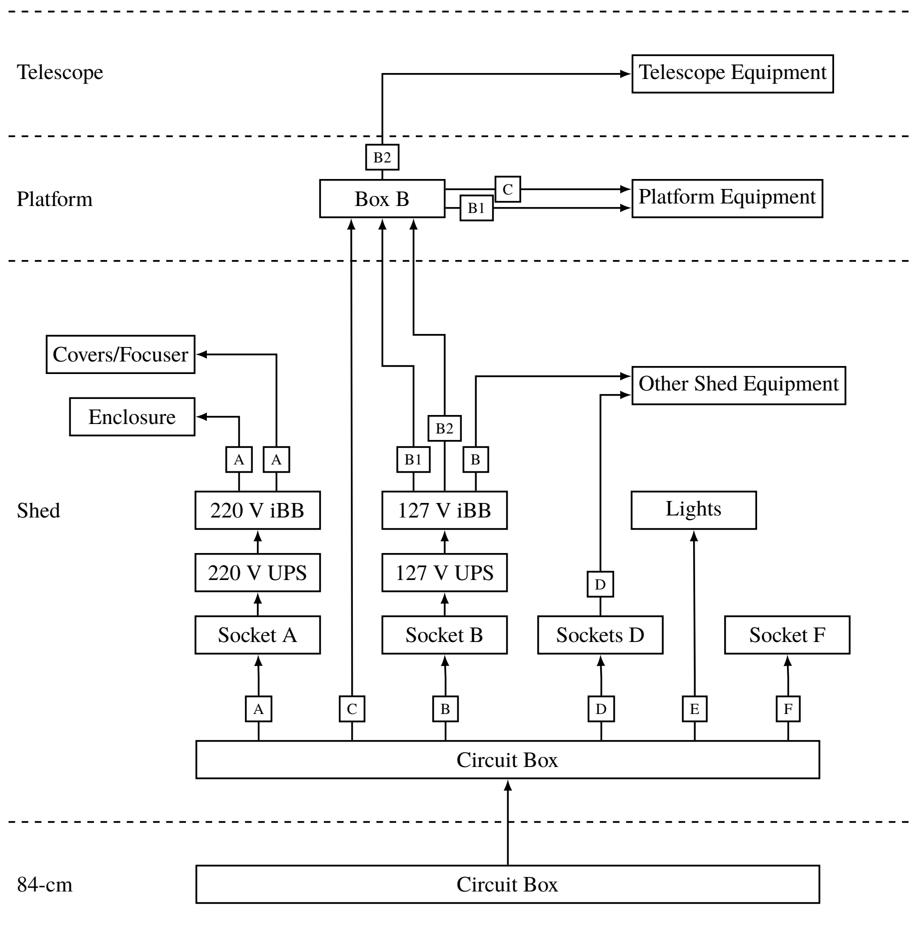

Figure 4.1: Schematic of the Distribution of Electrical Power. The letters A to F refer to circuits.

Table 4.1: Circuits

Circuit	Connection	Voltage	Breaker	Use
Master	L1-L2	220 V	80 A	Master for all circuits
A	L1-L2	220 V	30 A	Wall socket (NEMA L6-20R) in shed for 220 V UPS
B	L2-N	127 V	30 A	Wall socket (NEMA L5-30R) in shed for 127 V UPS
C	L1-N	127 V	20 A	Platform
D	L2-N	127 V	20 A	Wall sockets (NEMA 5-15R) in shed
E	L2-N	127 V	20 A	Lights in shed
F	L1-L2	220 V	30 A	Wall socket (NEMA L6-20R) in shed (next to door)

The 127 V circuits are generated between one of the two phases (L1 or L2) and the neutral (N). As a consequence, the 127 V circuits are live-neutral-ground, with 127 V between live and neutral and with neutral nominally at the ground level.

The wall sockets in the shed are labelled with their circuit.

Circuits A and B are regulated after the wall sockets by the two UPS units. The other circuits are unregulated.

4.3 UPS Units

There are two UPS units in the rack in the shed. Both are Eaton 9310 models with nominal capacities of 3000 VA or 2700 W. Each is equipped with an external battery module, which extends the capacity to about 20 minutes of supply at full load.

4.3.1 220 V UPS

The 220 V UPS is an Eaton PW9130G3000R-XL2U with PW9130N3000R-EBM2U external battery module. It is configured for 220 V 60 Hz input and output. Both the input and output are 220 V live-live-ground, with 220 V between the two lives and 127 V between each live and the ground.

Figure 4.4 shows a schematic of the electrical power connections.

The UPS is supplied via a NEMA L6-20P to C19 coupler connected to the NEMA L6-20R wall socket of circuit A and the C20 input socket of the UPS.

One of the NEMA L6-20R output sockets is connected to the 220 V iBootBar. No other output sockets are used.

If the UPS fails, it can be bypassed manually by connecting the NEMA L6-20P plug of the 220 V iBootBar to directly to the wall socket of circuit A.

4.3.2 127 V UPS

The 127 V UPS is an Eaton PW9130L3000R-XL2U with PW9130N3000R-EBM2U external battery module. It is configured for 127 V 60 Hz input and output.

Figure 4.4 shows a schematic of the electrical power connections.

The UPS is supplied via a NEMA L5-30P plug connected to the NEMA L5-30R wall socket of circuit B.

Two of the NEMA 5-20R output sockets are connected to the NEMA 5-15P plugs of the 127 V iBootBar. No other output sockets are used.

If the UPS fails, it can be bypassed manually by connecting the two NEMA 5-15P plugs of the 127 V iBootBar directly to the wall sockets of circuit D.

4.4 iBootBars

There are two iBootBars in the rack in the shed, one 127 V and one 220 V. Both are the sole loads on their corresponding UPS units.

4.4.1 220 V iBootBar

This is a DataProbe iBootBar iBB-C20. Figure 4.6 shows a schematic of the electrical power connections.

The C20 input socket is connected to the 220 V UPS unit with a cable with C19 and NEMA L6-20P plugs.

The connections to the type F output sockets ("C13 female") are given in Table 4.2. The iBootBar can supply up to 20 A.

The iBootBar is connected to the LAN at the address given in Table 6.1. The HTTP and telnet account names and passwords are "admin" and "admin".

TODO: Configure coatli/coatli account.

TODO: Configure names.

4.4.2 127 V iBootBar

This is a DataProbe iBootBar iBB-2N15-M. Figure 4.7 shows a schematic of the electrical power connections.

The two NEMA 5-15P input plugs are connected to the 127 V UPS unit.

The connections to the NEMA 5-15R output sockets are given in Table 4.2. The iBootBar can supply up to 15 A to each bank of four output sockets.

The iBootBar is connected to the LAN at the address given in Table 6.1. The HTTP and telnet account names and passwords are "admin" and "admin".

The modem facility is not used.

TODO: Configure coatli/coatli account.

TODO: Configure names.

TODO: Configure watchdog.

Table 4.2: iBootBar Output Sockets

Socket	220 V iBootBar	127 V iBootBar
1	Enclosure	Cable B1 (Platform Electronics)
2	Covers/Focuser	Box A
3	-	Cable B2 (Telescope Electronics)
4	-	Lantronix EDS
5	-	Rack Power Strip (Rack Electronics)
6	-	
7	-	-
8	-	

4.5 Rack Power Strip

Adjacent to the 127 V iBootBar is a 8-way NEMA 5-15R power strip. Figure 4.8 shows a schematic of the electrical power connections.

The power strip powers the computers and network equipment in the rack, specifically:

- The Ethernet fiber adapter.
- The Apple Time Capsule (`time-capsule`)
- The 8-port Ethernet switch.
- The Control Apple Mac mini (`control`)
- The Data Apple Mac mini (`data`)
- The Acer Windows PC (`pc`)
- The monitor.

The entire power strip, and hence all of the connected equipment, is supplied and switched by a single output socket of the 127 V iBootBar.

4.6 Box A

Box A is a smart control box located in the shed. Figure 4.9 shows a schematic of the electrical power connections to Box A.

Box A is connected to circuit B and circuit D. Circuit B powers the electronics, internal heater, and internal fans in Box A. Circuit D is used to power the external fans and external heater via NEMA 5-15R sockets.

The connection to circuit B is via a NEMA 5-15P to C13 cable. The NEMA 5-15P plug is connected to an output socket of the 127 V iBootBar and the C13 plug is connected to the C14 input socket on Box A.

The connection to circuit D is via a NEMA 5-15P to C19 cable. The NEMA 5-15P plug is connected to one of the wall sockets of circuit D and the C19 plug is connected to the C20 input socket on Box A.

Circuit B is switched and fuzed with a 1 A fuze at the entrance to Box A.

TODO: Is circuit D switched and fuzed?

NOTE: The external heater and fans are not yet installed or connected.

4.7 Box B

Box B is a dumb electrical distribution box located on the platform. Figure 4.10 shows a schematic of the electrical power connections to Box B.

Box B is connected to circuits B1, B2, and C. Circuits B1 and B2 are subcircuits of circuit B. Circuit B1 is used to power electronics, internal heaters, and internal fans in Boxes C and D, the two other boxes on the platform. Circuit B2 is used for power the electronics, internal heaters, and internal fans in Boxes E and F, the two boxes on the telescope. Circuit C is used to power the two NEMA 5-15R plugs on Box B (for general use), the three lights on the platform (one with manual control, one with manual/electronic control, and one emergency), and the external heater on the platform.

The connection to circuits B1 and B2 are via cables with NEMA 5-15P plugs connected to the 127 V iBootBar.

The connection to circuit C is hardwired to the circuit box in the shed. The connections are hardwired at Box B.

The three circuits are switched and fuzed (with 3 A fuzes) at the entrance to in Box B.

The manually-controlled light is hardwired to Box C and has a manual switch on Box B.

TODO: Replace 1 A fuze for circuit B1 with 3 A fuze.

4.8 Box C

Box C is a smart control box located on the platform. Figure 4.11 shows a schematic of the electrical power connections to Box C.

Box C is connected to circuits B1 and C. Circuit B1 is a subcircuit of circuit B. Circuit B1 is used to power the electronics, the internal heater, and the internal fans. Circuit C is used to power an external light and the external heater on the platform.

The connection to circuit B1 is via a cable with a C13 plug that connects to the C14 input socket on Box C. The cable is hardwired to Box B.

The connection to circuit C is via a cable with a C19 plug that connects to the C20 input socket on Box C. The cable is hardwired to Box B.

The connections to the manually/electronically-controlled light and heater are via the two NEMA 5-15R sockets on Box C. The light is controlled both by a relay and by a manual switch on Box C (with the light being on if either the relay or manual switch are on). The heater is controlled by a relay.

Circuit B1 is switched and fuzed with a 1 A fuze at the entrance to Box C.

TODO: Is C fuzed?

4.9 Box D

Box D is a smart control box located on the platform. Figure 4.12 shows a schematic of the electrical power connections to Box D.

Box D is connected to circuit B1. Circuit B1 is a subcircuit of circuit B. Circuit B1 is used to power the electronics, the internal heater, and the internal fans.

The connection to circuit B1 is via a cable with a C13 plug that connects to the C14 input socket on Box C. The cable is hardwired to Box B.

Circuit B1 is switched and fuzed with a 1 A fuze at the entrance to Box D.

4.10 Box E

Box E is a smart control box located on the DDOTI telescope. Figure 4.13 shows a schematic of the electrical power connections to Box E.

Box E is connected to circuit B2. Circuit B2 is a subcircuit of circuit B. Circuit B2 is used to power the electronics, the internal heater, and the internal fans.

The connection to circuit B2 is somewhat complex. A hardwired cable leaves Box B and connects via a CA3LS male plug to the CA3LS female "CUSTOM" socket on the mount. This socket is connected to a cable that passes through the mount, exits along the counterweight axle, and terminates in a C13 plug. This C13 plug is connected to the C14 input socket on Box E.

Circuit B2 is switched and fuzed with a 1 A fuze at the entrance to Box E.

4.11 Box F

Box F is a smart control box located on the COATLI telescope. Figure 4.14 shows a schematic of the electrical power connections to Box F.

Box F is connected to circuit B2. Circuit B2 is a subcircuit of circuit B. Circuit B2 is used to power the electronics, the internal heater, and the internal fans.

The connection to circuit B2 via Box E. A cable passes through the mount from the COATLI telescope to the DDOTI telescope. On the COATLI side, the has a C13 plug that connects to the C14 socket on Box F. On the DDOTI side, it has a type E connector ("C14 male") which connects to a type F ("C13 female") connector on a cable hardwired to Box E.

TODO: Switching off Box E also switches off Box F? I think not. That is, the connection to Box F is before the switch and fuze in Box E.

Circuit B2 is switched and fuzed with a 1 A fuze at the entrance to Box F.

4.12 Bibliography

- "Eaton 9300 UPS 700/3000 VA User's Guide" (Revision 8)
- "iBootBar Installations and Operations" (Version 1.5)

4.13 Trouble-Shooting

- Check cables. Has one been disconnected or worked itself lose?
- Check switches. Is the equipment switched on? Boxes A, C, D, E, and F have switch for their regulated input (circuits B, B1, or B2). Box B has switches for circuits B1, B2, and C. The Macs and the PC have power switches. The ASTELCO equipment has power switches.
- Check fuzes. Has one blown? Boxes A, C, D, E, and F have 1 A fuzes for their regulated input (circuits B, B1, or B2). Box B has 3 A fuzes for circuits B1, B2, and C.
- For circuits connected via an iBootBar (A, B, B1, and B2), check that the corresponding output socket is on. The state of the output sockets is given by the row of 8 green LEDs on the front of each iBootBar.
- The emergency lights come on if the corresponding circuit (C for the platform and E for the shed) has no power. This can happen because a breaker trips or because the OAN mains supply has failed.
- For circuits not connected via a UPS unit (C, D, E, and F), check that the OAN mains supply is working.
- For circuits connected via a UPS unit (A, B, B1, and B2), check that the corresponding UPS is working.
- Check the breakers in the circuit box in the shed. Has one tripped?
- Check the breaker in the circuit box in the 84-cm. Has it tripped?
- Check the equipment has not failed.

Figure 4.2: The circuit box in the 84-cm telescope building. The breakers for the COATLI spur are at the lower left.

Figure 4.3: The circuit box the shed. The master breaker is at the top. The breakers for circuits A–F are at the bottom.

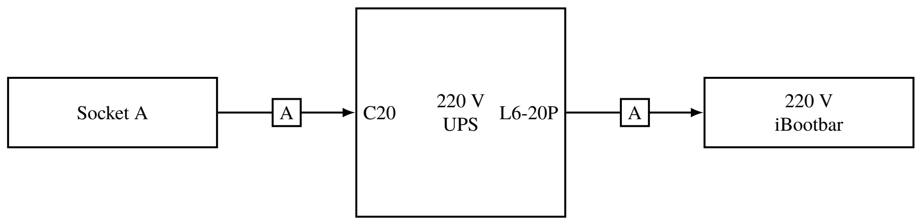

Figure 4.4: Schematic of the Electrical Power Connections To and From the 220 V UPS

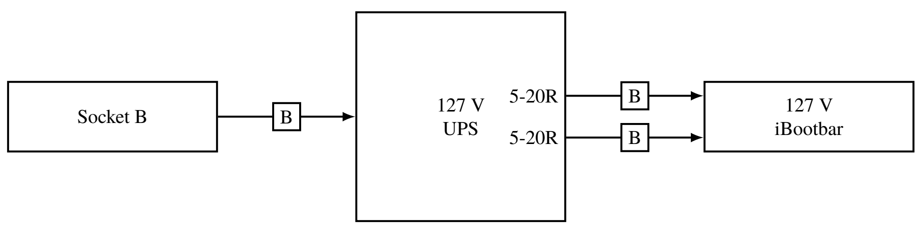

Figure 4.5: Schematic of the Electrical Power Connections To and From the 127 V UPS

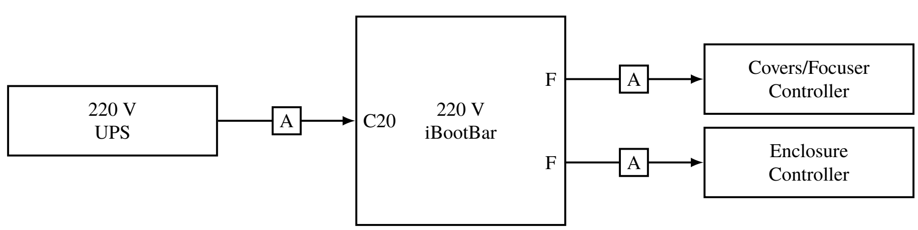

Figure 4.6: Schematic of the Electrical Power Connections To and From the 220 V iBootBar

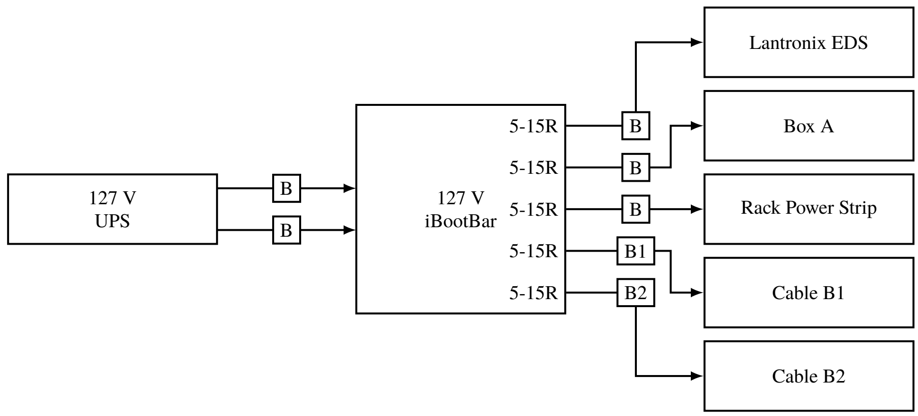

Figure 4.7: Schematic of the Electrical Power Connections To and From the 127 V iBootBar

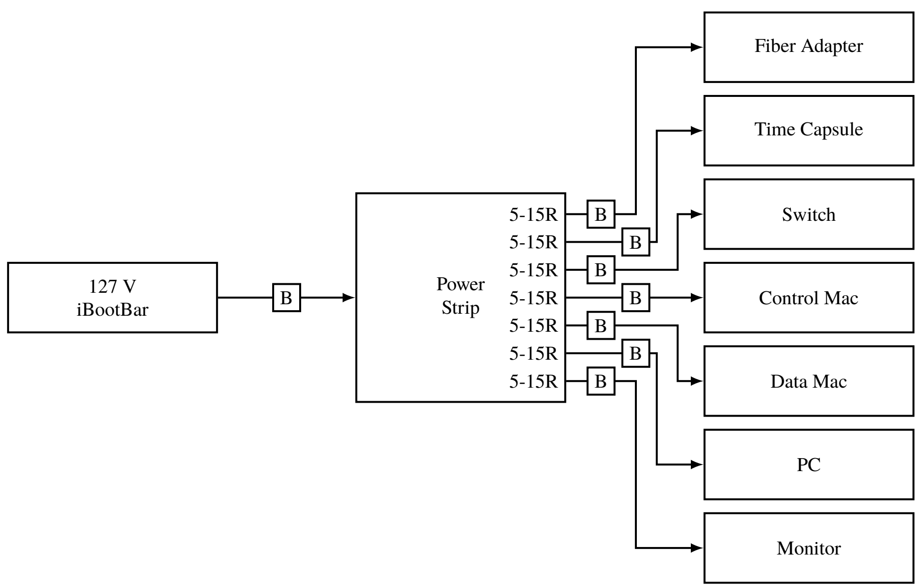

Figure 4.8: Schematic of the Electrical Power Connections To and From the Rack Power Strip

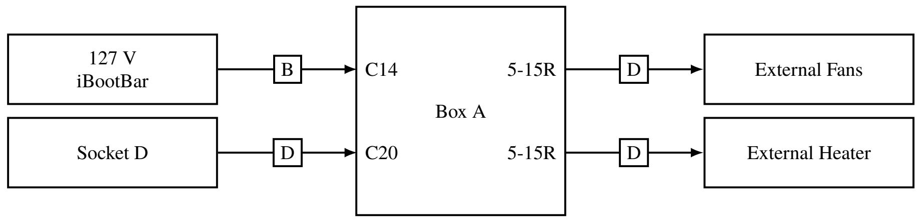

Figure 4.9: Schematic of the Electrical Power Connections To and From Box A

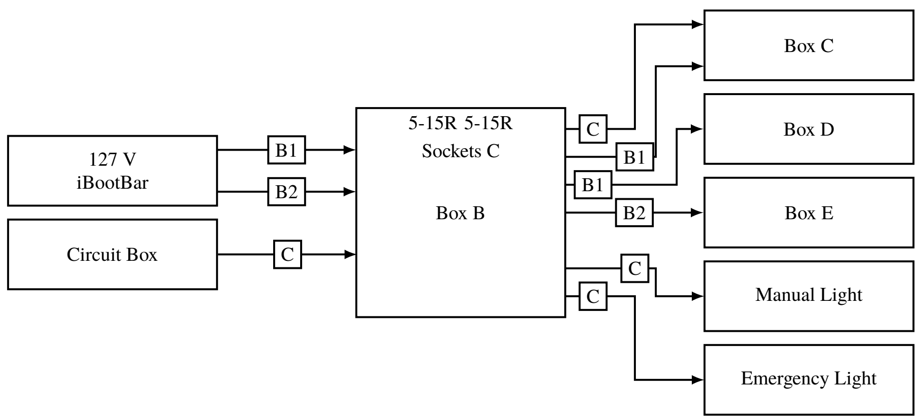

Figure 4.10: Schematic of the Electrical Power Connections To and From Box B

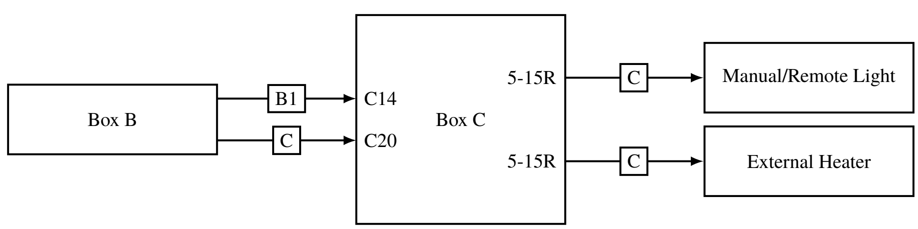

Figure 4.11: Schematic of the Electrical Power Connections To and From Box C

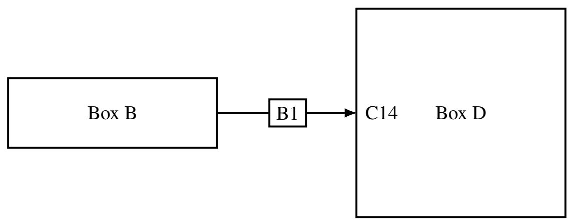

Figure 4.12: Schematic of the Electrical Power Connections To Box D

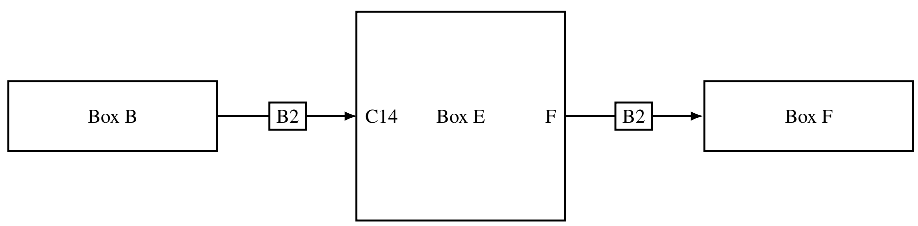

Figure 4.13: Schematic of the Electrical Power Connections To and From Box E

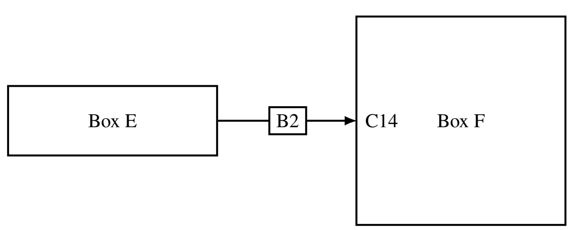

Figure 4.14: Schematic of the Electrical Power Connections To Box F

Chapter 5

Electrical Grounding

5.1 Grounding Rods

We have installed a network of ground rods to the east of the 84-cm telescope building. There is one main rod and two delta or triad rod systems. The three systems are connected through a ground bar in a box on the eastern wall of the 84-cm telescope.

The 84-cm telescope building is grounded through an independent network of grounding rods just to the south of the building.

TODO: Photo. Better description.

5.2 Grounding System

Figure 5.1 shows a schematic of the electrical grounding system. These grounding cable from the grounding rods runs through the conduit from the 84-cm to the COATLI installation. It is terminated at a protected grounding bar underneath the metal walkway. This is the "tau-point" of the grounding system. From here, spurs are used to ground the electrical system in the shed, the walkways, the tower, and the platform.

TODO: Photo of the tau-point.

TODO: Cable calibres.

The ground bar in the shed is used to provide ground to circuit box and hence to the circuits and the sockets in the shed. It is also used to ground the rack.

Circuits B1, B2, and C run from the shed to Box B on the platform. However, their ground is not connected in Box B. Instead, the ground bar on the platform is used to provide ground for Box B and subsequently for the sockets on the platform (in boxes B and C), the cables to boxes C, D, E, and F, and the mount.

TODO: Make sure the ground is connected to the cables between the boxes.

The Astelco controllers in the shed are connected to the platform and mount. There are undoubtedly ground loops through these connections. However, the connections

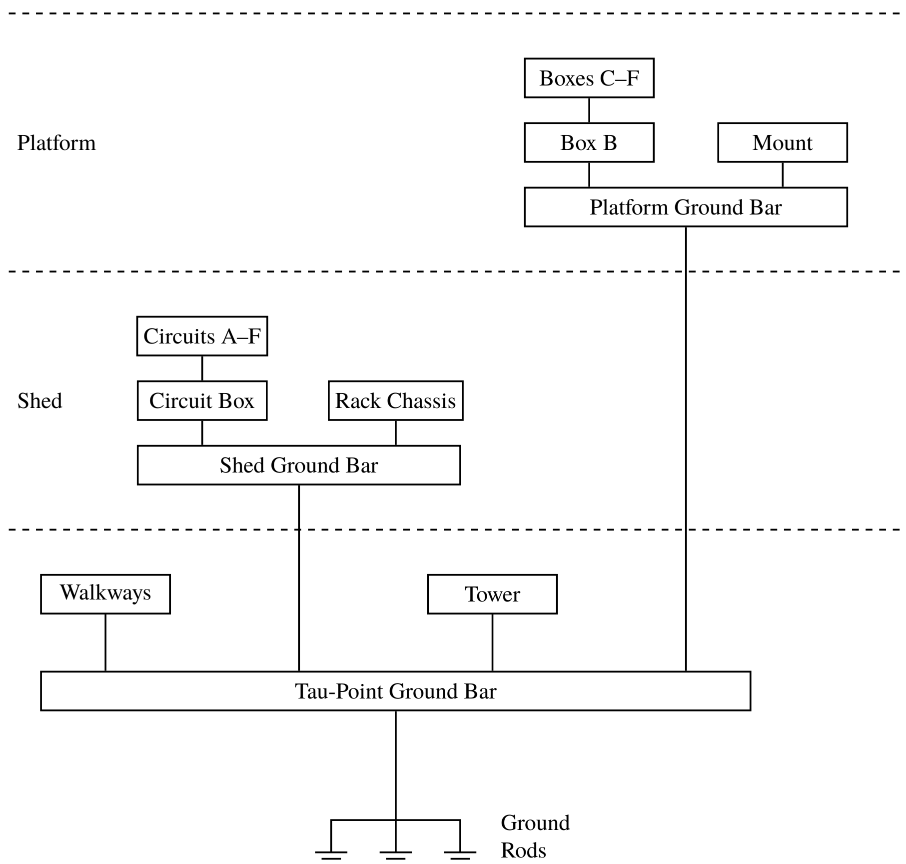

Figure 5.1: Schematic of the Electrical Grounding System

from the platform to the tau-point is through a heavy-gauge cable, and this is likely to mitigate these ground loops.

5.3 Ground Resistance

In October 2016 we measured a ground resistance of about 5.5 Ω at all three the ground bars (the tau-point, shed ground bar, and platform ground bar) using the three-point method. We further measured a resistance of about 0.8 Ω between the grounding point of the NTM-500 mount and the platform grounding bar and between the ground contacts of the outlets of the iBootBars and the shed grounding bar. This suggests that the grounding system is working well.

Chapter 6

Network

6.1 Internet Connection

6.2 LAN

The Time Machine uses 10.0.1/24 as a LAN. The addresses of the equipment on the LAN are given in Table 6.1.

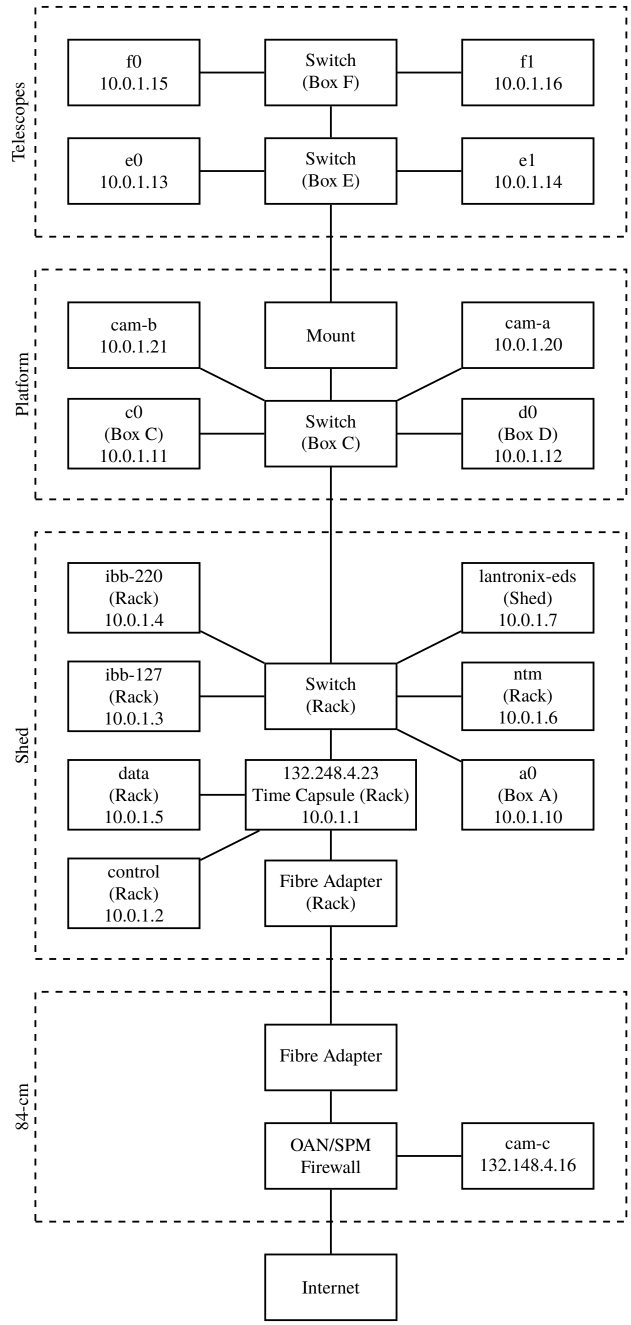

Figure 6.1: Network Physical Topology

Table 6.1: LAN Addresses

Address	Equipment
10.0.1.1	Time Machine (LAN)
10.0.1.2	Control
10.0.1.3	iBootBar 127 V
10.0.1.4	iBootBar 220 V
10.0.1.5	Data
10.0.1.6	NTM Controller
10.0.1.7	Lantronix EDS
10.0.1.8	PC
10.0.1.10	Minnowboard a0
10.0.1.11	Minnowboard c0
10.0.1.12	Minnowboard d0
10.0.1.13	Minnowboard e0
10.0.1.14	Minnowboard e1
10.0.1.15	Minnowboard f0
10.0.1.16	Minnowboard f1
10.0.1.20	Camera a
10.0.1.21	Camera b

Chapter 7

Webcams

Chapter 8

Enclosure

News

2017 Feb 23: Proximity Sensor Failure

The proximity sensor that indicates to the controller that the enclosure is closed failed: it always indicated that the enclosure was closed, even when it was open. As a result, the enclosure could not be closed by the controller.

In collaboration with ASTELCO, we have shorted the sensors contacts on the PLC. Specifically, we have installed a jumper between the L+ and I3 terminals of U3 in the enclosure controller. This indicates to the controller that the enclosure is always open.

In this state, the controller can close the enclosure but is not able to sense when the enclosure is actually closed and the motors should be stopped. Thus, when the enclosure closes it is typically stopped by a motor current error or by a safety rail error. These have to be cleared by pressing the error reset button on the enclosure controller.

We have ordered a new sensor and hope to install it soon.

8.1 Description

COATLI is protected by an ASTELCO ARTS enclosure, shown in Figure 8.1. The ARTS enclosure consists of a tower, a platform with balconies, and set of folding arches that support a flexible waterproof fabric roof.

The enclosure can open to 60, 120, and 180 deg and can be controlled manually or automatically. The enclosure is oriented ENE to WSW and opens from the ENE towards the WSW.

The enclosure can open and close in wind speeds of up to 90 km/h and has a survival windspeed of 180 km/h.

Figure 8.1: The COATLI enclosure.

Figure 8.2: The enclosure controller in the shed.

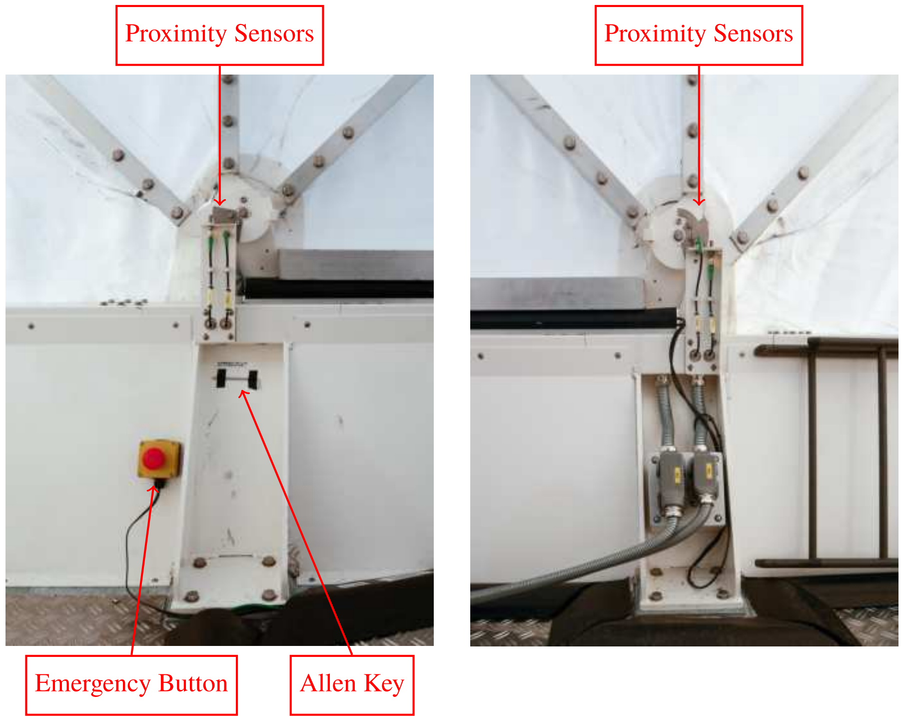

Figure 8.3: The north (left) and south (right) bearings for the folding roof. Notice the proximity sensors, the emergency stop button for the mount, and the Allen key to escape in an emergency.

The controller for the enclosure, shown in Figure 8.2 is located in a cabinet in the shed. The controller and the motors are powered by 220 V 60 Hz from the Circuit A via the 220 V UPS and 220 V iBootBar.

The enclosure is opened and closed by two geared motors, one on each balcony. The position is sensed by proximity sensors on the bearings (60, 120, and 180 deg) and at the point that the last arch closes (0 deg).

The enclosure has an electromagnetic lock, shown in Figure 8.4, that holds it firmly closed. If the lock is not activated, the wind can open the roof a few centimeters and allow the ingress of rain or snow.

The enclosure controller should normally be switched on at all times in order to keep the electromagnetic lock activated.

The enclosure has a rain sensor, also shown in Figure 8.4. In automatic mode, it will automatically close if the rain sensor gets wet.

The enclosure has a safety seal along the lower edge of the opening. The motors will stop if this is pressed. The avoids the enclosure closing on someone or something.

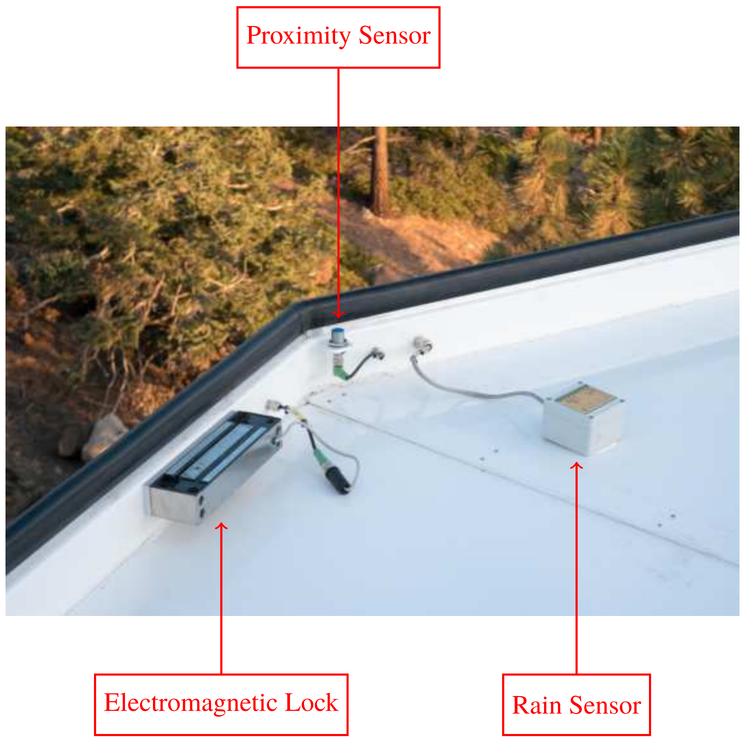

Figure 8.4: The enclosure electromagnetic lock (left), 0 deg proximity sensor (the cylinder with the blue top in the center), and rain sensor (the white box with the copper contacts on the right).

Figure 8.5: The enclosure safety seal, the black rubber seal on the lower edge of the enclosure opening. If this is pressed, the motors will stop and an error is set in the controller.

Figure 8.6: The enclosure emergency stop buttons, next to the main access ladder (left) and on the northern motor cowling (right).

However, it is easy to activate the safety rail when entering or leaving the enclosure.

The enclosure also has two emergency stop buttons, one at the bottom of the main access ladder and the other on the northern motor cowling. These are shown in Figure 8.6. Again, the motors will stop if either of these are pressed.

The two semi-circular elevated areas at the ends of the platform, shown in Figure 8.7, are not load bearing and are marked with “no step” signs. If you attempt to walk on these, you will likely fall.

Do not walk on the elevated areas at the ends of the platform!

If you are trapped in the enclosure and cannot summon help, you can escape by using the Allen key taped below the northern bearing to remove one of the sloping side panels to gain access to the balcony. See Figure **??**.

8.2 Remote Operation

Under no circumstances ascend to the platform or balconies if the enclosure is in remote mode as the enclosure can close without warning.

In remote mode:

- The switches on the enclosure controller to open and close the enclosure are deactivated.
- The robotic control system can open and close.

Figure 8.7: Do not walk on the elevated areas at the ends of the platform as they are not load bearing. Note the “no step” signs.

- The enclosure will close automatically if the rain sensor gets wet.

The enclosure can be placed in remote mode only from the panel on the door of the enclosure controller in the shed (see Figure 8.8). To place the enclosure in remote mode:

1. Move the main power switch to “ON”.
2. Move the mode selector switch to “REMOTE”.

8.3 Local Operation

If you wish to ascend to the platform or balconies, you must put the enclosure in local mode.

If you wish to ascend to the platform or balconies, you must use a safety harness, line, and helmet.

Before opening the enclosure, check on the webcams that the telescope is not pointed to towards the sun. In the home position, the telescope is pointed to the north pole.

In local mode:

- The switches on the enclosure controller to open and close the enclosure are active.
- The robotic control system cannot open or close.

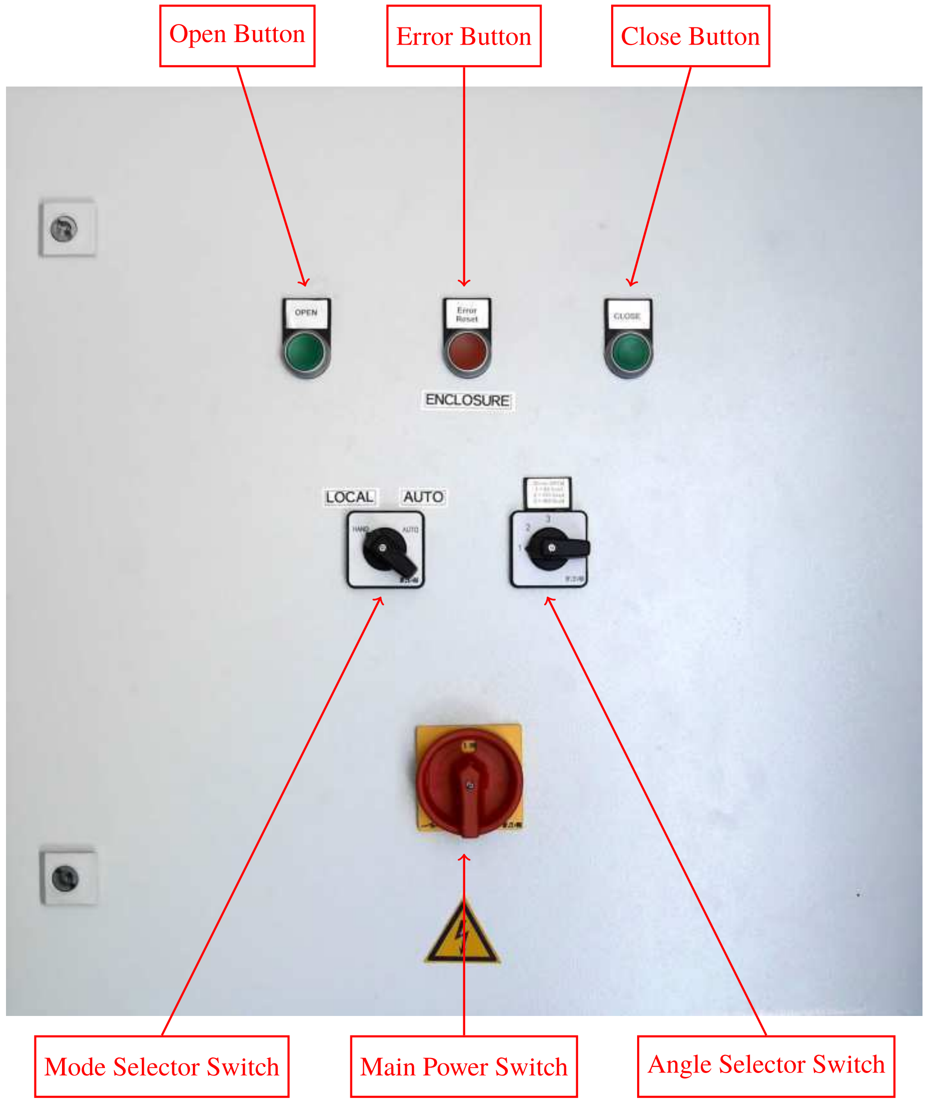

Figure 8.8: The enclosure controller door and control panel. Bottom: the main power switch. Middle row, left to right: the mode selector switch (“LOCAL” and “REMOTE”) and the angle selector switch (60, 120, and 180 deg). Top row, left to right: the open button, the error button, and the close button.

- The enclosure will not close if the rain sensor gets wet.

The enclosure can be placed in local mode only from the panel on the door of the enclosure controller in the shed (see Figure 8.8). To place the enclosure in local mode and open or close:

1. Make sure the main power switch is “ON”.
2. Move the mode selector switch to “LOCAL”.
3. If there is an error, the red error button will flash or be constantly lit. Investigate the error, and clear it before proceeding: The following error states are signaled by the red error button:
    - Fast flashing (4 Hz): The safety seal around the enclosure cover has been activated. Follow the procedure in §8.4.1 to clear the error.
    - Slow flashing (2 Hz): One or both of the motor current safety relays have been activated. This can happen if the enclosure is opened and closed continously for several minutes. Follow the procedure in §8.4.2 to clear the error.
    - Constant: One or both of the emergency stop buttons have been pressed. There is one emergency stop button at the bottom of the north ladder and another on the cowling around the north motor. Follow the procedure in §8.4.3 to clear the error.
4. To open, set the angle selector switch to the desired angle (60, 120, and 180 deg) and then press and hold the open button until the green light goes out. The 60 deg position gives access to the dome while continuing the shade the telescope from the elements.
5. To close, press and hold the green close button until the light goes out.
6. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to “REMOTE”.

8.4 Maintenance Procedures

8.4.1 Resetting a Safety Seal Error

If the safety seal is pressed the error button on the enclosure controller door flashes rapidly (4 Hz) and the enclosure will not operate. This procedure describes how to reset the error.

Use a harness, line, and helmet when you work on the platform or balconies.

Requirements

You will need:

- At least one person.
- The key to the shed.

Procedure

1. Remove whatever is pressing the safety seal.
2. Move the mode selector switch to “LOCAL”.
3. Press the error button to clear the error.
4. Verify that the error button no longer signals an error. That is, that is no longer flashes.
5. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to “REMOTE”.

8.4.2 Resetting a Motor Current Error

The motors are protected by current safety relays. In normal operation, these should not activate. However, if they do the error button on the enclosure controller door flashes slowly (2 Hz) and the enclosure will not operate. This procedure describes how to reset the error.

Be extremely careful when working inside the controller cabinet as it uses 220 VAC.

Use a harness, line, and helmet when you work on the platform or balconies.

Requirements

You will need:

- At least one person.
- The key to the shed.

Procedure

1. Open the controller door and locate the motor current safety relays K7 and K8 (see Figure 8.16).
2. Press the blue buttons on K7 and K8 to reset them.
3. Close the controller door.
4. Move the mode selector switch to "LOCAL".
5. Verify that the error button no longer signals an error. That is, that is no longer flashes.
6. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to "REMOTE".

8.4.3 Resetting an Emergency Button Error

If one of the emergency buttons is pressed the error button on the enclosure controller door will be constantly lit and the enclosure will not operate. This procedure describes how to reset the error.

Use a harness, line, and helmet when you work on the platform or balconies.

Requirements

You will need:

- At least one person.
- The key to the shed.

Procedure

1. Twist any activated emergency button clockwise to release it.
2. Move the mode selector switch to "LOCAL".
3. Press the error button to clear the error.
4. Verify that the error button no longer signals an error. That is, that is no longer is constantly lit.
5. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to "REMOTE".

8.4.4 Manual Opening/Closing with Power

If the enclosure cannot be operated normally using remote mode or local mode, you can bypass the control system and operate it manually. There are two modes, depending on whether power is available. Here we document the procedure for opening or closing with power. Subsequently we document the procedure for opening or closing without power.

If power is available and the motors work, the enclosure can be opened and closed by manually activating the relays in the enclosure controller for the motor brakes, motors, and electromagnetic lock.

This is not to be undertaken lightly, as there are risks both to personnel and equipment. First, these procedures require working in proximity to live 220 VAC. Second, many of the usual safety features that protect the equipment are not available. For example, if you accidentally activate the motor relays incorrectly, you can short the relays and will probably damage them. For a similar reason, it is necessary to disable the PLC to avoid it attempting to activate the relays while they are being activated manually.

Be extremely careful when working inside the controller cabinet as it uses 220 VAC.

Requirements

You will need:

- At least one person.
- The key to the shed.
- Two small flat-headed screwdrivers.
- Two low-voltage jumper cable.
- A multimeter.

All of these can be found in the tool box in the COATLI equipment cabinet in the ground floor of the 84-cm telescope building.

Procedure for Closing the Enclosure

To close the enclosure:

1. Switch off the enclosure controller.

   Move the main power switch on the controller door from ON to OFF.

2. Deactivate the PLC.

   Remove the two cables from the L+ terminal of U2. See Figure 8.9.

Figure 8.9: The PLC U2 is deactivated by removing the two cables from the L+ terminal of U2.

Figure 8.10: Jumpers shorting the PLC relays. The yellow jumper shorting Q1 of U3 deactivates the motor breaks. The green jumper shorting Q1 of U4 activates the electromagnetic lock.

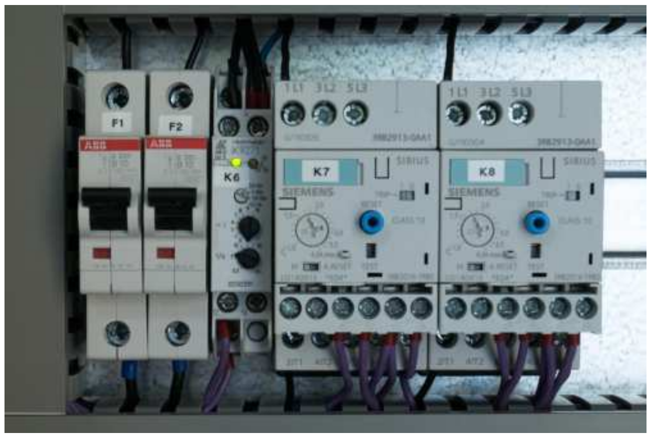

Figure 8.11: The green LED on K6 lights up indicates that the motor brakes have been deactivated. The orange LED to the right of the green LED also lights up for a few seconds.

Figure 8.12: The relays that control the motors (K1 and K4 to close and K2 and K3 to open) and motor brakes (K5).

Figure 8.13: The diode across terminals 24 and 25 of the output connector. When the electromagnetic lock is activated, there are 24 VDC across the diode.

3. Prepare to deactivate the motor brakes.

   Short the Q1 relay of U3 using a jumper cable. See Figure 8.10.

4. Prepare to activate the electromagnetic lock.

   Short the Q1 relay of U4 using a jumper cable. See Figure 8.10.

5. Switch on the enclosure controller.

   Move the main power switch on the controller door from OFF to ON.

6. Check that the PLC is deactivated.

   Check that the RUN/STOP LED on U2 does not light up. See Figure 8.9. (The RUN/STOP LEDs on U3 and U4 should light up.) If the LED on U2 does light up, you have not correctly disconnected its power. Start again.

7. Check that the motor breaks are deactivated.

   Check that the green LED on K6 lights up to indicate that the motor brakes have been deactivated. The orange LED to the right of the green LED should also lights up for a few seconds. See Figure 8.11. If they do not do this, you have not correctly connected the jumper across the Q1 relay of U3. Start again.

8. Check that the electromagnetic lock is activated.

   Check that there is 24 VDC across the diode between terminal 24 and 25 of the output connector. See Figure 8.13. If there is not, you have not correctly connected the jumper aross the Q1 relay of U4. Start again.

9. Run the motors to close the enclosure.

Use two screwdrivers to move the sliders of K1 and K4 from 0 to 1 and hold them there until the enclosure is closed. See Figure 8.12. You may stop opening the enclosure at any point by releasing the sliders. Once the enclosure is fully closed you will hear the relays K9 and K10 activating and you should release the sliders.

10. Switch off the enclosure controller.

    Move the main power switch on the controller door from ON to OFF.

11. Prepare to activate the motor brakes.

    Remove the jumper shorting Q1 of U3.

12. Switch on the enclosure controller.

    Move the main power switch on the controller door from OFF to ON.

Procedure for Opening the Enclosure

To open the enclosure:

1. Switch off the enclosure controller.

   Move the main power switch on the controller door from ON to OFF.

2. Deactivate the PLC.

   Remove the two cables from the L+ terminal of U2. See Figure 8.9.

3. Prepare to deactivate the motor brakes.

   Short the Q1 relay of U3 using a jumper cable. See Figure 8.10.

4. Prepare to deactivate the electromagnetic lock.

   If you have previously activated the electromagnetic lock by shorting the Q1 relay of U4 using a jumper cable, remove the jumper cable. See Figure 8.10.

5. Switch on the enclosure controller.

   Move the main power switch on the controller door from OFF to ON.

6. Check that the PLC is deactivated.

   Check that the RUN/STOP LED on U2 does not light up. See Figure 8.9. (The RUN/STOP LEDs on U3 and U4 should light up.) If the LED on U2 does light up, you have not correctly disconnected its power. Start again.

7. Check that the motor breaks are deactivated.

   Check that the green LED on K6 lights up to indicate that the motor brakes have been deactivated. The orange LED to the right of the green LED should also lights up for a few seconds. See Figure 8.11. If they do not do this, you have not correctly connected the jumper across the Q1 relay of U3. Start again.

8. Check that the electromagnetic lock is deactivated.

   Check that there is 0 VDC across the diode between terminal 24 and 25 of the output connector. See Figure 8.13. If there is not, you have not correctly disconnected the jumper across the Q1 relay of U4. Start again.

9. Run the motors to open the enclosure.

   Use two screwdrivers to move the sliders of K2 and K3 from 0 to 1 and hold them there until the enclosure is open. See Figure 8.12. You may stop opening the enclosure at any point by releasing the sliders. Once the enclosure is fully open you will hear the relays K9 and K10 activating and you should release the sliders.

10. Switch off the enclosure controller.

    Move the main power switch on the controller door from ON to OFF.

11. Prepare to activate the motor brakes.

    Remove the jumper shorting Q1 of U3.

12. Switch on the enclosure controller.

    Move the main power switch on the controller door from OFF to ON.

8.4.5 Manual Opening/Closing without Power

If the enclosure cannot be operated normally using remote mode or local mode, you can bypass the control system and operate it manually. There are two modes, depending on whether power is available. Here we document the procedure for opening or closing without power. Previously we documented the procedure for opening or closing with power.

If power is not available or one of the motors has failed, the enclosure can be opened or closed by driving the motor axles manually with portable electric drills. This procedure requires two people.

This is not to be undertaken lightly, as it involves working on the balcony. However, when carried out with appropriate safety precautions and with calm, it is quite safe.

Be extremely careful when working inside the controller cabinet as it uses 220 VAC.

Use a harness, line, and helmet when you work on the platform or balconies.

Requirements

You will need:

- Two people.

Figure 8.14: Opening or closing the enclosure with portable electric drills. The motor brake is disengaged by pushing the lever under the motor away from the platform.

- The key to the shed.
- Two portable electrical drills with 6 mm hex drives.
- A small flat-headed screwdriver.
- A low-voltage jumper cable.
- A multimeter.

Two suitable drills with drives are stored in the COATLI equipment cabinet in the ground floor of the 84-cm telescope building. The batteries are normally connected to wall socket.

Procedure for Closing the Enclosure

To close the enclosure:

1. Switch off the enclosure controller.

   Move the main power switch on the controller door from ON to OFF.

2. Deactivate the PLC.

   Remove the two cables from the L+ terminal of U2. See Figure 8.9.

3. Prepare to activate the electromagnetic lock.

   Short the Q1 relay of U4 using a jumper cable. See Figure 8.10.

4. Switch on the enclosure controller.

   Move the main power switch on the controller door from OFF to ON.

5. Check that the PLC is deactivated.

   Check that the RUN/STOP LED on U2 does not light up. See Figure 8.9. (The RUN/STOP LEDs on U3 and U4 should light up.) If the LED on U2 does light up, you have not correctly disconnected its power. Start again.

6. Check that the electromagnetic lock is activated.

   Check that there is 24 VDC across the diode between terminal 24 and 25 of the output connector. See Figure 8.13. If there is not, you have not correctly connected the jumper aross the Q1 relay of U4. Start again.

7. Use appropriate safety equipment: harnesses, lines, and helmets. These are found in the shed.

8. One person should ascend to the northern balcony with one drill and one to the southern balcony with the other drill.

9. Use your safety line to secure yourself to the balcony rail. Loop the line over the rail and then fasten the clasp on the line itself.

10. Set the direction of the drill appropriately to close the enclosure.

11. Insert the drill into the motor axle. See Figure 8.15.

12. Push the lever underneath the motor away from the platform to release the brake. Keep the brake released and run the electric drill to turn the motor axle. The two people should do this relatively slowly and coordinate; if one gets too far ahead of or behind the other, you can damage the arch or bearing.

13. Once the enclosure is closed, release the brake lever, remove the drills, and descend from the platform.

Procedure for Opening the Enclosure

To open the enclosure:

1. Switch off the enclosure controller.

   Move the main power switch on the controller door from ON to OFF.

2. Use appropriate safety equipment: harnesses, lines, and helmets. These are found in the shed.

3. One person should ascend to the northern balcony with one drill and one to the southern balcony with the other drill.

4. Use your safety line to secure yourself to the balcony rail. Loop the line over the rail and then fasten the clasp on the line itself.

Table 8.1: Enclosure Controller Components

Code	Component
K6	Dold IK9217
K7/K8	Siemens 3RB2016-1PB0
	Siemens 3RB2913-0AA1

5. Set the direction of the drill appropriately to open the enclosure.
6. Insert the drill into the motor axle. See Figure 8.15.
7. Push the lever underneath the motor away from the platform to release the brake. Keep the brake released and run the electric drill to turn the motor axle. The two people should do this relatively slowly and coordinate; if one gets too far ahead of or behind the other, you can damage the arch or bearing.
8. Once the enclosure is open, release the brake lever, remove the drills, and descend from the platform.

8.5 Controller

8.6 Control

The server for the enclosure runs on `control`.

It starts automatically when `control` is rebooted, but if necessary can be stopped, started, or restarted expliciatly by issuing the following commands on `control`:

- `sudo stopserver enclosure`
- `sudo startserver enclosure`
- `sudo restartserver enclosure`

Server requests can be issued from any of the Mac or Linux machines on the COATLI LAN. The following requests are supported:

- `request enclosure initialize`

  Initialize the server and enclosure hardware.

  For this request to be accepted, the server activity must not be `starting` or `error`.

  If the request is accepted, the server activity changes to `initializing` and then, once it has initialized, to `idle`.

Figure 8.15: The Enclosure Controller. Top rail, left to right: U1 is the power supply for the PLC; U2 is the PLC; U3 and U4 are extension units for the PLC; K11 to K16 are relays to convert between ADAM and PLC signal levels; finally two stacked ADAM modules. Middle rail, left to right: K1 to K4 are relays for the motors; K5 is the relay for the motor brakes; and +24 VDC and 0 VDC distribution blocks. Bottom rail, left to right: F1 and F2 are breakers for the motors; K6 is the delay relay to run the motors for a few seconds one the enclosure is open in order to synchronize the motors; K7 and K8 are motor current safety relays; 220 VAC live and neutral distribution blocks; K10 is XXX; and K9 is XXX.

- `request enclosure open` ⟨angle⟩

  Open the enclosure to the specified ⟨angle⟩. If ⟨angle⟩ is omitted, a default value of `180` is assumed.

  Valid values of ⟨angle⟩ are `60`, `120`, and `180`.

  For this request to be accepted, the server activity must not be `starting`, `started`, `initializing`, or `error`.

  If the request is accepted, the server activity changes to `opening` and then, once it has opened to the specified angle, to `idle`.

- `request enclosure close`

  Close the enclosure.

  For this request to be accepted, the server activity must not be `starting`, `started`, `initializing`, or `error`.

  If the request is accepted, the server activity changes to `closing` and then, once it has closed, to `idle`.

- `request enclosure stop`

  Stop the enclosure.

  For this request to be accepted, the server activity must not be `starting` or `error`.

  If the request is accepted, the server activity changes to `stopping` and then, once it has stopped, to `started` (if the server has not been initialized) or to the activity after the previous completed request.

- `request enclosure reset`

  Reset an error in the enclosure.

- `request enclosure status`

8.7 Bibliography

- "Technical Specifications: ASTELCO Remote Telescope Station (ARTS)", Version V-1304-21.

Chapter 9

Covers

Chapter 10

Mount

Chapter 11

Telescope

11.1 Description

11.1.1 Optics

The COATLI telescope is a 50-cm $f/8$ Ritchey-Crétien supplied by ASTELCO. The as-built quality of the optics are $lambda/10.9$. The design and as-built optical parameters are given in Table 11.1. The as-built radii of curvatures were measured by the manufacturer with a spherometer. Figures 11.1 and 11.2 show the results of Zygo interferometry of the optics supplied by the manufacturer.

The mirrors are coated with aluminium protected with a layer of MgF_2.

TODO: Image quality. Field.

TODO: Scale.

TODO: Mirror thicknesses

TODO: Mirror material

11.1.2 Mechanics

The primary mirror cell is mainly carbon fiber, with an aluminum dovetail and instrument flange. Carbon fiber Serrutier struts support the aluminum secondary ring. The structs have ball-and-socket joints at both ends, which help maintain collimation at different pointings. The telescope is equipped with motorized covers over the primary mirror and baffle and a motorized focuser for the secondary. The primary mirror can be adjusted in tilt, the secondary mirror in center and tilt, and the primary baffle in tilt with respect to the primary. Figures 11.3 to 11.6 show plans of the telescope.

TODO: Confirm primary baffle moves with respect to M1.

TODO: Get updated STEP from ASTELCO. Our telescope has a different focusers.

TODO: Have Alex make more plans.

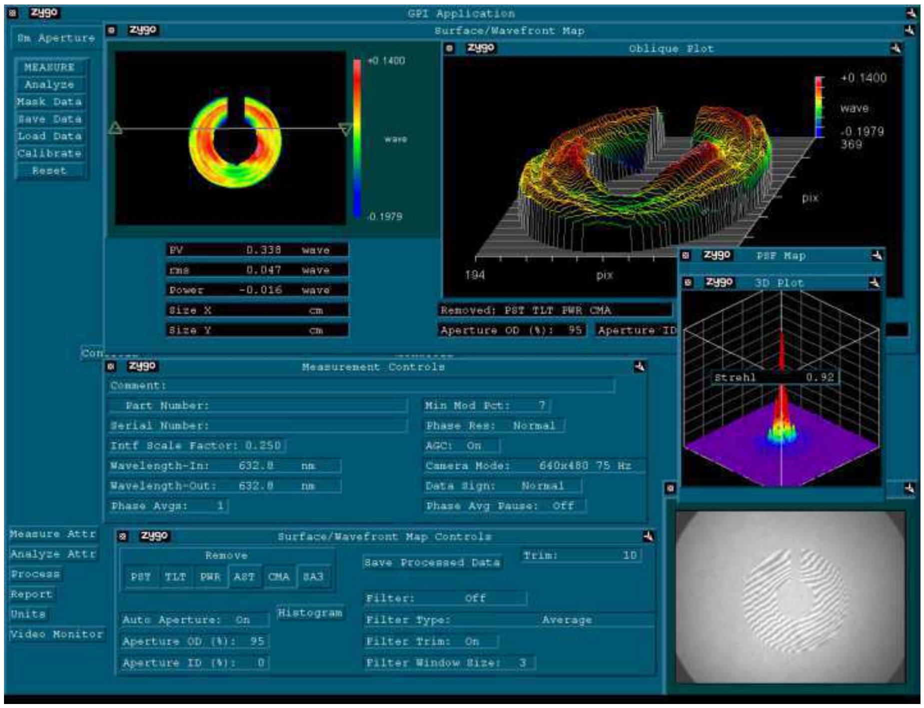

Figure 11.1: Zygo analysis of the optics. Piston, tilt, defocus, and coma have been removed, since these ae irrelevant or can be corrected by alignment.

Table 11.1: Telescope Optical Parameters

Component	Parameter	Design	As-Built
M1	Clear Aperture Diameter (mm)	500	
	Radius of Curvature (mm)	2500	2547.0
	Focal Ratio	$f/2.5$	$f/2.547$
	Conic Constant	-1.081	
	Central Hole Diameter (mm)	120	
M2	Clear Aperture Diameter (mm)	172	
	Radius of Curvature (mm)	1073.58	1143.0
	Focal Ratio	$f/3.12$	$f/3.32$
	Conic Constant	-4.484	
M1+M2	Focal Ratio	$f/8$	
	Vertex of M1 to Vertex of M2 (mm)	880.957	
	Vertex of M1 to Focal Plane (mm)	300	300 ± 0.5
	Flange to Focal Plane (mm)	136	
	RMS Wavefront Error (nm)	105	58
	Wavefront Error (RMS)	$\lambda/6$	$\lambda/10.9$

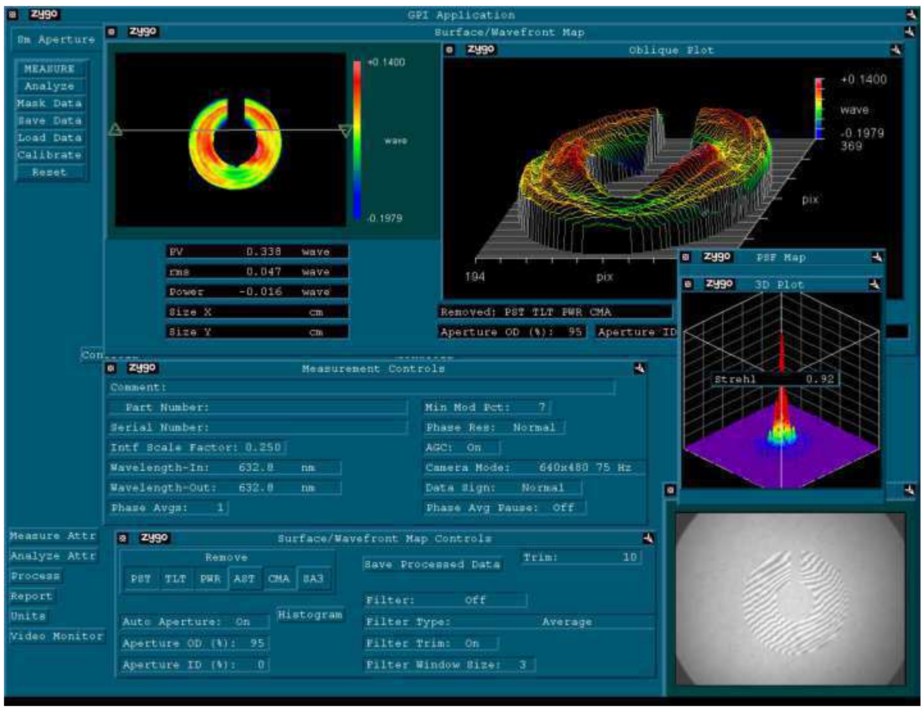

Figure 11.2: Zygo analysis of the optics. Piston, tilt, defocus, coma, and astigmatism have been removed. The very small change in image quality compared to Figure 11.1 – from 0.047 waves to 0.046 waves – serves to demonstrate that optics have negligible astigmatism.

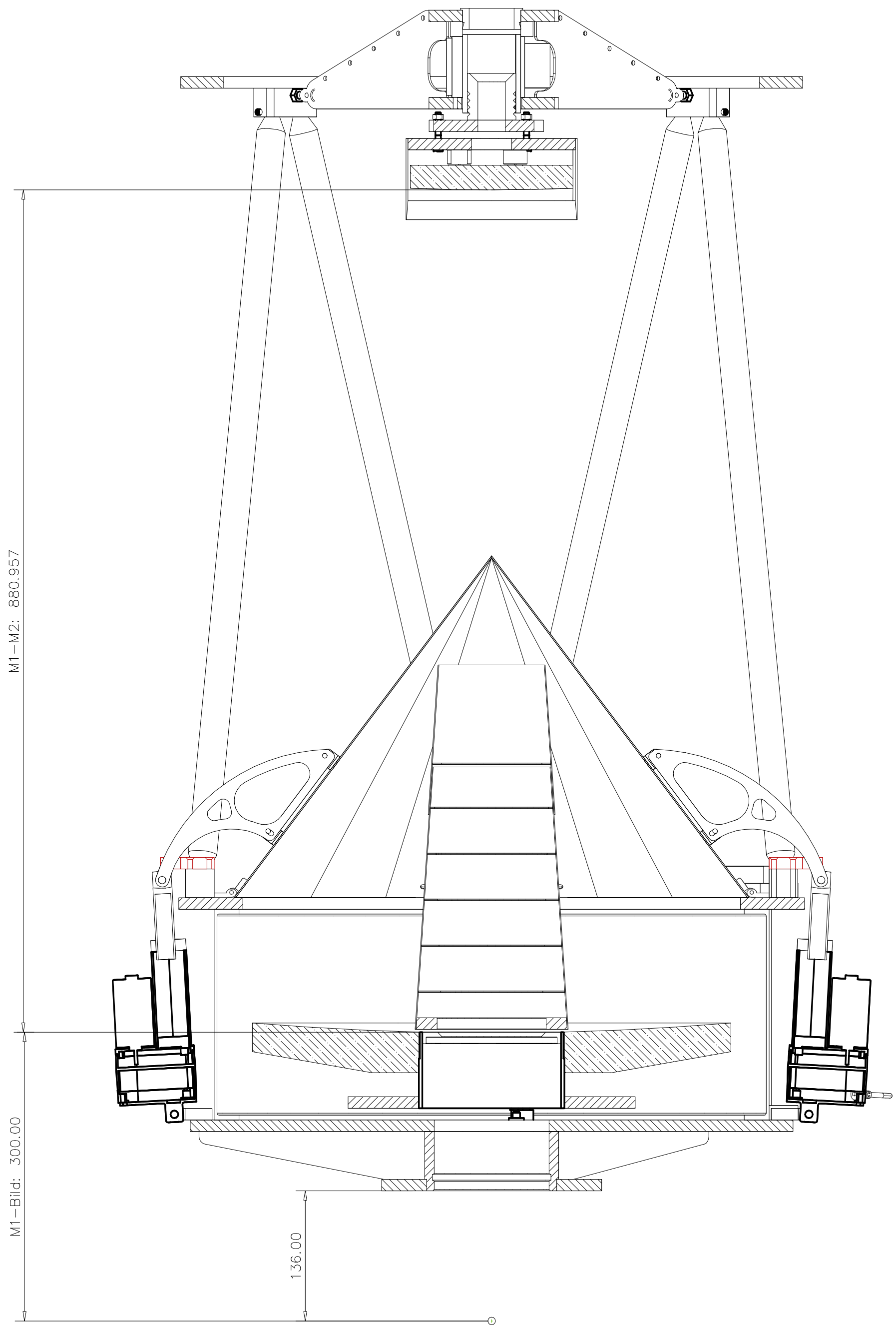

Figure 11.3: Lateral section of the telescope. Note that our telescope has a focuser with a different design.

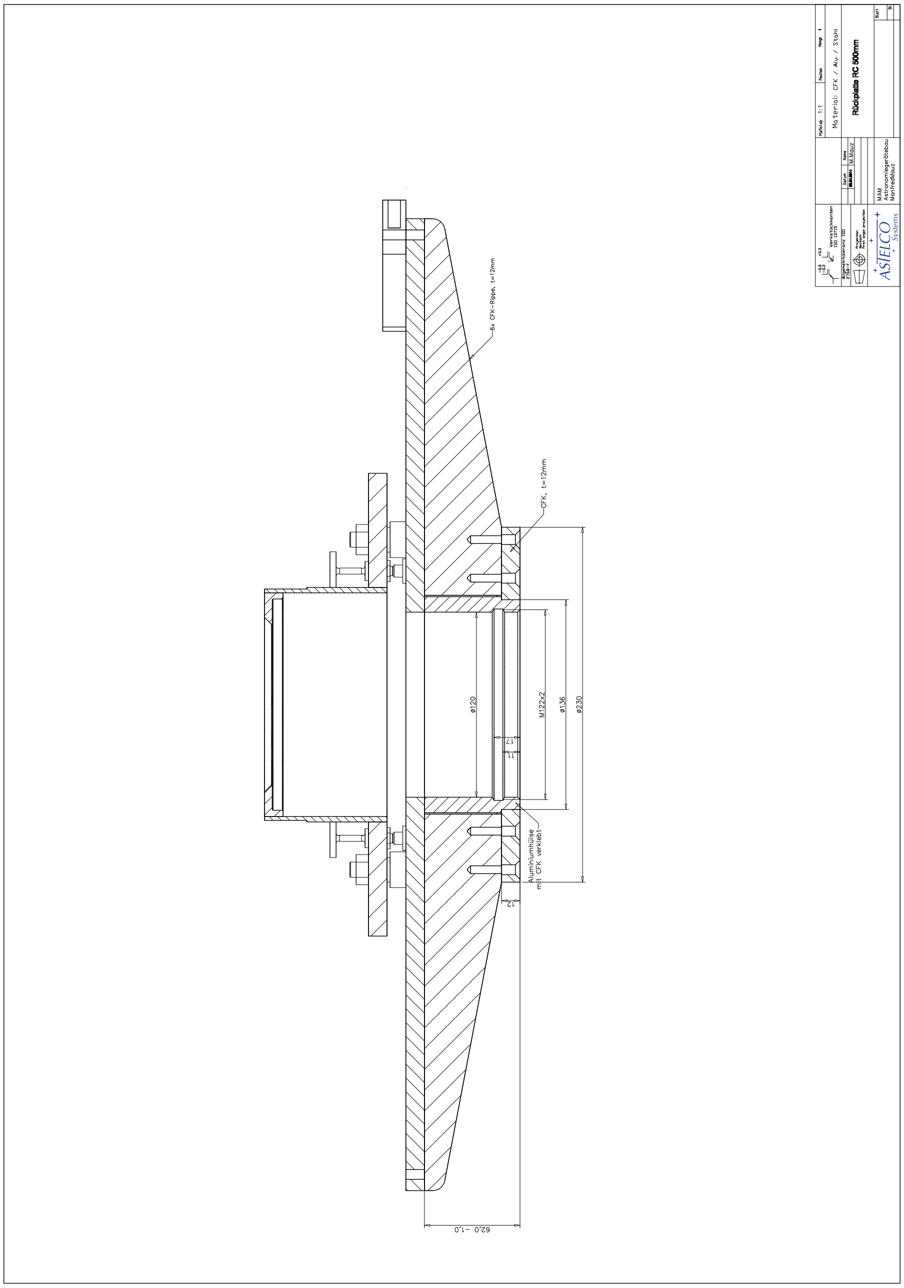

Figure 11.4: Lateral section of the backplane of the primary mirror cell.

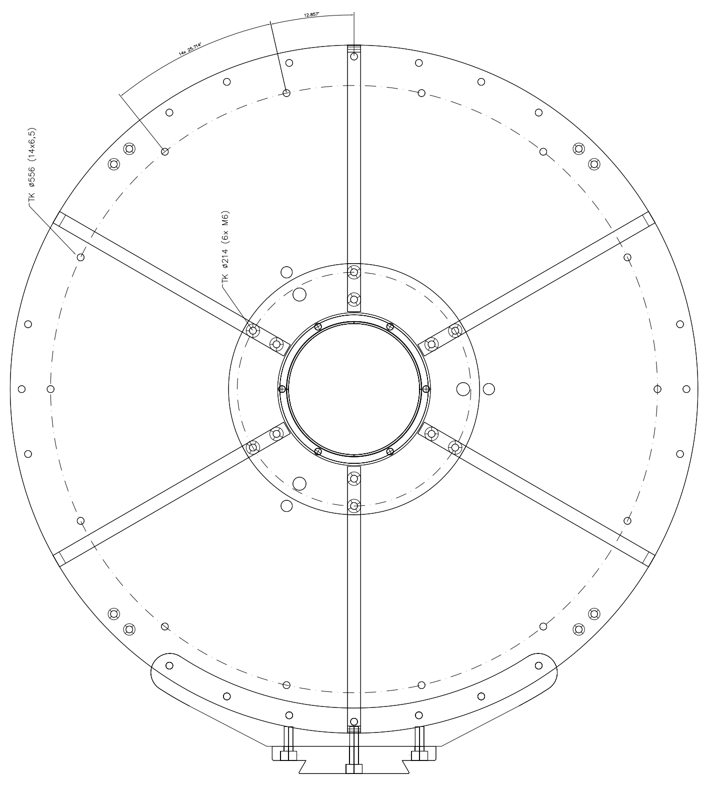

Figure 11.5: Lateral section of the telescope.

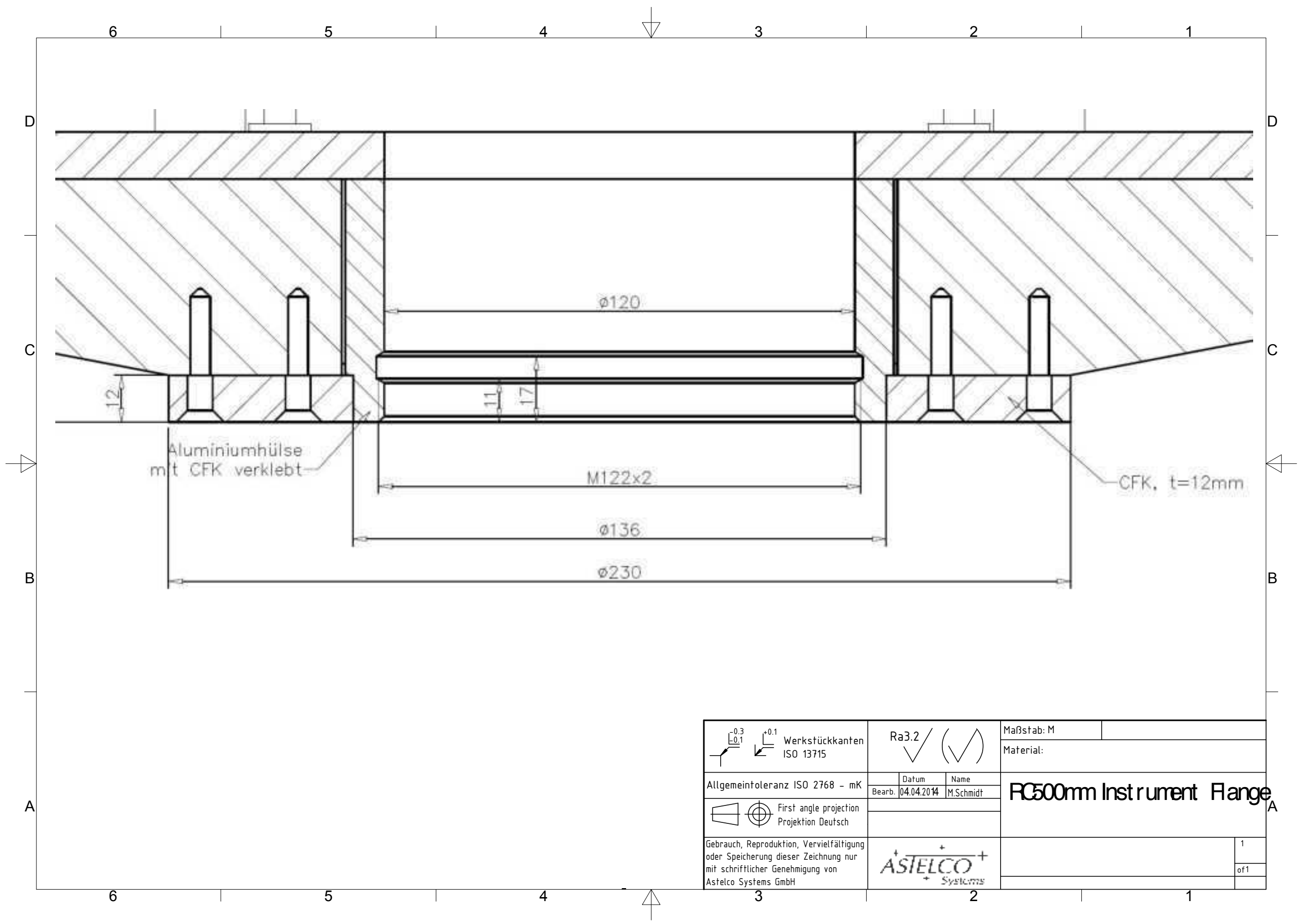

Figure 11.6: Lateral section of the instrument flange.

11.2 Resumen

Se presentan los métodos a seguir para retirar o instalar los espejos del telescopio COATLI para su aluninización o servicio de sus componentes.

11.3 Descripción general

COATLI es un telescopio de tipo Ritchey-Chretien de 500 mm de diámetro trabajando en F/8 en una montura ecuatorial de tipo alemán.

El tubo del telescopio, mayormente construido de fibras de carbono tejidas y prensadas, tiene una estructura básica montada sobre el eje de declinación, a la que en adelante se llamará cubo del telescopio o simplemente cubo. En su parte inferior presenta la platina de montaje de instrumentos, en el interior contiene a la celda del primario, que consiste de una placa de soporte y Tip-Tilt.

En la parte superior del cubo se encuentran las bases de los tubos que forman la estructura Serrurier. Dicha estructura, se completa con el anillo superior, que porta la araña, la araña al sistema de enfoque y éste a la celda del secundario.

En la base del cubo se encuentran tres tornillos de alineación con tuercas M17 provenientes de la placa de soporte del primario. Entre la placa de soporte y el cubo llevan estos tornillos cada uno un muelle formado por rondanas con forma de menisco. Al lado de éstos tornillos se encuentran tres prisioneros Allen MXX que una vez conseguida la alineación, fijan la placa de soporte del primario.

El bafle del primario pasa a través del boquete central del espejo y se fija en el cubo con tres pares de tornillos similares a los anteriores, tuercas MXX y prisioneros MXX, de manera que su inclinación es independiente de la del espejo primario. Estos tornillos se acceden desde el exterior del cubo, por su agujero central.

La araña se fija en su posición por medio de cuatro tornillos insertados en sendos cilindros, cada uno con una tuerca exterior y otra interior con lo que se puede obtener un descentrado de hasta Nmm del secundario.

La celda del secundario, consiste de una placa sobre la que el espejo va pegado y a la que se fija el bafle mediante tres tornillos radiales. En el bafle, además van montadas tres pestañas de seguridad para el caso de que el secundario se despegase. La alineación se obtiene en forma idéntica a las anteriores, En este caso las tuercas son M10 y los prisioneros MXX

Finalmente, nótese que en la cara sur del estator del eje de AR se encuentra un botón metálico que, al mantenerse presionado, libera los frenos de ambos ejes y es entonces posible mover manualmente el telescopio a las posiciones adecuadas para las operaciones que a continuación se detallarán.

11.4 Consideraciones y precauciones generales

- Los siguientes procedimientos causarán o bien se iniciarán con un desbalanceo del telescopio en ambos ejes.
- Recuerde siempre que la única posición relativamente segura en caso de desbalanceo del telescopio, es la de reposo, en la que el eje de AR se encuentra en equilibrio estable y en el eje de Dec. la torca residual es en todo caso muy pequeña.
- No confie nunca en que los frenos serán capaces de contrarestar la torca de una posición desbalanceada, se recomienda contar en estos casos , con una tercera persona cuya única función sea la de prevenir una falla de los frenos.

11.5 Desensamble de la celda del secundario

11.5.1 Requerimientos

- Dos personas
- Llave española M10
- Llave Allen MXX

11.5.2 Procedimiento

- Presione el botón de liberación de los frenos, oriente horizontalmente el tubo del telescopio y libere el botón.
- La persona 2 colocará la funda de protección del secundario.
- La persona 1 extraerá las tuercas M10 y sus rondanas del soporte de la celda, mientras la persona 2 sostiene la celda.
- La persona 2 extraerá la celda mientras la persona 1 toma las rondanas que forman el muelle.
- La persona 2 pondrá la celda con el secundario en lugar seguro.
- Sujetando el tubo y las pesas, presione el botón de liberación de los frenos y regrese el telescopio a la posición de descanso.

11.6 Ensamble de la celda del secundario

11.6.1 Requerimientos

- Dos personas

- Llave española M10
- Llave Allen MXX

11.6.2 Procedimiento

- Presione el botón de liberación de los frenos, oriente horizontalmente el tubo del telescopio y libere el botón.
- La persona 2 presentará los tornillos de la celda en las cercanías de sus correspondientes boquetes de la placa de montaje.
- La persona 1 instalará en los tres tornillos, las rondanas que forman los muelles.
- La persona 1 elegirá la rotación correcta de los tornillos, ya que los prisioneros Allen se accionarán a través de los boquetes que al efecto existen en la placa de montaje.
- Introdúzcanse los tornillos M10 en sus correspondientes boquetes
- La persona 1 se asegurará de que los prisioneros han quedado accesibles y los desenroscará de manera que no entorpezcan el ajuste siguiente.
- La persona 2 empujará la celda suavemente, hasta que las rondanas de los muelles entren en contacto con la celda y la placa.
- La persona 1 instalará las tuercas M10 y sus rondanas de soporte de la celda, apretándolas a mano.
- La persona 1 aplicará una precarga mediante dos vueltas de las tuercas usando la llave española M10
- La persona 1 ajustará los prisioneros Allen para fijar la celda en esa posición.
- Presione el botón de liberación de los frenos y lleve el telescopio a la posición de reposo.

11.7 Desensamble del Bafle del primario

11.7.1 Requerimientos

- Dos personas
- Llave española Mxx
- Llave Allen MXX

11.7.2 Procedimiento

- Abra los pétalos de protección del primario.
- Presione el botón de liberación de los frenos, oriente horizontalmente el tubo del telescopio y libere el botón.
- La persona 2 sujetará el bafle usando guantes de látex, permitiendo las oscilaciones que se producirán, pero manteniendo una ligera presión hacia la celda
- La persona 1 localizará las tuercas MXX de soporte y alineación del bafle dentro del boquete del Cubo y procederá a extraerlas con sus rondanas de forma pareja, para limitar las oscilaciones del bafle.
- La persona 2 extraerá el bafle mientras la persona 1 vigila las rondanas que forman el muelle, mismas que no deberían salirse de los tornillos gracias a un arosello que debe impedirlo.
- La persona 2 colocará el bafle en lugar seguro y protegido.
- Cierre los pétalos de protección del primario.
- Presione el botón de liberación de los frenos y regrese a la posición de reposo.

11.8 Ensamble del Bafle del primario

11.8.1 Requerimientos

- Dos personas
- Llave española Mxx
- Llave Allen MXX

11.8.2 Procedimiento

- Abra los pétalos de protección del primario.
- Presione el botón de liberación de los frenos, oriente horizontalmente el tubo del telescopio y libere el botón.
- La persona 2 usando guantes de látex, introducirá el bafle por el boquete del primario, girándolo según las instrucciones que le dará la persona 1 para hacer coincidir los tornillos con las perforaciones correspondientes.
- La persona 1 insertará las tuercas MXX de soporte y alineación del bafle dentro del boquete del Cubo y procederá a atornillarlas a mano.
- La persona 1 aplicará una precarga a las tuercas girándolas dos vueltas
- Cierre los pétalos de protección del primario.

11.9 Desensamble de la celda del primario

Si se encuentra instalado algún instrumento en la celda del primario, desinstálelo siguiendo el procedimiento recomendado para dicho instrumento. Si el Bafle del primario está instalado, siga el correspondiente procedimiento de desinstalación.

11.9.1 Requerimientos

- Dos personas
- Llave española M17
- Llave Allen MXX
- Guantes de látex

11.9.2 Procedimiento

- Abra los pétalos de protección del primario. Puede ser necesario retirar alguno?
- Presione el botón de liberación de los frenos, oriente el tubo del telescopio hacia el cenit y libere el botón.
- La persona 1 localizará las tuercas M17 de soporte y alineación del primario en la parte inferior del Cubo y procederá a extraerlas con sus rondanas de forma pareja, para limitar las oscilaciones del primario.
- La persona 2, con guantes de látex extraerá el primario con su celda sujetándolo a través del boquete del primario.
- Mientras tanto, la persona 1 vigilará las rondanas que forman el muelle, mismas que no deberían salirse de los tornillos gracias a un arosello que debe impedirlo.
- La persona 2 colocará el primario con su celda en lugar seguro y protegido. Esto puede requerir mas aclaraciones
- Presione el botón de liberación de los frenos y regrese a la posición de reposo.

11.10 Ensamble de la celda del primario

11.10.1 Requerimientos

- Dos personas
- Llave española M17
- Llave Allen MXX
- Guantes de látex

11.10.2 Procedimiento

- Abra los pétalos de protección del primario. Puede ser necesario retirar alguno?
- Presione el botón de liberación de los frenos, oriente el tubo del telescopio hacia el cenit y libere el botón.
- La persona 2, con guantes de látex sujetando la celda a través del boquete del primario presentará, los tornillos de la celda en las cercanías de sus correspondientes boquetes en el Cubo.
- La persona 1 indicará a la 2 la rotación correcta de la celda para los siguientes pasos
- La persona 1 vigilará las rondanas que forman el muelle, mismas que no deberían salirse de los tornillos gracias a un arosello que debe impedirlo.
- Introdúzcanse los tornillos Mxx en sus correspondientes boquetes
- La persona 1 desatornillará los prisioneros de fijación de la celda, de manera que no entorpezcan el ajuste siguiente.
- La persona 1 atornillará las tuercas M17 de soporte y alineación del primario en la parte inferior del Cubo apretándolas a mano.
- La persona 1 aplicara una precarga a las tuercas usando la llave española M17, dándole dos vueltas a cada una.
- La persona 1 ajustará los prisioneros Mxx
- Presione el botón de liberación de los frenos y regrese a la posición de reposo.

11.11 Notas

- Ya que la inclinación del bafle del primario es independiente de la alineación del espejo, es necesario contar con un método para alinearlo. Se sugiere usar hilos cruzados desde los tubos Serrurier, formando una cruz a la altura de la entrada del bafle y ya que la exactitud de la posición de dicha retícula puede ser engañosa por causa de la inclinación de los tubos, incertidumbres en la alineación del láser y posibles asimetrías, se puede verificar su centrado observando el paso del láser, una vez alineado con el secundario, usando un papel sobre la misma retícula. Si fuese necesario, se pueden modificar los hilos para señalar el nuevo punto de referencia para realinear el bafle con ese punto, para lo que sería necesario abrir el acceso a los tornillos en la base del bafle.
- Es conveniente fabricar una cubierta para el primario para protegerlo durante las manipulaciones.
- La funda del bafle del secundario ajusta demasiado, se recomienda aumentar su diámetro y añadirle un resorte para facilitar su instalación.

11.12 Recoating

ASTELCO recommend removing the aluminum and MgF_2 coatings by soaking in a 10% solution of NaOH for several hours.

11.13 Preguntas

¿Cuáles son las constantes cónicas medidas de los espejos?

¿En qué material están construidos?

¿Las películas de Al tienen capas protectoras? Y de ser así, ¿Qué procedimiento debe seguirse para retirarlas?

Una vez retirado el bafle y las tuercas de los tornillos de jalar del primario, para retirarlo del telescopio:

¿El espejo y su base caben entre las barras del serrurier o es necesario desmontar antes algo más?

¿Es necesario para aluminizar, despegar el primario y/o el secundario de las placas de carbón que los portan?, de ser así, ¿Cuáles son los procedimientos necesarios para hacerlo y posteriormente para pegarlo?

¿Cuál es el cemento con el que está pegado? ¿Cuál es su expectativa de vida?

En ambas celdas, ¿Qué es lo que evita que los tornillos de jalar giren? Y ¿Sobre qué apoyan los tornillos de empujar?

Chapter 12

Interim Instrument

12.1 Introduction

The interim instrument is a simple direct imager that will be used for commissioning the telescope and early science pending the delivery of the definitive high-resolution imager. It is based on an air-cooled Finger Lakes Instruments Microline ML3200 detector and a Finger Lakes Instruments CFW-1-5 filter wheel. The wheel accepts five 50 mm diameter filters. We have installed $BVRI$ and clear filters.

12.2 Detector

The interim instrument uses a Finger Lakes Instruments Microline ML3200 detector with an Kodak KAF-3200ME CCD. The detector has a thermoelectric cooler and can nominally reach 60 C below ambient. Heat is vented to air via heat exchanger and fan. The detector serial number is ML0053812.

The CCD has 2184×1472 active pixels each 6.8 μm square. It is front-illuminated, but employs a microlens array to boost the fill-factor and quantum efficiency.

The maximum field diameter is 18 mm, which is well within the nominal diffraction-limited field of the telescope of 26 mm. The measured pixel scale is 0.351 arcsec and the field is 12.8×8.7 arcmin.

The full data image from the CCD is 2267×1510. The vertical structure is:

- 34 dark lines
- 1472 photoactive lines
- 4 dark lines

Each photoactive line has the following horizontal structure:

- 8 inactive pixels
- 1 photoactive pixel
- 3 inactive pixels
- 34 dark reference pixels
- 2184 photoactive pixels
- 34 dark reference pixels
- 1 photoactive pixel
- 2 inactive pixels

The inactive pixels do not accumulate charge and read only the bias level. The dark reference pixels accumulate only dark current and read the bias level plus the dark level. The photoactive pixels accumulate both dark current and photoelectric current and read the bias level plus the dark level plus the photon signal.

The single columns of photoactive pixels close to the start and end of each line are for monitoring horizontal CTE.

The dark lines have a similar structure, with dark reference pixels replacing the photoactive pixels.

12.3 Filters

We plan to install 5-mm thick BVRI and clear filters. The BVRI filters will be supplied by Custom Scientific. The clear filter will be a window supplied by Edmund Optics.

The detector is a

12.4 Mechanical Design

Figure 1 shows a CAD model of the telescope and the interim instrument. The CAD model of the Astelco RC500 telescope was supplied by Astelco. The CAD model of the instrument was developed in the Instituto de Astronomía of the UNAM.

Figure 1. CAD model of the Astelco RC500 telescope, the interim instrument, the finder, and the electronics cabinet.

Figure 2 shows an exploded view of the components of the interim instrument. Table 1 lists the mechanical components. The total weight of the instrument excluding the filter wheel, filters, and detector is 6.8 kg. When the filter wheel (0.77 kg) and the camera (1.36 kg) are included, the weight rises to 8.93 kg.

Figure 2. Exploded view of the interim instrument.

Table 1. List of mechanical components of the interim instrument.

1.2 Description of the Components. The following is a brief description of each component: 1.- Instrument flange: This is the mechanical interface with the telescope, and permits the interim instrument (and eventually the definitive instrument) to be mounted. The instrument flange will be attached to the telescope flange by six M10x1.5 bolts (part 13) and nuts (part 14). The bolts pass through six smooth, 11 mm diameter holes in the instrument flange. These holes will also serve as templates for the six simular holes that will be drilled in the telescope flange in situ; these holes are not part of the standard telescope design. These holes are shown in Figure 3.

Figure 3. The six holes to be drilled in the telescope flange. .

2.- Extension barrel: The function of this component is simply to serve as an interface between the instrument flange and the filter wheel. The length is chose to place the detector in the nominal focal plane of the telescope, as shown in Figure 4. (See also the diagram "T0500-20 focal plane without corrector 2014-06-06" supplied by Astelco.)

Figure 4. Position of the focal plane of the camera and telescope.

3, 4 y 5: Interface EB/CFW1-5, Interface CFW1-5/Camera and Adapter for centering: These interfaces serve to attach the filter wheel and the camera to the telescope, via the extension barrel. They will be fabricated by a CNC machine. They have a series of through bolts that will act to avoid rotation of the wheel and camera. These bolts are shown in Figure 5. The filter wheel will be modified with six through holes through the outer rim to accomodate these bolts. This modification will not significantly affect the operation or rigidity of the wheel.

Figure 5. The filter wheel between the two interfaces. The Interface CFW1-5/Camera also supports the detector using four bolts with lock washers. These will keep the bolts tight even in the presense of rapid movements by the telescope.

Figure 6. The detector and its interface plate. N.B.: The design uses SS thread-locking inserts. N.B.: The design uses and lock washers, to guard against bolts or nuts coming loose because of vibrations or motion.

2. Finder and Support: 2.1 Overview. The finder is a IDS UI-1540RE-M-GL detector head with a Fujinon HF35HA-1B 35 mm f/1.6 C-mount lens. The detector is an Aptina MT9M001STM CMOS device with a format of 1280 by 1024 and 5.4 micron pixels. The field is about 9 by 11 degrees and the pixel scale is about 30 arcsec. Figure 7 and Table 2 show the components of the finder and its support.

Figure 7. Exploded view of the finder and its support

Table 2. List of mechanical components of the finder .

2.2 Functional Description. 1.- Holder grip top: This component acts to couple the finder support to the the upper ring of the telescope. The shape of the cut-out follows that of the ring. As shown in Figure 8, in theory the finder can be located at any azimuth, but locating it close to the polar axis is probably beneficial for reasons of torque and balance.

Figure 8. Left: although the finder can be mounted at any azimuth, we plan to mount it closes to the polar axis. Right: the assembly of the holder is straightfoward.

2.- Holder grip bottom: These two identical components are used to firmly attach the Holder grip top to the upper ring. We will use four lock washers (5) between components 1 and 2, as shown in Figure 7.

3.- Camera interface with holder grip: This is a 90 degree bracket, with holes to make it lighter, and two sets of four through holes for bolts. These bolts attach the interface to the holder grip top and to the detector (see Figure 9). Lock washers will be used with the bolts.

Figure 9. The finder detector head and the support.

3. The electronics cabinet support The interim instrument will use one electronics cabinet mounted opposite the dovetail. (The definitive instrument will use two cabinets mounted at 90 and 270 degrees of azimuth from the dovetail.) The electronics cabinet will be bolted to two L brackets, as shown in Figures 10 and 11. The two brackets are similar, with the exception that the lower bracket attaches to two holes on the telescope whereas the upper bracket attaches to three. These holes in the telescope appear in the model supplied by Astelco. We will use five M6x1.0 bolts, nuts, and lock washers. The total weight of the two brackets, bolts, nuts, and washers is 290 g.

Figure 10. Exploded diagram of the electronics cabinet.

Figure 11. The electronics cabinent mounted on the telescope.

The upper bracket has slots which will permit minor adjustments of its position with respect to the cabinet and and the telescope (see Figure 12). They will be attached to the telescope with four M5 bolts.

Figure 12. Slots in the upper bracket will permit fine adjustment.

12.5 Control

The server for C0 runs on `f1`.

It starts automatically when `f1` is rebooted, but if necessary can be stopped, started, or restarted expliciatly by issuing the following commands on `f1`:

- `sudo stopserver C0`
- `sudo startserver C0`
- `sudo restartserver C0`

Server requests can be issued from any of the Mac or Linux machines on the COATLI LAN. The following requests are supported:

- `request C0 movefilterwheel` ⟨filter⟩

  Move the filter wheel to the specified ⟨filter⟩.

  The server activity must be `idle` for this request to be accepted. The server activity changes to `moving` and then, once the filter wheel has finished moving, to `idle`.

  The ⟨state⟩ argument can be:

  - The filter name: `C`, `BB`, `BV`, `BR`, or `BI`.

- An integer from 0 to 4 specifying the slot number.

- `request C0 setcooler` ⟨state⟩

  Set the cooler to the specified ⟨state⟩.

  The server activity must be `idle` for this request to be accepted. The server activity does not change.

  The ⟨filter⟩ argument can be:

  - a decimal fraction

    Turn on the cooler. Set the cooler set temperature to the value given.

    The initial set temperature is `-30`.

  - `on`

    Turn on the cooler. Do not change the current cooler set temperature.

  - `off`

    Turn off the cooler. Do not change the current cooler set temperature.

  - `following`

    Turn on the cooler. Periodically adjust the cooler set temperature to the value of the detector housing temperature. This setting is intended to extract the heat generated by the CCD electronics without generating excessive waste heat.

  - `open`

    This is an alias currently defined to be for `on`. When the executor server opens the telescope, it requests C0 to use this cooler state.

  - `closed`

    This is an alias currently defined to be `following`. When the executor server closed the telescope, it requests C0 to use this cooler state.

Bibliography

- "FLI MicroLine Drawings for 25-mm Shutter", 2015.
- "FLI MicroLine Imaging System User's Guide", 2009.
- "FLI MicroLine ML3200 Data Sheet", 2015.
- "Kodak KAF-3200ME Image Sensor", 2008, Revision 3.0.