DDOTI Technical Manual

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Chapter 1

Introduction

This is the technical manual for the DDOTI[1] installation, 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 aid DDOTI and OAN/SPM technical staff perform preventative and corrective maintenance of the equipment.

For an overview of the DDOTI project, we recommend our 2016 SPIE paper:

- "DDOTI: the deca-degree optical transient imager", Watson et al. 2016, Proc. SPIE, 9910, 99100G

DDOTI is funded by CONACyT (LN 232649, LN 260369, LN 271117, and 277901), the Universidad Nacional Autónoma de México (CIC and DGAPA/PAPIIT IG100414, IT102715, AG100317, IN109418, IG100820, and IN105921), the NASA Goddard Space Flight Center, and the University of Maryland (NNX17AK54G). DDOTI is operated and maintained by the Observatorio Astronómico Nacional and the Instituto de Astronomía of the Universidad Nacional Autónoma de México. We acknowledge the contribution of Neil Gehrels to the development of DDOTI.

[1]http://coatli.astroscu.unam.mx

Part I

Operations

Chapter 2

Safety

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

2.1 Feedback

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

2.2 Priorities

> *The safety priorities at the DDOTI installation, from highest to lowest, are:*
>
> 1. *Personnel safety: avoiding injury and death to personnel.*
> 2. *Equipment safety: avoiding damage or loss of equipment.*
> 3. *Observing and data preservation.*

2.3 Personnel Safety

The DDOTI installation is potentially one of the most dangerous installations at the OAN/SPM. Personnel safety is more important than equipment safety or observations. 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.

> *You may work alone on the closed platform. However, someone else must be present when you ascend or descend.*

You should have someone to close the enclosure manually after you have entered and open it manually for you to leave. 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 to ascend the tower. When you are working on the balcony or another position from which you might fall, attach your line to one of the eyes, to the balcony rail, or to something equivalently strong. In cold weather, we strongly recommend using gloves.*

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 various points: the eyes in the platform floor and balconies 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.

> *Transport equipment and tools to and from the platform using the appropriate equipment provided: ropes, locking carabiners, locking hooks, straps, a tool carrier, and an equipment bag.*

Using this equipment in an appropriate manner will significantly reduce the risk of something falling. This equipment is stored in the project cabinet in the ground-floor of the 84-cm telescope. When you use the rope, you can fasten the upper end to one of the eyes in the platform using a locking carabiner. See Figure 2.1. When lifting heavy equipment to the platform, consider using the locking hook.

MAGUI: This equipment, shown in Figure 2.1, is stored in the project cabinet in the ground-floor of the 84-cm telescope. Using this equipment in an appropriate manner will significantly reduce the risk of something falling. When you use the rope, you can fasten the upper end to one of the eyes in the platform using a locking carabiners. When lifting heavy equipment to the platform, consider using the locking hook.

> *Return equipment and tools to their usual storage location when you have finished using them.*

Figure 2.1: Equipment to safely transport equipment to and from the platform: ropes, locking carabiners, straps, a tool carrier, and an equipment bag.

This ensures that equipment can be found when it is next needed. This is especially important for safety equipment.

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, it is likely that they will collapse and you will fall.

If you need to summon help and do not have a portable radio, you can use the static emergency radio located between the 84-cm building and DDOTI.

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

Note that box C has 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 box C is not switched.

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

2.4 Equipment Safety

Only open the enclosure explicitly when conditions are benign. 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 been 35 km/h or greater at any moment in the previous 30 minutes.*
4. *There are other circumstance which, in the judgement of observatory technical staff, dictate that it is not safe to open.*

These rules are implemented in the DDOTI weather server. If you check the DDOTI web interface (see §3), 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 DDOTI is currently lower until we have greater confidence in its reliability and performance in high winds.

Before opening the enclosure, check on the webcams in the interface (see §3) that the telescope is not pointed to towards the sun.

In the home position, the telescopes are pointed 30 degrees below the northern horizon. This is to protect the telescope corrector lenses from falling debris or water drops.

The enclosure controller (see §11) 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

Interface

This chapter describes the interface used by the observatory staff to interact with the DDOTI control system.

3.1 Access

The address of the DDOTI web site is:

> http://ddoti.astrossp.unam.mx/

The web site contains the interface and documentation. They are only directly available to computers on the mountain-top network, although ssh port-forwarding can make it indirectly available elsewhere.

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

3.2 Main Page

Figure 3.1 shows an example of the main page of the interface. The major elements of the interface are:

- Thumbnail images from the webcams. Clicking on the thumbnail images brings up larger images, examples of which are shown in Figures 3.2, 3.3, 3.4, and 3.5. These images are useful for checking the status of the enclosure and telescope. At night, one needs to switch on the enclosure lights (see §3.2) to see anything in the webcams.
- A thumbnail image from the all-sky camera. Clicking on the thumbnail image brings up a larger image. This is useful for checking for clouds.

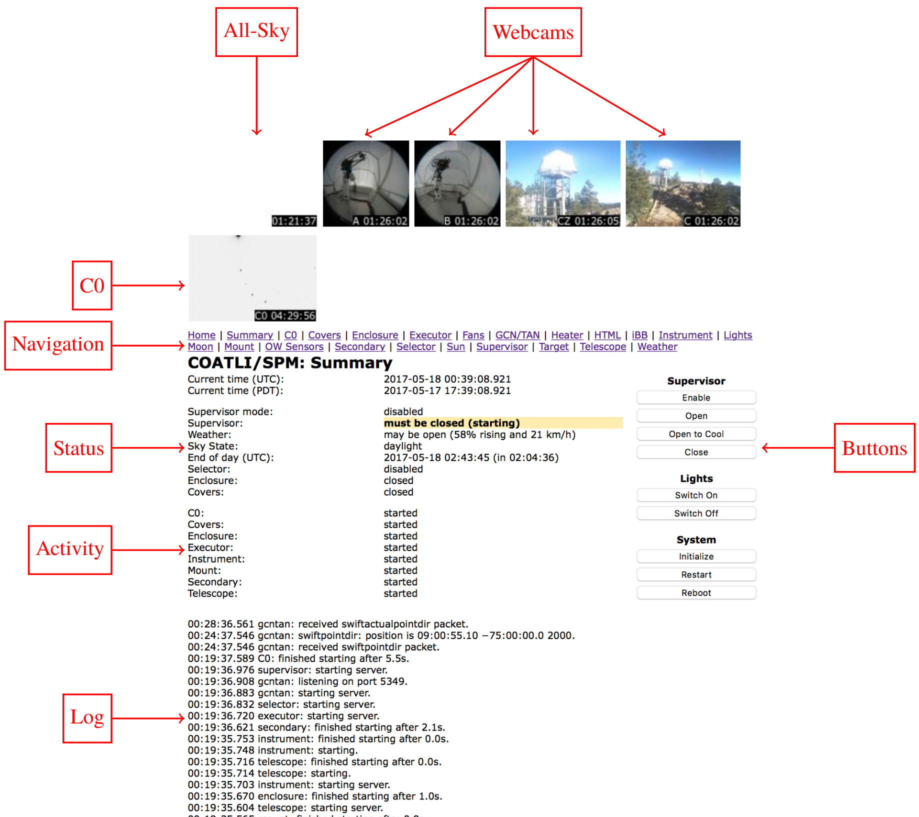

Figure 3.1: An example of the main page of the interface. The major elements are labelled and described in the text.

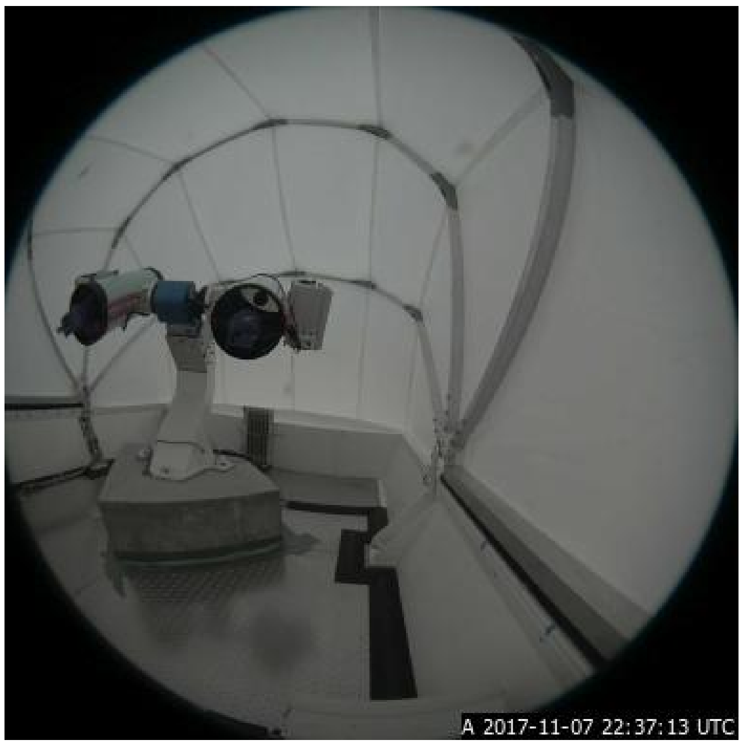

Figure 3.2: An example view from webcam A (in N corner of the enclosure looking to the SSW).

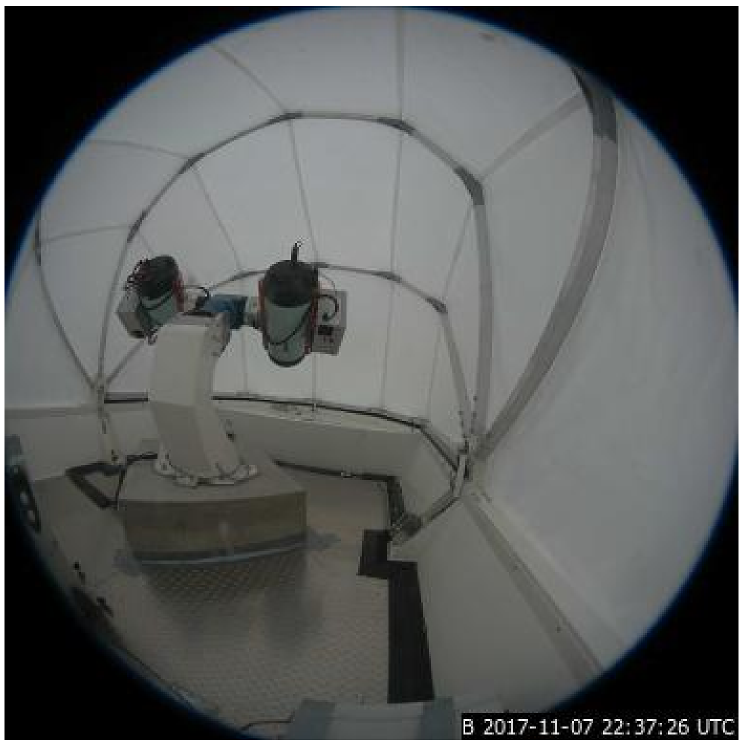

Figure 3.3: An example view from webcam B (in S corner of the enclosure looking to the NNE).

Figure 3.4: An example view from webcam CZ (on the 84-cm telescope building looking towards DDOTI). Webcam CZ is actually just a fixed zoom of webcam C.

Figure 3.5: An example view from webcam C (on the 84-cm telescope building looking towards DDOTI).

- A thumbnail image of the latest image taken by the C0 detector. Clicking on the thumbnail image brings up a larger image. This is useful for checking focus.

- A navigation section. Clicking on these links will bring up the detailed page for the corresponding control system server. These pages are typically used by the team members to diagnose problems.

- A status section. In the main page this gives:

  - The UTC time.
  - The civil time at the observatory (PST or PDT).
  - The supervisor mode ("enabled", "disabled", "open", "opentocool", or "closed").
  - A description of whether the supervisor mode permits the enclosure to be open and why.
  - A description of whether the current weather conditions permit the enclosure to be open and why (wind, rain, and humidity).
  - A description of the current sky state (daylight, twilight, and night).
  - The time of the next day/twilight/night transition in UTC.
  - The enclosure state (open or closed).

- The activity section. If a control system server activity is not "idle" (for example, if it is "started", "initializing", "moving", "tracking", "opening", or "closing"), this is shown here. If a server activity is "idle", it is not shown here. Thus, if all of the servers are "idle", this section is empty.

  Errors and warnings are shown here in red and yellow respectively.

- The log section. This section shows the latest log messages from the control system in reverse order.

- The buttons. These are used to interact with the control system.

  - Enable. Enabled the supervisor. This permits the supervisor to open and close according to the weather and sky state. Note that the supervisor only takes decisions to open, open to cool, or close if it is enabled.
  - Open. Force the supervisor to open and to stay open until explicitly instructed otherwise.
  - Open to Cool. Force the supervisor to open to cool and to stay open to cool until explicitly instructed otherwise. Opening to cool opens the enclosure partially, and starts to cool the CCD. It is typically used at the end of the day to cool the enclosure, telescope, and CCD ready for observations after sunset.
  - Close. Force the supervisor to close and to stay closed until explicitly instructed otherwise.

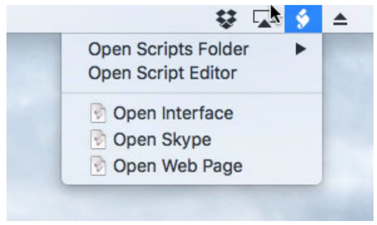

Figure 3.6: The script menu, in the upper right, can open the interface and Skype on the Access Mac.

- Switch On. Switch on the enclosure lights. This is useful when you want to use the webcams to check the status of the telescope or enclosure. Of course, one does not want to turn the lights on if the telescope is observing.
- Switch Off. Switch off the enclosure lights.
- Restart. Schedule a restart of the control system servers for the top of the next minute. This can be used to recover from software problems.

3.3 Running the Interface on the Access Mac in the Shed

The interface can be run locally on the Access Mac in the Shed.

If you need to log into the Mac, use the "ddoti" account with password "ddoti".

If the interface and Skype are not running, you can select "Open Interface" or "Open Skype" from the script menu in the upper right, as shown in Figure 3.6.

Chapter 4

Operations

DDOTI is in regular robotic operation under the responsibility of the observatory staff. Weather permitting, DDOTI will operate from 30 minutes before sunset to the end of morning astronomical twilight.

4.1 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 DDOTI technical teams.

4.2 Communications

Communication between the observatory staff and the team will take place primarily through the RATIR/COATLI/DDOTI operations Skype chat.

4.3 Daily Operations

The daily operating procedure is:

1. At the latest one hour before sunset, the observatory staff will carry out a review of the DDOTI installation.

   This revision has three elements. The observatory staff will:

   (a) Check that all of the control system servers are not showing errors in the web interface (see §3.1). If there are problems, attempt to solve them by pressing the “Restart” button in the web interface and giving the system a couple of minutes to restart. If that doesn’t work, seek the help of a team member.

   (b) Check that the webcams in the web interface are not showing an unusual situation.
   (c) If necessary, carry out an on-site inspection of DDOTI. For example, after a snowfall, it might not be obvious from the webcams whether snow remains on the roof of the enclosure.

   MAGUI: To interact with the COATLI/OAN control system, in regular robotic operation, the observatory staff will use the web interface described in section 3.

   If the observatory staff consider that decisions to open and close the installation can be safely taken by the control system, they will enable the supervisor by pressing the “Enable” button in web interface (see §3.1).

   If the observatory staff considers that decisions to open and close the installation cannot be safely taken by the control system, they should explicitly force the supervisor to maintain the telescope closed by pressing the “Close” button in the web interface (see §3.1)..

   The observatory staff will report the result of their inspection in the Skype chat and will indicate whether they are enabling the supervisor or forcing it to close.

2. If the supervisor is enabled and weather conditions are benign, the control system will:
   (a) Open partially to cool about half an hour before sunset;
   (b) Open completely to observe at sunset; and
   (c) Close at the end of morning astronomical twilight.

   If the supervisor is enabled and weather conditions are not benign, the control system will not open (if closed) or will close (if open).

   If the supervisor is enabled and weather conditions change from not benign to benign, the control system will open partially to cool (between half and hour before sunset and sunset) or open completely to observe (between sunset and the end of morning astronomical twilight).

3. The supervisor considers weather conditions to be *not benign* if:
   (a) It is raining or snowing.
   (b) The humidity is 85% or higher and rising or previously reached 90% and has not yet fallen below 80%.
   (c) The wind average speed has been 30 km/h or greater at any moment in the previous 30 minutes.

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

4. The observatory staff will monitor DDOTI during the night. Their primary responsibilities are:

   (a) If the observatory staff consider that decisions to open and close the installation can be safely taken by the control system, they should enable the supervisor by pressing the "Enable" button in the web interface (see §3.1) and report this in the Skype chat.

   (b) If the observatory staff consider that decisions to open and close the installation cannot be safely taken by the control system, they must explicitly force the supervisor to maintain the telescope closed by pressing the "Close" button in the web interface (see §3.1) and report this in the Skype chat.

   (c) The observatory staff should verify that the control system opens and closes as expected according to the weather conditions and the state of the supervisor. If it does not close, they should intervene as described in §4.4.

   (d) When the control system closes (at the end of the night, in response to weather conditions, or if the supervisor is forced to close), it switches the lights on for safety. At the end of the process, if the control system can determine that the enclosure closed correctly, it will switch the lights off. If it cannot, it will leave the lights switched on. Thus, if the lights are left on, this indicates that there was a problem during closing and the observatory staff should intervene as described in §4.4.

   (e) The observatory staff should report explicit changes to the supervisor state (e.g., use of the "Enable" and "Close" buttons) and any other relevant information in the Skype chat.

   As their other duties permit, the observatory staff are encouraged to report other conditions or occurrences that might degrade the ability of the telescope to observe (e.g., failures of the control system or failures to focus) in the Skype chat.

5. During the evening and night, interventions by the observatory staff are limited to whatever is necessary to close DDOTI and return it to a safe state. Once the observatory staff have intervened, DDOTI must be closed and may not open again until the next day.

6. Requests by team members for interventions beyond those needed to close DDOTI correctly will be directed to the Secretario Técnico of the observatory.

4.4 Interventions to Close

The control system should normally operate without problems and with minimal action on the part of the observatory staff beyond setting the supervisor mode. However, in the event of a failure, the observatory staff may need to intervene to close.

If the control system does not close when expected or does not close correctly, the observatory staff should:

1. First attempt to close normally:
    (a) Press the "Close" button in web interface (see §3.1). This should turn on the enclosure lights and close.
    (b) Check the web interface and webcams for success or failure.
2. If that fails, attempt an emergency close:
    (a) Press the "Emergency Close" button in the web interface (see §3.2). This should turn on the enclosure lights and close.
    (b) Check the web interface and webcams for success or failure.
3. If that fails, close the enclosure locally according to the procedure in §11.2.2.
4. If that fails, close the enclosure manually according to the procedures in §11.2.6.

4.5 Weekly Inspection

The observatory staff should carry out a physical inspection of the installations during daytime at least once per week (if weather conditions permit). The Secretario Técnico will determine the schedule for this inspection.

Safety Considerations

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

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

Requirements

You will need:

- At least two persons.
- The key to the shed (see §5.3).
- Weather conditions adequate for opening the enclosure and ascending to the platform.

Procedure

1. Verify that there is a fire extinguisher in the shed.
2. Verify that the web interface and the Skype chat are open on the control Mac in the shed. If they are not, open them by following the procedures in §3.3.
3. Inspect the inside of the shed.
4. Inspect the columns and underside of the platform.
5. Open the enclosure locally to 30 degrees using the procedure in §11.2.2.
6. One person should ascend to the platform to inspect: the electronics boxes, the instrument, the telescope, the mount, and the platform.
7. Close the enclosure locally using the procedure in §11.2.2, but leave the enclosure controller in local mode.
8. The person on the platform should inspect the enclosure roof from the inside.
9. Open the enclosure locally using the procedure in §11.2.2.
10. The person on the platform should descend.
11. Leave the enclosure controller in remote mode.
12. Report that the revision has been carried out in the Skype chat. Additionally, report any anomalies in the Skype chat.

4.6 Soft Shut-Down and Start-Up

A "soft" shut-down is appropriate for circumstances in which electrical power will continue to be supplied to DDOTI. This is the normal situation over the winter break. In this case, we can leave the computers on and rely on the electromagnet to maintain the enclosure closed.

4.6.1 Soft Shut-Down

Safety Considerations

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

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

> *The enclosure controller cabinet uses 220 VAC. Switch off the power using the main power switch on the door before working inside the cabinet (see Figure §11.9) .*

Requirements

You will need:

- At least two persons.
- The key to the shed (see §5.3).
- Weather conditions adequate for opening the enclosure and ascending to the platform.
- A clean tarpaulin, one long rope, and one short red cord You can find clean tarpaulins in the shelves next to the cabinet in the 84-cm and rope in the tool-drawer of the cabinet.

Procedure

1. Place the enclosure in local mode.

   Move the enclosure controller mode selector switch to "LOCAL" (see Figure §11.9).

2. If the weather permits, open the enclosure to 60 deg.

   Set the angle selector switch to 60 deg and then press and hold the open button until the green light goes out.

3. Both persons should ascend to the platform.

4. Move the telescope so that it is pointed vertically with the CCDs on the bottom and the focusers on the top. To move the telescope, release the brake on the mount by pressing the "BRAKE" button.

5. Press the mount emergency stop button.

6. Cover the telescope with a tarpaulin. Be very careful not to place stress on the CCDs.

   Wrap the long rope around the telescopes and tarpaulin, below the two electronics boxes but above the lower end of the telescopes and the CCDs, and then pass a loop over the telescopes, between the east and west sets, and fasten the rope on itself to prevent it slipping down. Gather the loose ends of the tarpaulin below and fasten them with a short red cord. See Figure 4.1.

   We repeat: The tarpaulin and the ropes must not come into contact with the CCDs and must not place any stress on them. The tarpaulin and ropes can only come into contact with the telescope tubes, focusers, and electronics boxes.

Figure 4.1: The telescope covered by a tarpaulin. The rope should go around the telescopes (green lines on the right, solid in front and dashed behind), below the two electronics boxes but *above the lower end of the telescopes and the CCDs*, and then over the the telescopes (red lines on the right), between the east and west sets, and fasten on itself to prevent it slipping down. The loose ends of the tarpaulin should be gathered and tied with a short red rope. The tarpaulin and the ropes *must not come into contact with the CCDs* and must not place any stress on them.

7. Descend from the platform.
8. Close the enclosure.

   Press and hold the close button until the green light goes out.
9. Switch off the enclosure controller.

   Move the main power switch on the controller door from ON to OFF. (see Figure §11.9).
10. Open the enclosure controller cabinet.
11. Engage the manual lock. This switches on the enclosure electromagnet and actuates the enclosure emergency stop buttons. This ensures that the electromagnet stays energized even if the PLC fails and that the PLC cannot attempt to open the enclosure.

    Move the manual lock switch inside the enclosure controller cabinet from OFF to ON. See Figure 11.5.
12. Close the enclosure controller cabinet.
13. Switch on the enclosure controller.

    Move the main power switch on the controller door from OFF to ON.
14. Place the enclosure in remote mode.

    Move the enclosure controller mode selector switch to "REMOTE".
15. Make sure the "PROHIBIDO EL PASO" signs are left in position at the bottom of the access ladders.
16. Leave the shed locked. Return the shed keys to the tool box (see §5.3).

4.6.2 Soft Start-Up

Safety Considerations

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

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

The enclosure controller cabinet uses 220 VAC. Switch off the power using the switch on the door before working inside the cabinet.

Requirements

You will need:

- At least two persons.
- The key to the shed (see §5.3).
- Weather conditions adequate for opening the enclosure and ascending to the platform.

Procedure

1. In the shed, switch off the enclosure controller.

   Move the main power switch on the controller door from ON to OFF (see Figure §11.9).

2. Open the enclosure controller.
3. Disengage the manual lock.

   Move the manual lock switch inside the enclosure controller from ON to OFF. See Figure 11.5.

4. Close the enclosure controller.
5. Switch on the enclosure controller.

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

6. Place the enclosure in local mode.

   Move the enclosure controller mode selector switch to "LOCAL".

7. If the weather permits, open the enclosure to 60 deg.

   Set the angle selector switch to 60 deg and then press and hold the open button until the green light goes out.

8. Both persons should ascend to the platform.
9. Remove the tarpaulin from the telescope.
10. Disengage the mount emergency stop button on the platform.
11. Move the telescope to the parked position, pointed just below the northern horizon. To move the telescope, release the brake on the mount by pressing the "BRAKE" button.
12. Descent from the platform.
13. Close the enclosure.

    Press and hold the close button until the green light goes out.

14. Place the enclosure in remote mode.

    Move the enclosure controller mode selector switch to “REMOTE”.

15. Make sure the “PROHIBIDO EL PASO” signs are left in position at the bottom of the access ladders.

16. Leave the shed locked. Return the shed keys to the tool box (see §5.3).

17. Store the tarpaulin in the shelves next to the cabinet in the 84-cm and the rope in the tool-drawer of the cabinet.

4.7 Hard Shut-Down and Start-Up

A “hard” shut-down is appropriate for circumstances in which electrical power will not continue to be supplied to DDOTI. This occurred, for example, in the evacuations for COVID-19. In this case, we must shut down the computers and cannot rely on the electromagnet to maintain the enclosure closed.

4.7.1 Hard Shut-Down

Requirements

You will need:

- Two people plus the participation of a remote team member.
- The key to the shed (see §5.3).
- Weather conditions adequate for opening the enclosure and ascending to the platform.
- The tarpaulin and ropes required for the soft shut-down (see §4.6.1).
- The two riveted plates, a riveter, and rivets.

Procedure

1. Perform a soft shut-down (see §4.6.1).
2. Communicate with the remote team member. They will:
    (a) Log into a computer on the CU, Ensenada, or OAN networks of the Instituto de Astronomía (in order to gain ssh access to the firewall):
    ```
    $ ssh user@somewhere.astrosxx.unam.mx -p 2222 -A -L 8080:localhost:8080
    ```
    (b) Log into the firewall:
    ```
    somewhere$ ssh user@ddoti.astrossp.unam.mx -p 2222 -A -L 8080:localhost:80
    ```

(c) Halt the computer `access`:

```
firewall$ ssh user@10.0.1.2
access$ sudo shutdown -h -u now
```

(d) Switch off `access` from `ibb-127`.

```
firewall$ telnet 10.0.1.5
> get device #1
> set device #1 outlet <n> off
...
```

To log out of the iBootBar, use CTRL-] and then `quit`.

(e) Halt the computers `services`, `control`, `c0`, `d0`, `d1`, `d2`, `d3`, `e0`, `e1`, `e2`, `e3`:

```
firewall$ ssh ddoti@10.0.1.3
services$ sudo haltsoon
```

(f) Switch off `instrument`, `platform`, `services`, `control`, and `mount` from `ibb-127`.

```
$ ssh user@ddoti.astrossp.unam.mx -p 2222
firewall$ telnet 10.0.1.5
> get device #1
> set device #1 outlet <n> off
...
```

To log out of the iBootBar, use CTRL-] and then `quit`.

(g) Halt the computer `firewall`.

```
$ ssh user@ddoti.astrossp.unam.mx -p 2222 -L8080:localhost:80
```

Open a browser to `http://localhost:8080/` and halt the firewall from the web interface (select "Halt System" on the "Diagnostics" menu).

3. Switch off the two UPSes, the 127 V UPS and the 220 V UPS.

   On both UPSes, press the power button on the front panel for three seconds. The UPS will start to beep and will then switch off.

4. Switch off the power supply to the two UPSes.

   Open the breaker panel on the wall next to the door. Switch off circuits A and B.

5. Install the two riveted two plates, one on each side of the enclosure, that hold it closed. See Figure 4.2.

4.7.2 Hard Start-Up

Requirements

You will need:

- At least two persons.
- The key to the shed (see §5.3).
- Weather conditions adequate for opening the enclosure and ascending to the platform.
- A drill (to remove the riveted plates).

Figure 4.2: One of the riveted plates that hold the enclosure closed when power is switched off.

Procedure

1. Remove the two riveted two plates, one on each side of the enclosure, that hold it closed. See Figure 4.2.
2. Switch on the power supply to the two UPSes.

   Open the breaker panel on the wall next to the door. Switch on circuits A and B.
3. Switch on the two UPSes, the 127 V UPS and the 220 V UPS.

   On both UPSes, press the power button on the front panel for at least one second.
4. Switch on the computer `access`.

   Press the button on the rear right of the computer.
5. Communicate with the remote team member. They will:

   (a) Switch on the computers `instrument`, `platform`, `services`, `control`, and `access` from `ibb-127`.

   (b) Verify that all of the computers boot.
6. Perform a soft start-up (see §4.6.2).

Part II

Installations

Chapter 5

Buildings and Structures

The DDOTI installation is spread through four buildings or structures: the ground-floor of the 84-cm telescope building; the shed; the access walkways; and the tower, platform, and enclosure.

5.1 Civil Works

The shed, access, and tower are constructed on open space to the north of the 84-cm building. The buildings and structures were constructed in 2016 and the enclosure installed in 2017.

Figures 5.2 to 5.4 show the 2016 design drawings for the shed, access staircase and walkways, and the concrete columns that support the platform and telescope. The original design was largely based on that of COATLI, but with simplifications for the easier site and a slightly different telescope column. The DDOTI telescope column extended 40 cm above the platform floor (the COATLI column is flush with the platform floor) to reduce the height of the steel pier and increase its stability. Figure 5.5 shows the ASTELCO ARTS platform and the ASTELCO steel pillar mounted on the concrete columns (although this drawing is for COATLI, the DDOTI enclosure is identical except for the perforation in the platform floor). Figure 5.6 shows the ASTELCO pier. The center of rotation of the mount axes is about 6.5 meters above the ground level.

During the summer of 2016, the design of the telescope column was changed without this change being adequately communicated to the project. The telescope concrete column originally was designed with three parts, each square in cross section and tapering from 1.8, 1.2, and 0.6 meters to a side, like the COATLI column. The design was changed so that the middle and upper sections were uniformly 1.0 meters to a side (although some erroneous vestiges of the original column remain in Figures 5.2). Fortunately, this change was caught in time to allow the platform to be modified.

The original design was intended to be oriented with the long-axis of the enclosure aligned with geographic N-S (see Figure 5.3). However, when the site was laid out, the

Figure 5.1: The COATLI/OAN and DDOTI/OAN installations seen looking west. On the left is the COATLI/OAN shed, access staircase and walkways, tower, platform, and enclosure. In the middle is is 84-cm telescope building. On the right is the DDOTI/OAN tower, platform, enclosure, and shed. Photographer: Fernando Angeles.

surveyor made a sign error in the magnetic deviation. Instead of being aligned with geographic north (11 degrees west of magnetic north) the structures were aligned 22 degrees east of geographic north (11 degrees east of magnetic north). This error was not detected until the lower part of the telescope column had been poured. Fortunately, the column and enclosure could still accommodate the pier, mount, and telescopes.

5.2 Ground-Floor of the 84-cm Telescope Building

We use the ground-floor of the 84-cm telescope building for storage of equipment and as a temporary work space.

DDOTI tools and equipment are stored mainly in the equipment cabinet. They are to be used only for maintenance of COATLI and DDOTI and must be returned to the cabinet at the end of the maintenance procedure.

ASTELCO tools and equipment are stored in a locked metal box and are only to be used under the supervision of project or ASTELCO personnel.

5.3 Shed

The shed contains infrastructure and control electronics.

The door to the shed should be left locked.

The key should be hung on the shelves next to the cabinet in the ground-floor of the 84-cm telescope building (see Figure 5.7).

The temperature in the shed it controlled by a heater and a pair of fans (one inlet and one exhaust). The fans are controlled by a Lux WIN100 thermostat and are set to turn on at 10 C. The internal thermostat of the heater is set to its minimum level.

5.4 Bibliography

- "Building 2016 Drawing 1 - Columns", UNAM.
- "Building 2016 Drawing 2 - Plan and Location", UNAM.
- "Building 2015 Drawing 3 - Shed", UNAM.
- "ASTELCO Drawing 0500 – Platform", ASTELCO.
- "ASTELCO Drawing 5572 – Tower Mounting Plate", ASTELCO.
- "ASTELCO Drawing 6610 – Tower, Platform, and Enclosure", ASTELCO.
- "ASTELCO Drawing 6658 – Tower, Platform, and Enclosuure", ASTELCO.
- "ASTELCO Drawing 6662 – Interface", ASTELCO.

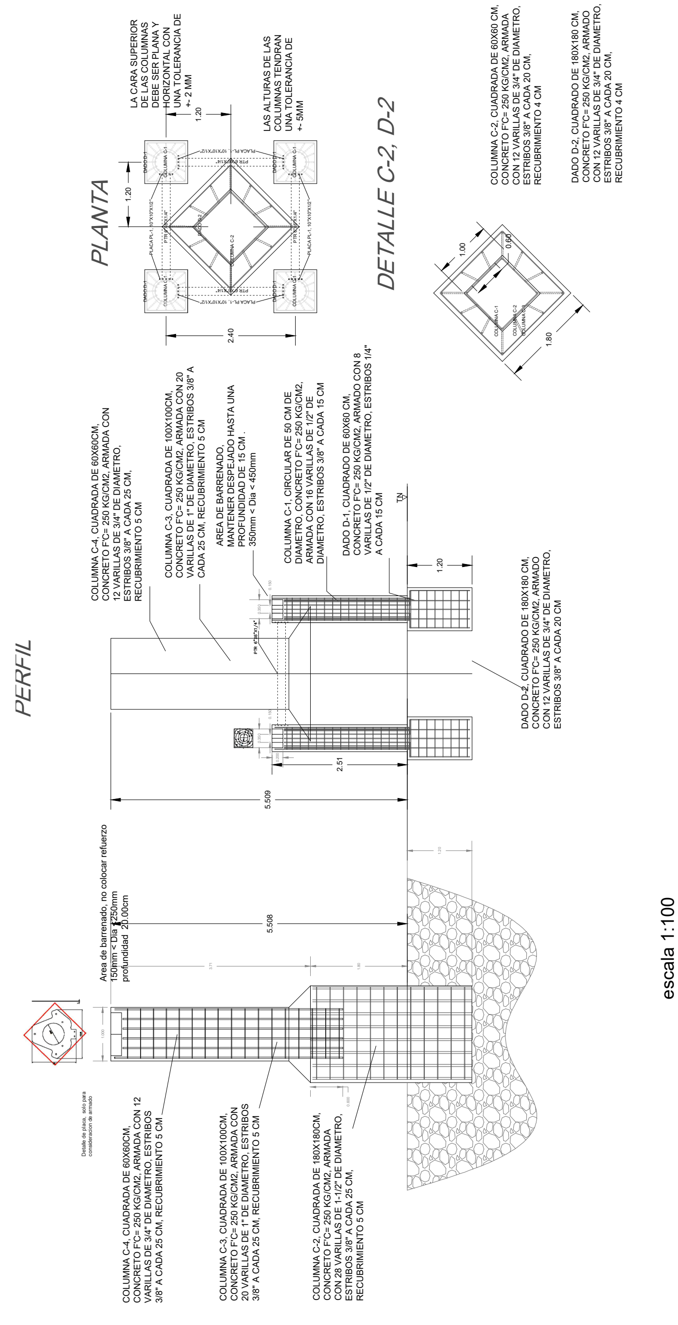

Figure 5.2: DDOTI original 2016 design drawing (1 of 3).

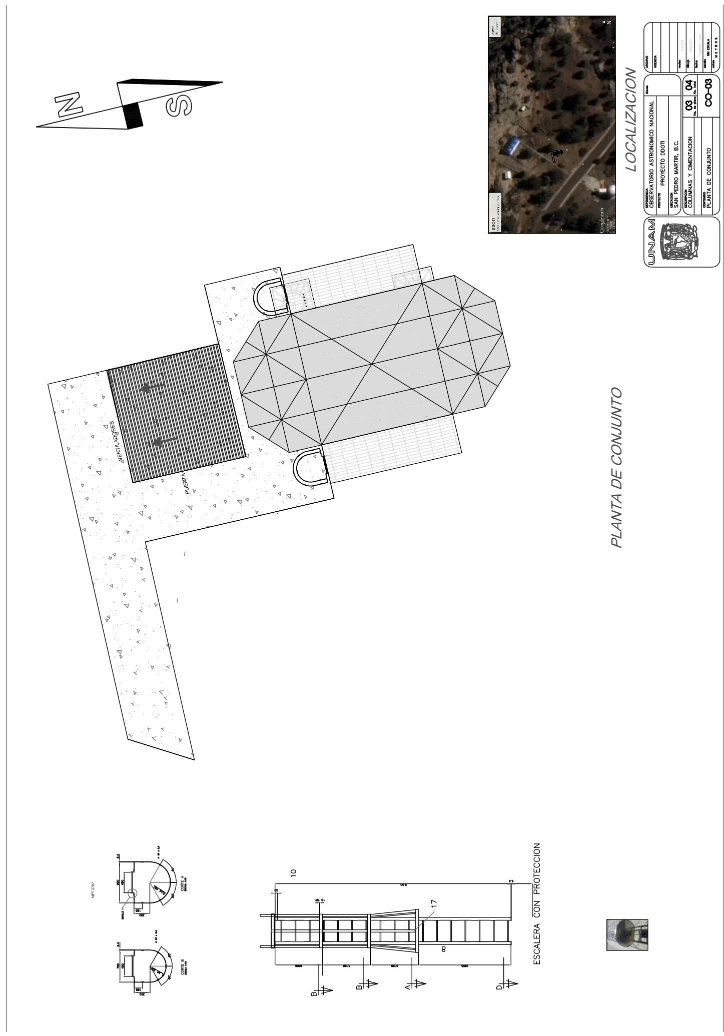

Figure 5.3: DDOTI original 2016 design drawing (2 of 3). Note that the actual installation is rotated approximately 22 degrees east of the orientation shown here.

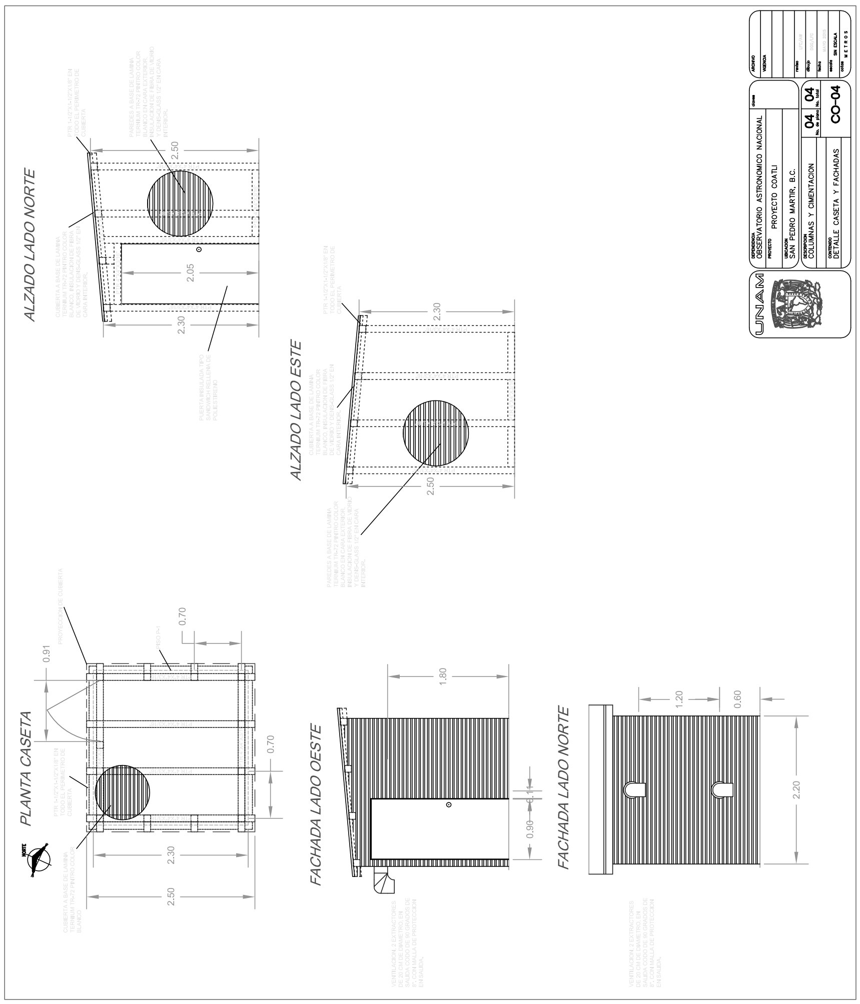

Figure 5.4: DDOTI original 2016 design drawing (3 of 3).

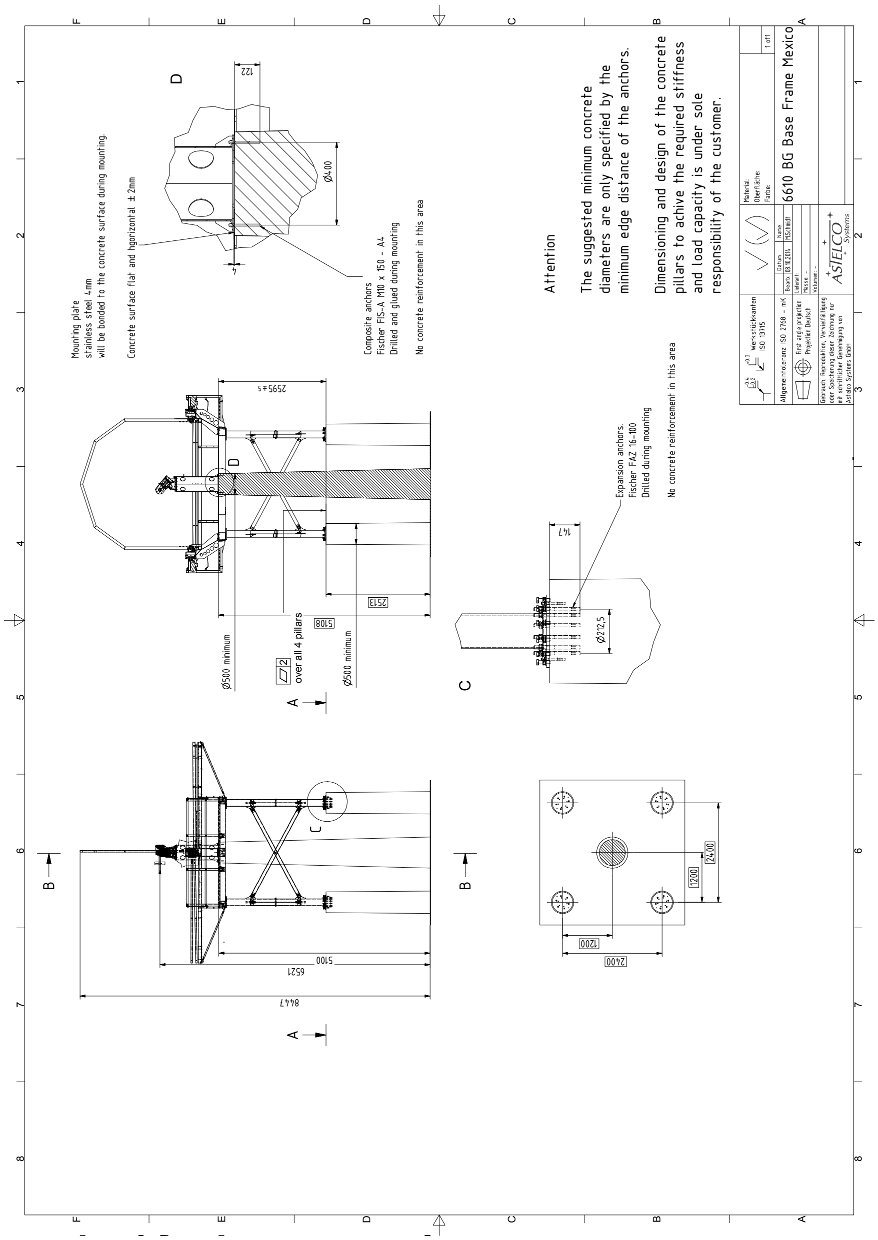

Figure 5.5: DDOTI ASTELCO platform and telescope pier (for COATLI).

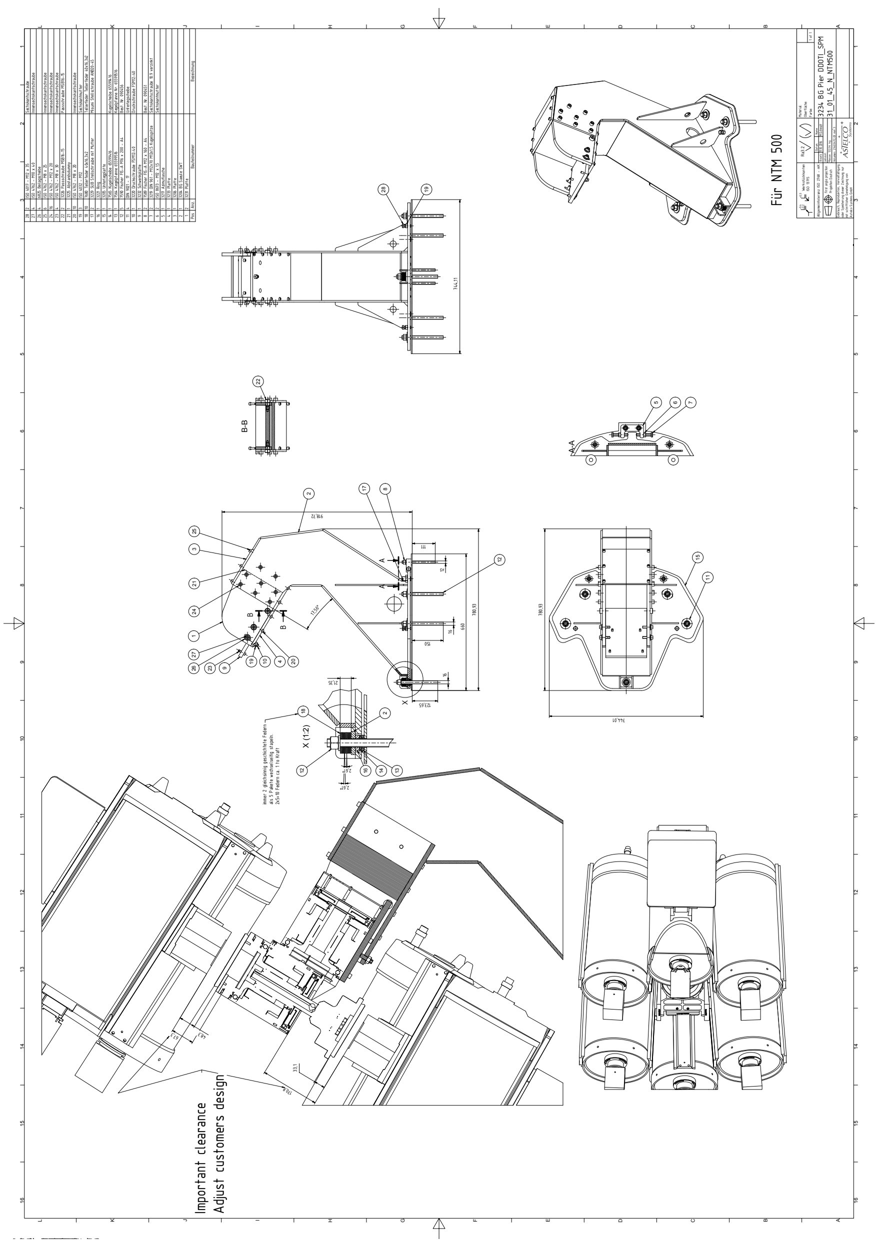

Figure 5.6: DDOTI ASTELCO pier.

Figure 5.7: The shed key is hung on the shelves next to the cabinet in the ground floor of the 84-cm telescope building.

- "ASTELCO Drawing 3205 – Pier Mounting Plate", ASTELCO.
- "ASTELCO Drawing 3234 – Pier", ASTELCO.
- "Lux WIN100 Manual", Lux.

Chapter 6

Electrical Power

This chapter describes the electrical power system in the DDOTI installation. The electrical grounding system is described in Chapter 7.

Figure 6.1 shows a schematic of the electrical power system. The sections below describe each part in detail.

TODO: Don't know which DDOTI circuits are L1-N, L2-N, or L3-N.

6.1 External Mains Supply

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

The DDOTI installation is connected to the OAN electricity supply via an isolation transformer (on the north wall of the shed). This spur carries three phases (L1, L2, and L3) and neutral (N). The phases are protected by a 70 A breaker on a 30 kVA main breaker box inside the shed. The main breaker box is shown in Figure 6.2.

6.2 Circuits

Figure 6.3 shows the circuit box in the shed. The master breaker is 80 A. The electricity supply is divided between the circuits listed in Table 6.1, 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 220 V circuit, with 220 V between live and neutral and with neutral nominally at the ground level.)

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.

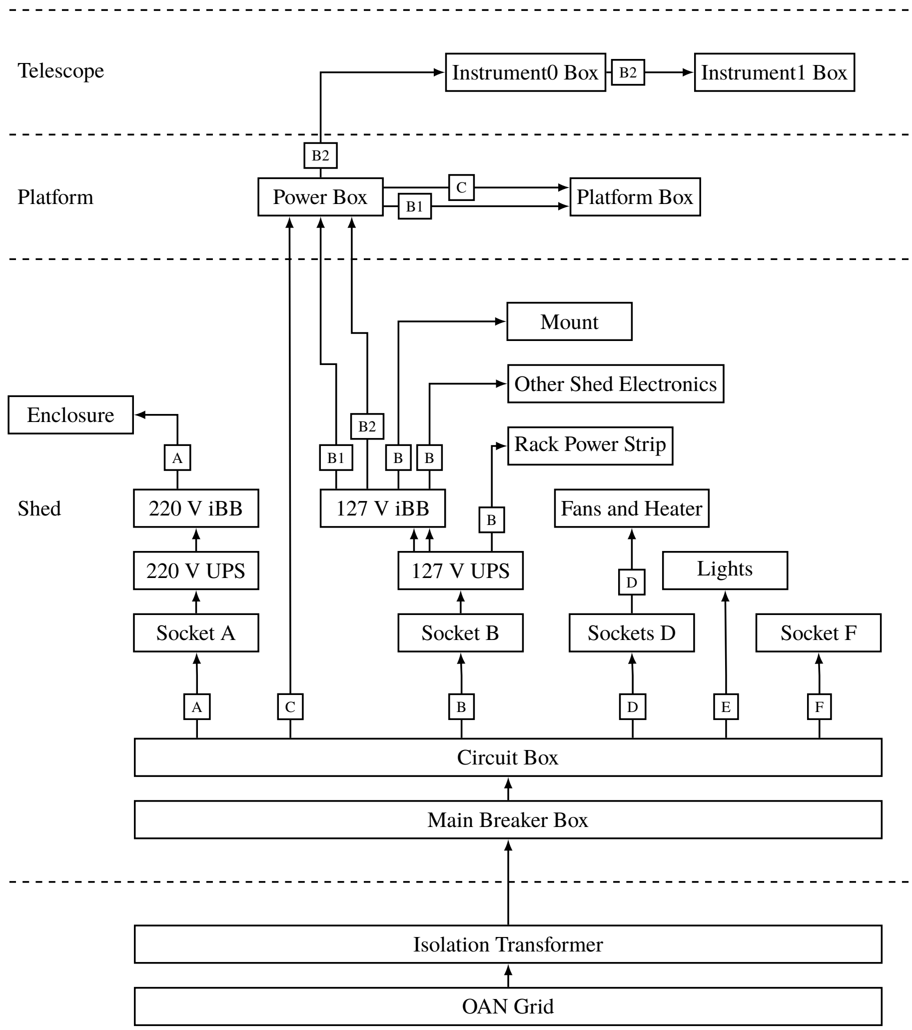

Figure 6.1: Schematic of the Distribution of Electrical Power. The letters A to F refer to circuits.

Figure 6.2: The main breaker box in shed.

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

6.3 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.

6.3.1 220 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 6.4 shows a schematic of the electrical power connections.

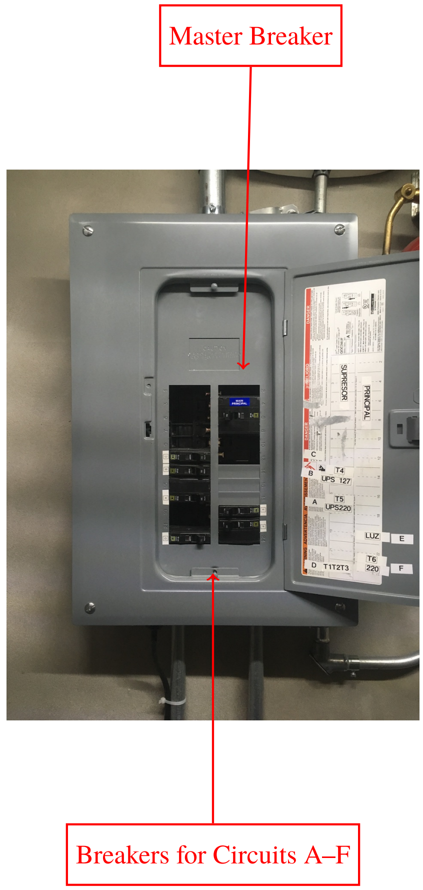

Figure 6.3: The circuit box the DDOTI shed. The master breaker is at the top. The breakers for circuits A–F are at the bottom.

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.

6.3.2 127 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 6.5 shows a schematic of the electrical power connections.

Table 6.1: Circuits

Circuit	Connection	Voltage	Breaker	Use
Master		220 V	70 A	Master for all circuits
A	L1-L2	220 V	30 A	Wall socket in shed for 220 V UPS (T5 1× NEMA L6-20R)
B	L2-N	127 V	30 A	Wall socket in shed for 127 V UPS (T4 1× NEMA L5-30R)
C	L1-N	127 V	15 A	Platform
D	L2-N	127 V	15 A	Wall sockets in shed (T1/T2/T3 2× NEMA 5-15R)
E	L2-N	127 V	15 A	Lights in shed
F	L1-L2	220 V	30 A	Wall socket in shed (T6 1× NEMA L6-20R)

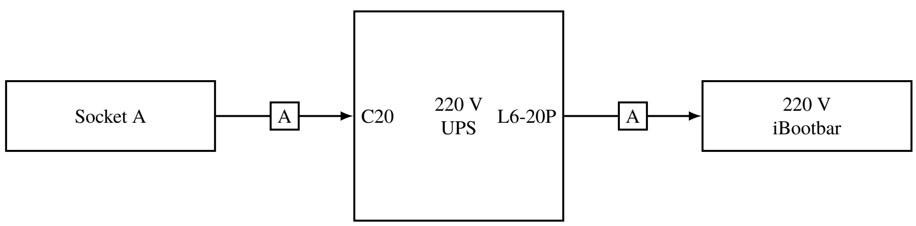

Figure 6.4: Schematic of the Electrical Power Connections To and From the 220 V UPS

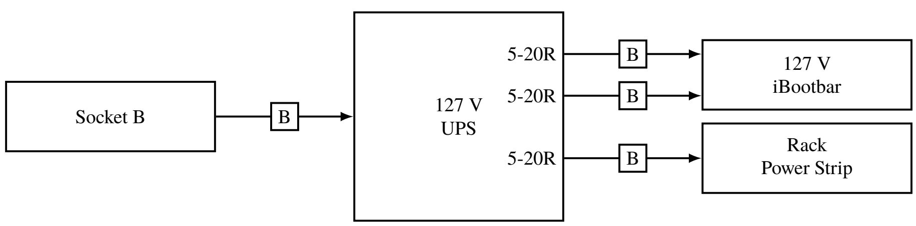

Figure 6.5: Schematic of the Electrical Power Connections To and From the 127 V UPS

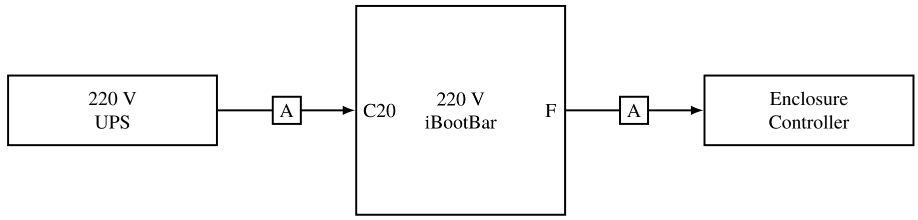

Figure 6.6: Schematic of the Electrical Power Connections To and From the 220 V iBootBar

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. Another NEMA 5-20R output socket is connected to the rack power strip.

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.

6.4 iBootBars

There are two iBootBars in the rack in the shed, one 127 V and one 220 V. Both are the connected to the corresponding 127 V and 220 V UPS units. They are physically located in the rear of the rack towards the top.

6.4.1 220 V iBootBar

This is a DataProbe iBootBar iBB-C20. Figure 6.6 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 6.2. The iBootBar can supply up to 20 A.

The iBootBar is connected to the LAN at the address given in Table 8.1. The HTTP and telnet account names and passwords are “ddoti” and “ddoti”. The HTTP interface is available from the DDOTI web interface home page.

6.4.2 127 V iBootBar

This is a DataProbe iBootBar iBB-2N15-M. Figure 6.7 shows a schematic of the electrical power connections.

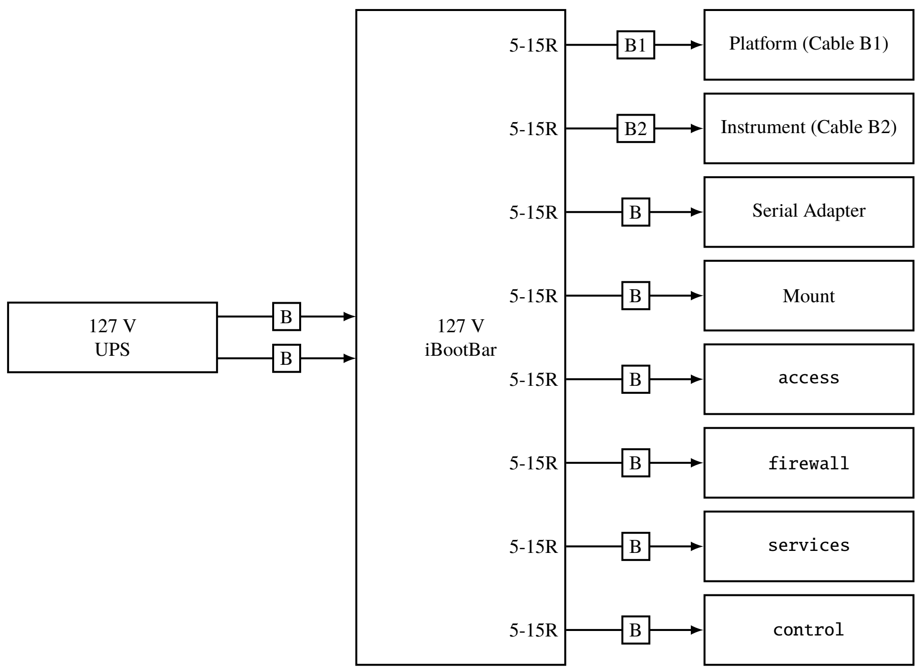

Figure 6.7: Schematic of the Electrical Power Connections To and From the 127 V iBootBar

Table 6.2: iBootBar Output Sockets

Socket	220 V iBootBar	127 V iBootBar
1	Enclosure	Platform (Cable B1)
2	-	`access`
3	-	Instrument (Cable B2)
5	-	Mount
5	-	`firewall`
6	-	`services`
7	-	`control`
8	-	`serial`

Table 6.3: Fuzes

Location	Circuit	Fuze
Power Box	B1	3 A
Power Box	B2	15 A
Power Box	C	15 A
Platform Box	B1	3 A
Instrument0 Box	B2	3 A
Instrument1 Box	B2	3 A

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 6.2. 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 8.1. The HTTP and telnet account names and passwords are “ddoti” and “ddoti”. The HTTP interface is available from the DDOTI web interface home page.

The modem facility is not used.

TODO: Configure watchdog.

6.5 Rack Power Strip

At the rear of the rack, adjacent to the 127 V iBootBar, is a 8-way NEMA 5-15R power strip. The power strip powers the computers and network equipment in the rack. The entire power strip, and hence all of the connected equipment, is directly supplied by the 127 V UPS.

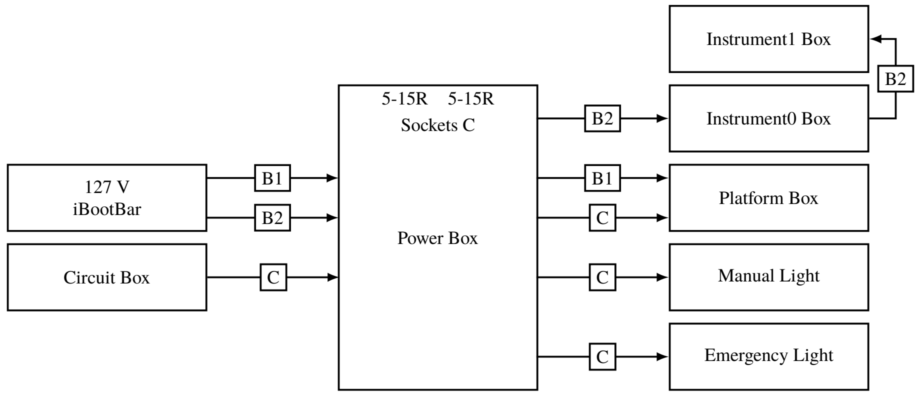

Figure 6.8: Schematic of the Electrical Power Connections To and From the Power Box

6.6 Power Box

The power box is a dumb electrical distribution box located on the platform. Figure 6.8 shows a schematic of the electrical power connections to Power Box.

The power box 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 Box E on the telescope. Circuit C is used to power the two NEMA 5-15R plugs on the power box (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 the power box.

The three circuits are switched and fuzed (see Table 6.3) at the entrance to the power box.

The manually-controlled light is hardwired to the platform box and has a manual switch on the power box.

6.7 Platform Box

The platform box is a smart control box located on the platform. Figure 6.9 shows a schematic of the electrical power connections to the platform box.

The platform box 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.

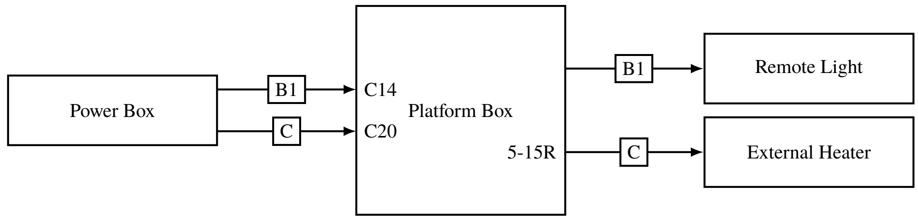

Figure 6.9: Schematic of the Electrical Power Connections To and From the Platform Box

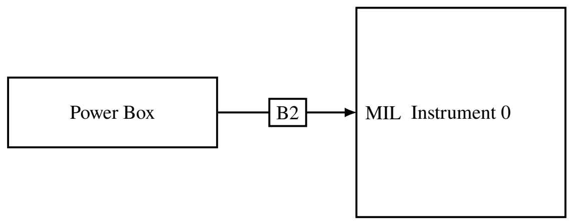

Figure 6.10: Schematic of the Electrical Power Connections To The Instrument0 Box

The connection to circuit B1 is via a cable with a C13 plug that connects to the C14 input socket on the platform box. The cable is hardwired to the power box.

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

The connections to the manually/electronically-controlled light and heater are via the two NEMA 5-15R sockets on the platform box. The light is controlled both by a relay and by a manual switch on the platform box (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 (see Table 6.3) at the entrance to the platform box.

6.8 Instrument0 Box

The instrument0 box is a smart control box located on the DDOTI telescopes. Figure 6.10 shows a schematic of the electrical power connections to the instrument0 box.

The instrument 0 box 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 via a cable with a MIL plug that connects to the MIL input socket on Box D. The cable is hardwired to the power box. The cable passes from the power box up onto the telescope through the mount and the custom connector.

Circuit B2 is switched and fuzed (see Table 6.3) at the entrance to the instrument0 box.

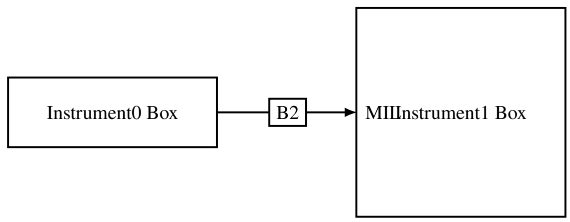

Figure 6.11: Schematic of the Electrical Power Connections To Instrument1 Box

6.9 The Instrument1 Box

The instrument1 box is a smart control box located on the pillar of the COATLI telescope. Figure 6.11 shows a schematic of the electrical power connections to Box E.

The instrument1 box 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 via a cable with a MIL plug that connects to the MIL input socket on the instrument1 box. The cable passes through the mount declination bearing to the instrument0 box and has an inline C13/C14 connector close to instrument0 box to allow instrument0 to be demounted.

Circuit B2 is switched and fuzed (see Table 6.3) at the entrance to Box E.

6.10 Trouble-Shooting

- Check cables. Has one been disconnected or worked itself lose?
- Check switches. Is the equipment switched on? The smart boxes have switch for their regulated input (circuits B, B1, or B2). The power box 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? See Table 6.3.
- 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 main breaker box. Has it tripped?
- Check the equipment has not failed.

6.11 Bibliography

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

Chapter 7

Electrical Grounding

This chapter describes the electrical grounding system in the DDOTI installation. The electrical power system is described in Chapter 6.

TODO: Measure DDOTI ground resistance.

7.1 Grounding Rods

We have installed a network of ground rods to the east of shed. 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 shed.

TODO: Photo.

7.2 Grounding System

Figure 7.1 shows a schematic of the electrical grounding system. These grounding cables from the grounding rods are connected at a protected grounding bar on the east side of the shed. This is the "tau-point" of the grounding system. From here, spurs are used to ground the electrical system in the shed, 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.

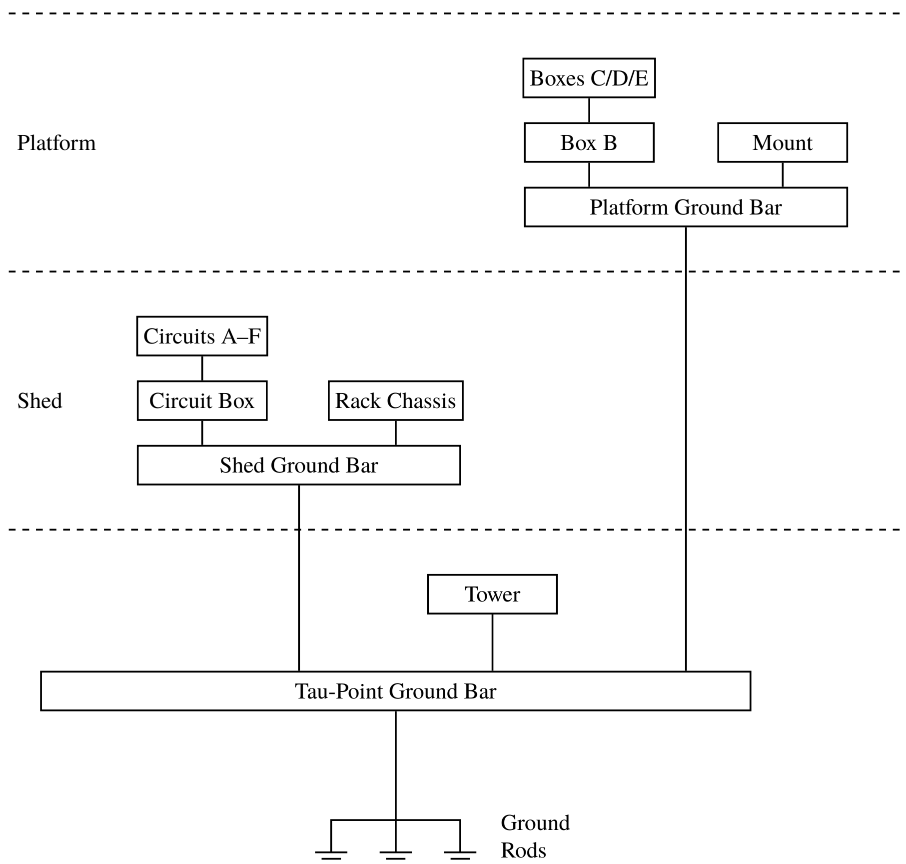

Figure 7.1: Schematic of the Electrical Grounding System

The Astelco controllers in the shed are connected to the platform and mount. There are undoubtedly ground loops through these connections. However, the connections from the platform to the tau-point is through a heavy-gauge cable, and this is likely to mitigate these ground loops.

Chapter 8

Network

TODO: haltsoon and rebootsoon

8.1 WAN and LAN Addresses

The observatory uses 132.248.4/24 as a WAN. DDOTI uses 10.0.1/24 as a LAN. The firewall computer in the rack in the shed serves as a firewall and router between the WAN and the LAN. The addresses of the equipment are given in Table 8.1.

8.2 Port Filtering and Forwarding

The observatory firewall filters access to `ddoti.astrossp.unam.mx` (132.248.4.24) from outside the observatory WAN except for ports TCP/22 (SSH), TCP/80 (HTTP), and TCP/5351 (GCN/TAN).

The firewall forwards certain TCP ports from its WAN address to hosts on the LAN. These are listed in Table 8.2. The firewall restricts access on most of these port, with only the main ssh port being open to all hosts.

8.3 Access

All of the hosts have an account ddoti with password ddoti. Local and ssh access is permitted on the Linux machines, but only local access is permitted on the `access`.

SSH access to `access` is limited to the accounts of project staff and the OAN/SPM network maintenance staff. Thus, remote access is accomplished by first logging into `access` using a non-ddoti account and then logging into a local machine using the ddoti account.

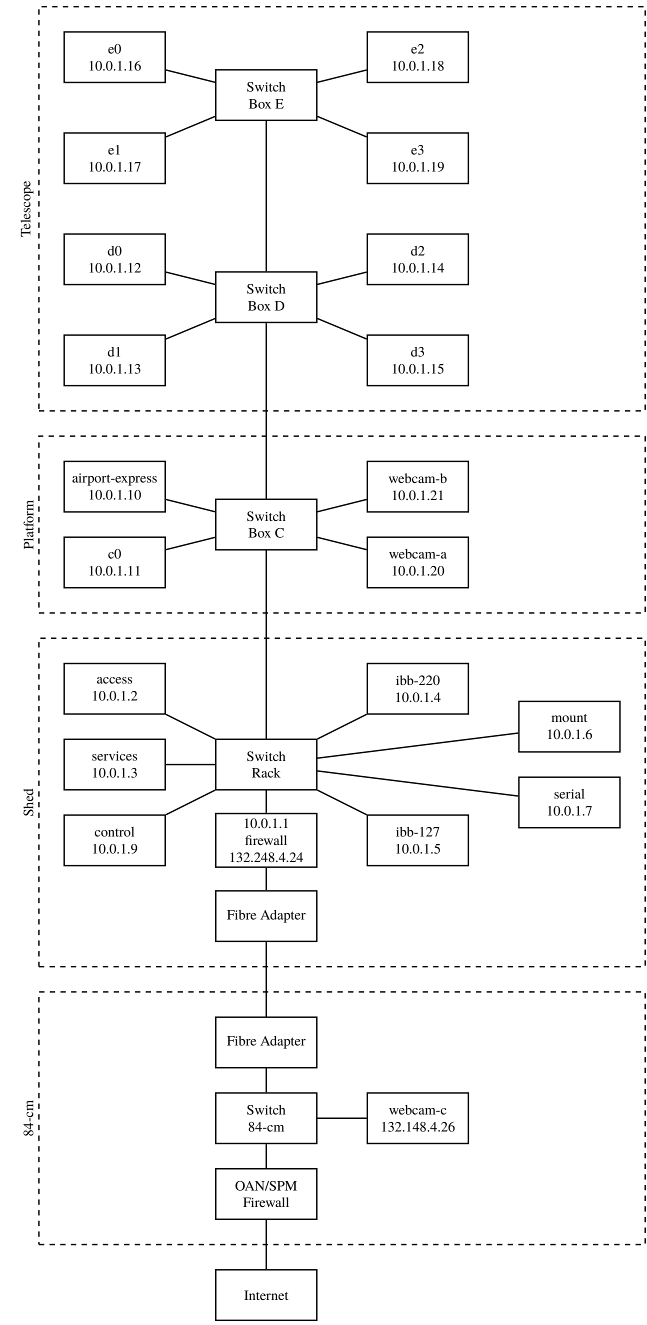

Figure 8.1: Network Physical Topology

Table 8.1: Addresses

Address	Name	Equipment	Location
132.248.4.24	`firewall`	HP Server	Rack
10.0.1.1	`firewall`	HP Server	Rack
10.0.1.2	`access`	Mac mini	Rack
10.0.1.3	`services`	HP Server	Rack
10.0.1.4	`ibb-220`	iBootBar 220 V	Rack
10.0.1.5	`ibb-127`	iBootBar 127 V	Rack
10.0.1.6	`mount`	Mount Controller	Rack
10.0.1.7	`serial`	HP Adapter	Shed Wall
10.0.1.8	`pc`	PC	Not currently installed
10.0.1.9	`control`	Linux Server	Rack
10.0.1.10	`airport-express`	Airport Express	Box C
10.0.1.11	`c0`	Minnowboard Turbot	Box C
10.0.1.12	`d0`	Minnowboard Turbot	Box D
10.0.1.13	`d1`	Minnowboard Turbot	Box D
10.0.1.14	`d2`	Minnowboard Turbot	Box D
10.0.1.15	`d3`	Minnowboard Turbot	Box D
10.0.1.16	`e0`	Minnowboard Turbot	Box E
10.0.1.17	`e1`	Minnowboard Turbot	Box E
10.0.1.18	`e2`	Minnowboard Turbot	Box E
10.0.1.19	`e3`	Minnowboard Turbot	Box E
10.0.1.20	`webcam-a`	Webcam	Platform (above Box B)
10.0.1.21	`webcam-b`	Webcam	Platform (above Box C)
132.248.4.26	`webcam-c`	Webcam	84-cm (NE side)

Table 8.2: Ports Forwarded from the WAN to the LAN

Port on WAN	Host on LAN	Port on LAN	Notes
22	`access`	22	Main ssh access.
80	`services`	80	Web page and interface.
873	`services`	5349	rsync.
2222	`firewall`	22	Backup ssh access.
5351	`services`	5351	GCN/TAN notices.

We recommend using an SSH public key to avoid needing to type passwords repeatedly. If you do not have a key, you can generate one by running these commands on your computer:

```
mkdir ~/.ssh
chmod 700 ~/.ssh
ssh-keygen -t rsa
```

Once you have generated a key, you can copy it to `access` using:

```
ssh-copy-id user@ddoti.astrossp.unam.mx
```

You should then by able to ssh to `access` without having to type your password.

Having copied the key to access, you can copy it to the ddoti accounts on the other computers on the LAN by running this command on `access`:

```
ssh-copy-id-to-lan
```

To use your key this, you should make sure that the key is forwarded by using the `-A` option to ssh when you connect to `access` or by adding the `ForwardAgent yes` option to your `.ssh/config` file.

8.4 Wireless Networks

There are two wireless networks for general use. The access Mac in the shed implements `apddoti0` and the Airport Extreme in Box C on the platform implements `apddoti1`. The password is “keplerxv”.

8.5 DHCP

The firewall runs a DHCP server that allocates addresses in the range 10.0.1.100 to 10.0.1.200.

Chapter 9

Lights

This chapter describes the lighting in the DDOTI installation.

9.1 Shed Lights

The shed has standard manual lights controlled by a switch just inside the door.

The shed lights are on circuit E and are backed up by emergency lighting that switches on if the power fails.

9.2 Platform Manual Lights

The platform manual lights controlled by a switch on Box B by the usual entrance to the platform. The lights are a small LED panel supplied by a 12 VDC power supply in Box B.

The platform manual lights are on circuit C and are backed up by emergency lighting that switches on if the power fails.

9.3 Platform Remote-Controlled Lights

9.3.1 Hardware

The platform remote-controlled lights controlled by Box C. The lights are a small LED panel supplied by a 12 VDC power supply in Box C. Electrically, the supply is switched by a H-bridge controlled by GPIO pin 481 on `c0`.

The platform remote-controlled lights are on circuit B1.

9.3.2 Control

The `lights` server for the remote-controlled lights runs on `c0`.

The server starts automatically after `c0` boots, but if necessary it can be stopped, started, or restarted explicitly by issing the following shell commands on `c0`:

- sudo stopserver lights
- sudo startserver lights
- sudo restartserver lights

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

- `request lights status`

  Show the status of the server.

  Obtain the values of the status data from the server and print them to stdout.

- `request lights initialize`

  Initialize the server and hardware. As part of the process of initializing, the lights will switch off.

- `request lights reset`

  Attempt to recover from an error.

- `request lights stop`

  Attempt to stop the current activity.

- `request lights switchon`

  Switch the lights on.

- `request lights switchoff`

  Switch the lights off.

There are buttons to control the lights on the web interface. These are useful for illuminating the platform to allow inspection by the webcams.

Chapter 10

Webcams

TODO: Photos of the webcams.

TODO: Photos with the webcams.

DDOTI uses webcams to monitor the platform and enclosure from inside and out.

10.1 Platform Webcams

There are two webcams installed on short posts on the platform. Webcam A is installed above Box B and webcam B is installed above Box C. Figures 10.1 and 10.2 show typical daytime views from webcams A and B. Between them, they can see all of the platform. The platform remote light allow the webcams to monitor the platform even at night. The webcams are Vivotek FE8174V with a 180 degree field of view. This model has an IP66-rated weatherproof housing and can operate down to −40 C.

The platform webcams are on the LAN at the addresses given in Table 8.1. The web interfaces can be accessed with the "ddoti" account with password "ddoti".

10.2 External

Webcam C is installed on the outside wall of the 84-cm, above the balcony, giving a view of the DDOTI enclosure. An electronic zoom of webcam C, that shows the enclosure in more detail, is known as webcam CZ. Figures 10.3 and 10.4 show typical daytime views from webcams C and CZ. The webcam is a Vivotek MD7560D with a 98×73 degree field of view lens. This model has an IP67-rated weatherproof housing and can operate down to −25 C.

The external webcam in on the observatory public network at the address given in Table 8.1. The web interfaces can be accessed with the "ddoti" account with password "ddoti".

10.3 Bibliography

- “FE8174/74V Data Sheet”, Vivotek.
- “FE8174V User’s Manual”, Vivotek.
- “MD7530/60 MD8562/62D Alignment”, Vivotek.
- “MD7560/60D Data Sheet”, Vivotek.
- “MD7530/7530D MD7560/7560D User’s Manual”, Vivotek.
- “MD7530/7530D MD7560/7560D Quick Installation Guide”, Vivotek.

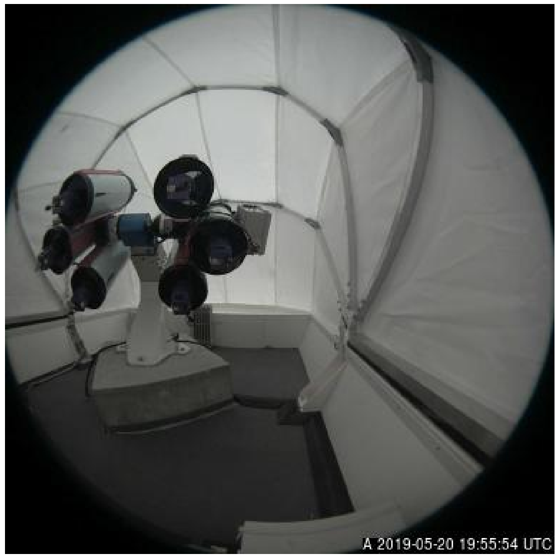

Figure 10.1: Typical daytime view from DDOTI webcam A.

Figure 10.2: Typical daytime view from DDOTI webcam B.

Figure 10.3: Typical daytime view from DDOTI webcam C.

Figure 10.4: Typical daytime view from DDOTI webcam CZ (en electronic zoom of webcam C).

Chapter 11

Enclosure

11.1 Description

DDOTI is protected by an ASTELCO ARTS enclosure, shown in Figure 11.1. The ARTS enclosure consists of a tower, a platform with balconies, and set of folding arches that support a flexible waterproof fabric roof.

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

The enclosure can open to 60, 90, 120, and 180 deg and can be controlled locally or remotely. The enclosure is oriented NNE to SSW and opens from the NNE towards the SSW.

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

The controller for the enclosure, shown in Figure 11.2 is located in a cabinet in the shed. The enclosure is opened and closed by two geared motors, one on each balcony. The position is sensed by proximity sensors on the bearings (fully open and partially open positions) and at the point that the last arch closes (closed position). 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 has an electromagnetic lock, shown in Figure 11.4, 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 electromagnet that holds the enclosure closed is normally activated by the PLC. However, we have modified the controller to add a switch inside the controller that switches on the enclosure electromagnet and actuates the enclosure emergency stop

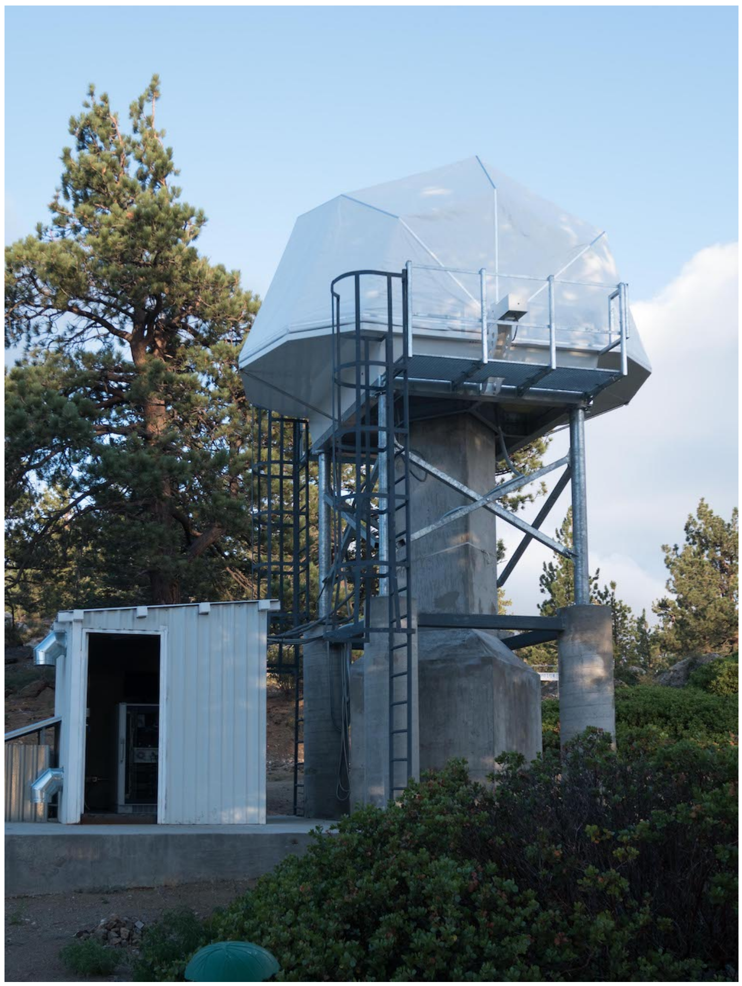

Figure 11.1: The DDOTI enclosure.

Figure 11.2: The enclosure controller in the shed.

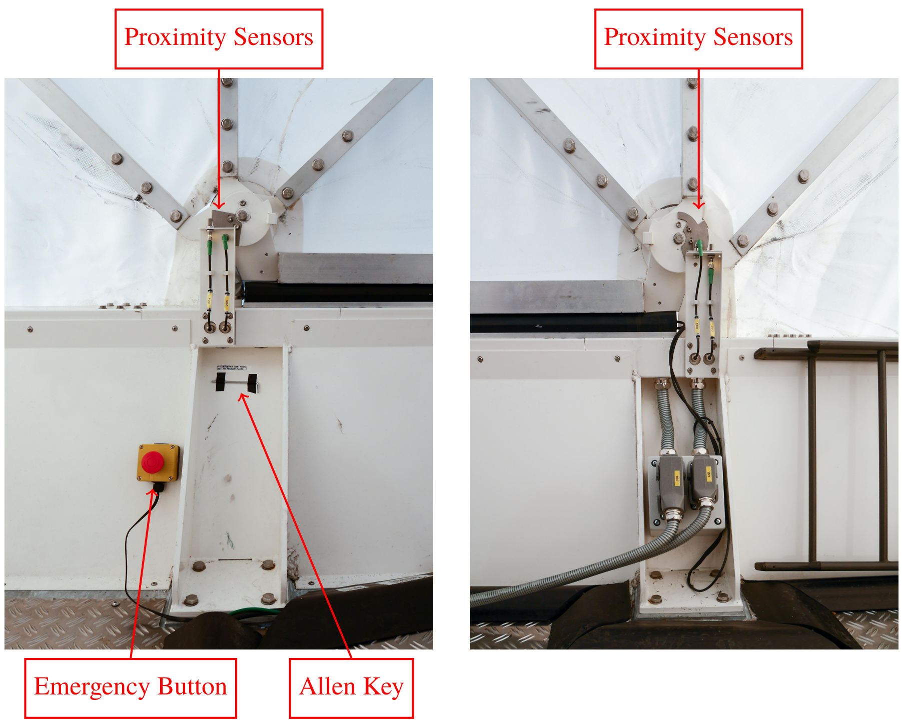

Figure 11.3: The north (left) and south (right) bearings for the folding roof. Notice the proximity sensors, the emergency stop button for the mount, and the Allen key to escape in an emergency. The COATLI installation is shown, but the DDOTI installation is similar.

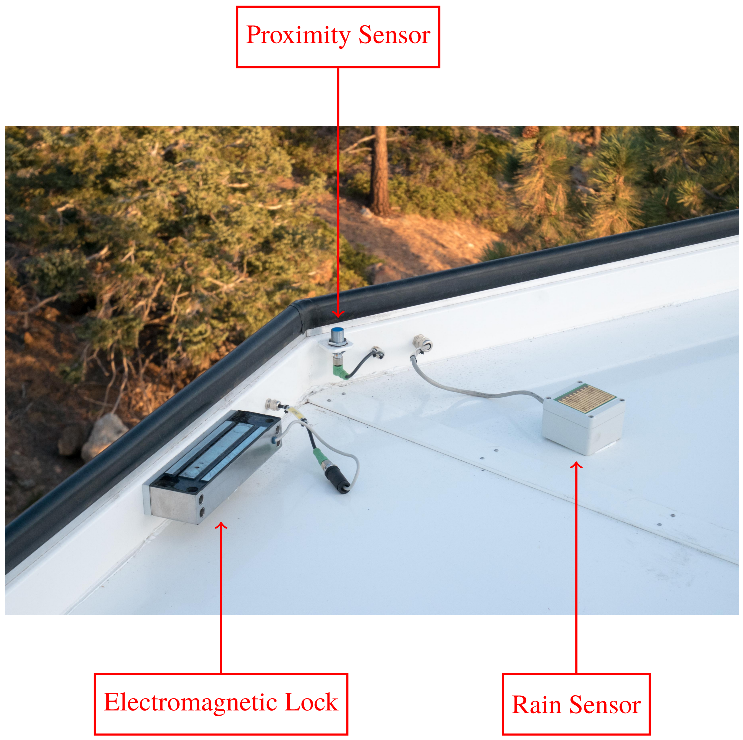

Figure 11.4: The enclosure electromagnetic lock (left), 0 deg proximity sensor (the cylinder with the blue top in the center), and rain sensor (the white box with the copper contacts on the right). The COATLI installation is shown, but the DDOTI installation is similar.

buttons. This ensures that the electromagnet stays energized even if the PLC fails and that the PLC cannot attempt to open the enclosure. This switch is shown in Figure 11.5.

The enclosure has a rain sensor, also shown in Figure 11.4. 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. This avoids the enclosure closing on someone or something. 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 11.7. 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 11.8, are not load bearing and are marked with "no step" signs. If you attempt to step on these, you will likely fall.

> *Do not step on the elevated areas at the ends of the platform! If need be, you can put your weight on the beams, but not on the panels.*

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 11.3.

The enclosure controller can be in remote or local mode. The mode is selected by the switch on the door of the enclosure controller in the shed (see Figure 11.9). In remote mode:

- The switches on the enclosure controller to open and close the enclosure and to reset errors are deactivated.
- The robotic control system can open and close.
- The enclosure will close automatically if the rain sensor gets wet.

In local mode:

- The switches on the enclosure controller to open and close the enclosure and to reset errors are active.
- The robotic control system cannot open or close.
- The enclosure will not close if the rain sensor gets wet.

If there is an error, the red error button on the enclosure controller will flash or be constantly lit. The interpretation depends on whether the controller is in local mode or remote more.

In remote mode, the red button will be constantly illuminated for all detected errors. The specific error can be diagnosed either by software (via the inputs to the ADAM module) or by switching to local mode.

In local mode, the following error states are distinguished:

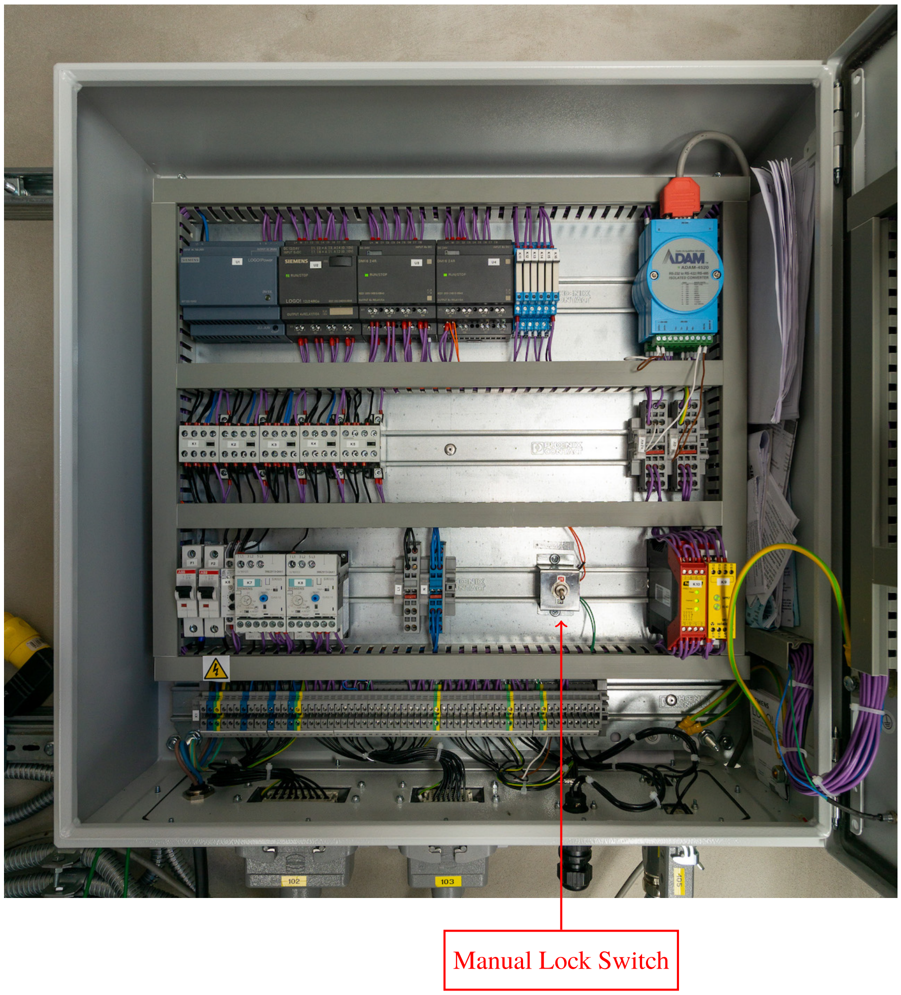

Figure 11.5: The inside of the enclosure controller cabinet showing the manual switch for the electromagnet.

Figure 11.6: 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. The COATLI installation is shown, but the DDOTI installation is similar.

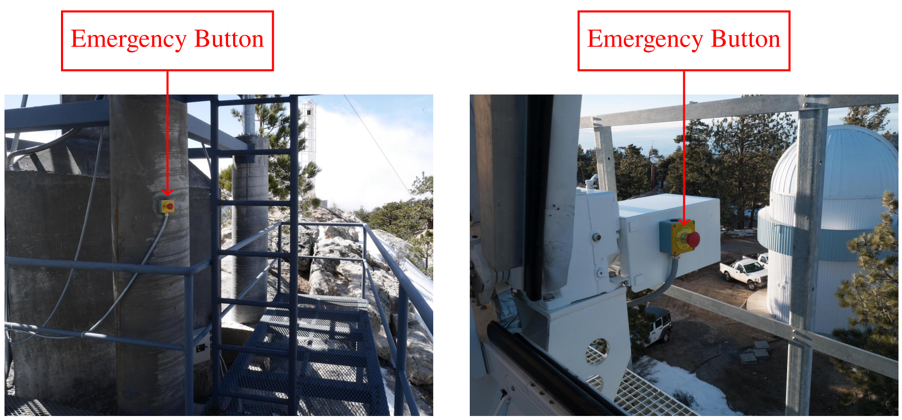

Figure 11.7: The enclosure emergency stop buttons, next to the main access ladder (left) and on the northern motor cowling (right). The COATLI installation is shown, but the DDOTI installation is similar.

Figure 11.8: Do not step on the elevated areas at the ends of the platform as they are not load bearing. Note the "no step" signs. If need be, you can put your weight on the beams, but not on the panels. The COATLI installation is shown, but the DDOTI installation is similar.

- 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 §11.2.5 to clear the error.
- Slow flashing (1 Hz): The motor under-current relay (K6) has been activated.
- Medium flashing (2 Hz): One or both of the motor over-current relays (K7 and K8) have been activated. This can happen if the enclosure is opened and closed continously for several minutes. Follow the procedure in §11.2.4 to clear the error.
- Fast flashing (4 Hz): The safety seal around the enclosure cover has been activated. Follow the procedure in §11.2.3 to clear the error.

11.2 Maintenance Procedures

11.2.1 Enabling Remote Mode

Safety Considerations

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

Requirements

You will need:

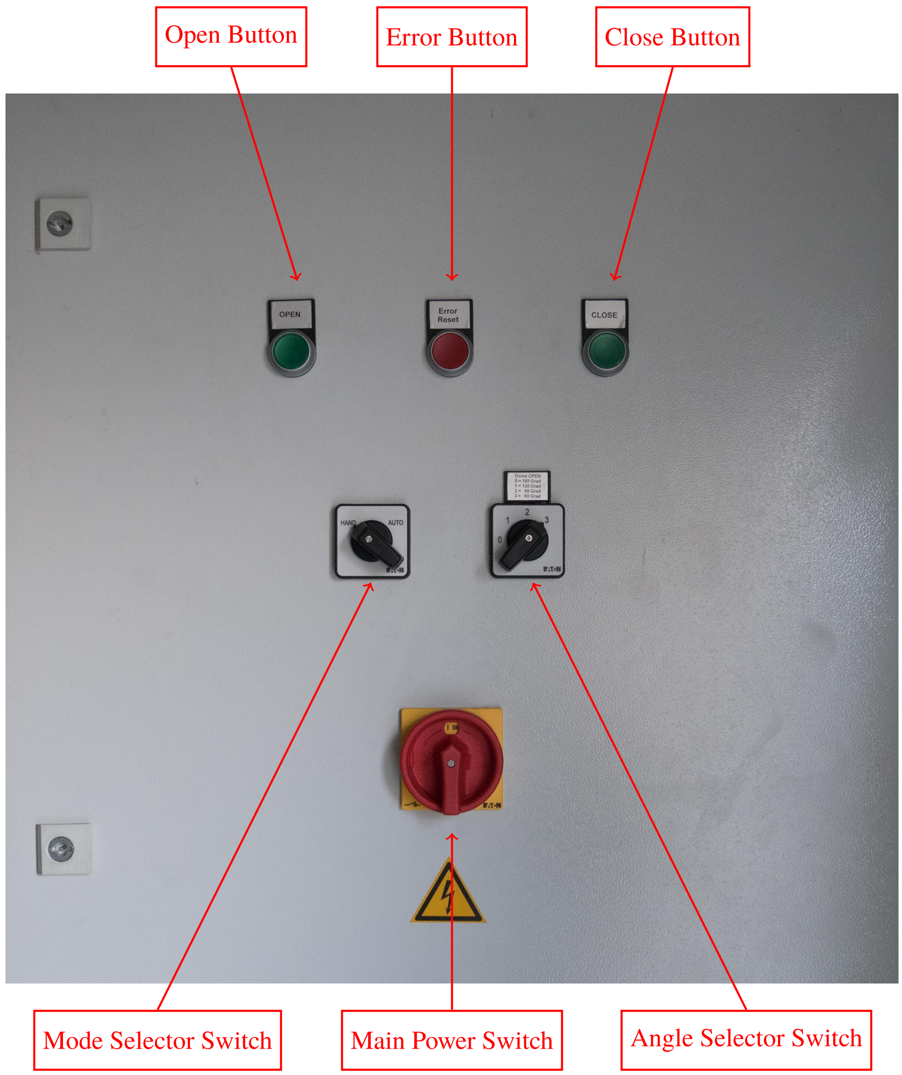

Figure 11.9: The enclosure controller door and control panel. Bottom: the main power switch. Middle row, left to right: the mode selector switch (“LOCAL” and “REMOTE”) and the angle selector switch (180 deg is fully open). Top row, left to right: the open button, the error button, and the close button.

- One person.
- The key to the shed (see §5.3).

Procedure

1. Go to the shed.
2. Move the main power switch on the enclosure controller door to “ON”.
3. Move the mode selector switch on the enclosure controller door to “REMOTE”.

11.2.2 Opening or Closing in Local Mode

Safety Considerations

In local mode, the control system cannot open or close enclosure.

In local mode, the rain sensor cannot close enclosure.

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.

Requirements

You will need:

- One person (to open or close only) or two or more persons (if you wish to ascend to the platform).
- The key to the shed (see §5.3).

Procedure

1. Go to the shed.
2. Move the enclosure controller main power switch on the enclosure controller to “ON”.
3. Move the enclosure controller mode selector switch to “LOCAL”.
4. If there is an error, the red error button will flash or be constantly lit. Investigate the error, and clear it before proceeding:

   In local mode, the following error states are distinguished:

- 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 §11.2.5 to clear the error.
- Slow flashing (1 Hz): The motor under-current relay (K6) has been activated.
- Medium flashing (2 Hz): One or both of the motor over-current relays (K7 and K8) have been activated. This can happen if the enclosure is opened and closed continously for several minutes. Follow the procedure in §11.2.4 to clear the error.
- Fast flashing (4 Hz): The safety seal around the enclosure cover has been activated. Follow the procedure in §11.2.3 to clear the error.

5. 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.
6. To close, press and hold the green close button until the light goes out.
7. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to "REMOTE".

11.2.3 Resetting a Safety Seal Error

If the safety seal is pressed the error button on the enclosure controller door flashes at 4 Hz in local mode and the enclosure will not operate. This procedure describes how to reset the error.

Safety Considerations

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

Requirements

You will need:

- At least two persons.
- The key to the shed (see §5.3).

Procedure

1. Go to the shed.
2. Move the enclosure controller main power switch on the enclosure controller to "ON".
3. Move the enclosure controller mode selector switch to "LOCAL".
4. One person should use a safety harness, safety line, and safety helmet and ascend to the platform. They should remove whatever is pressing the safety seal. They should then descend from the platform.
5. Press the error button to clear the error.
6. Attempt to move the enclosure slightly using the open or close buttons.
7. Verify that the error button no longer signals an error. That is, that is no longer flashes. If not, continue to investigate the error.
8. Close the enclosure.
9. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to "REMOTE".

11.2.4 Resetting a Motor Over-Current Error

The motors are protected by over-current relays. In normal operation, these should not activate. However, if they do the error button on the enclosure controller door flashes at 2 Hz in local mode and the enclosure will not operate. This procedure describes how to reset the error.

Safety Considerations

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

Requirements

You will need:

- One person.
- The key to the shed (see §5.3).

Procedure

1. Go to the shed.
2. Move the mode selector switch to “LOCAL”.
3. Move the enclosure controller main power switch on the enclosure controller to “OFF”.
4. Open the enclosure controller door.
5. Locate the motor over-current relays K7 and K8 (see Figure 11.11). Press the blue buttons on K7 and K8 to reset them.
6. Close the enclosure controller door.
7. Move the enclosure controller main power switch on the enclosure controller to “ON”.
8. Attempt to move the enclosure slightly using the open or close buttons.
9. Verify that the error button no longer signals an error. That is, that is no longer flashes. If not, continue to investigate the error.
10. Close the enclosure.
11. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to “REMOTE”.

11.2.5 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 in local mode and the enclosure will not operate. This procedure describes how to reset the error.

Safety Considerations

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

Requirements

You will need:

- At least two people.
- The key to the shed (see §5.3).

Procedure

1. Check the emergency button at the bottom of the ladder. If it is activated, twist it clockwise to release it.
2. One person should use a safety harness, safety line, and safety helmet and ascend to the platform. They should check the emergency button at on the north motor casing. If it is activated, they should twist it clockwise to release it. They should then descend from the platform.
3. Move the mode selector switch to “LOCAL”.
4. Press the error button to clear the error.
5. Attempt to move the enclosure slightly using the open or close buttons.
6. Verify that the error button no longer signals an error. That is, that is no longer flashes. If not, continue to investigate the error.
7. Close the enclosure.
8. If you wish to subsequently operate the enclosure remotely, move the mode selector switch to “REMOTE”.

11.2.6 Manual Opening or 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 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.

Safety Considerations

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.
- Two portable electrical drills with 6 mm hex drives.

Figure 11.10: 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 (see §5.3).

Two suitable drills with drives are stored in the DDOTI 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. Use appropriate safety equipment: harnesses, lines, and helmets. These are found in the shed.

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

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

6. Insert the drill into the motor axle. See Figure 11.10.

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 closed, release the brake lever, remove the drills, and descend from the platform.

9. Open the enclosure controller.

10. Engage the manual lock. This switches on the enclosure electromagnet and actuates the enclosure emergency stop buttons. This ensures that the electromagnet stays energized even if the PLC fails and that the PLC cannot attempt to open the enclosure.

    Move the manual lock switch inside the enclosure controller from OFF to ON. See Figure 11.5.

11. Close the enclosure controller.

12. Switch on the enclosure controller.

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

13. Place the enclosure in remote mode.

    Move the enclosure controller mode selector switch to “REMOTE”.

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. Open the enclosure controller.

3. Disengage the manual lock.

   Move the manual lock switch inside the enclosure controller from ON to OFF. See Figure 11.5.

4. Close the enclosure controller.

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

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

7. 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.

8. Set the direction of the drill appropriately to open the enclosure.
9. Insert the drill into the motor axle. See Figure 11.10.
10. 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.
11. Once the enclosure is open, release the brake lever, remove the drills, and descend from the platform.
12. Switch on the enclosure controller.

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

11.2.7 Shutting-Down Before and Starting-Up After the Winter Break

The observatory and DDOTI cease operations during a winter break of about three weeks. During the winter break the enclosure should be left closed and powered on but with a hardware override on the electromagnetic lock.

Safety Considerations

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 (see §5.3).

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

Procedure for Shutting-Down Before the Winter Break

To prepare the enclosure before the winter break:

1. Go to the shed.
2. Move the enclosure controller mode selector switch to "LOCAL".

3. If the weather permits, open the enclosure to 60 deg.

   Set the angle selector switch to the 60 deg and then press and hold the open button until the green light goes out.

4. Close the dome.

   Press and hold the close button until the green light goes out.

5. Switch off the enclosure controller.

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

6. Open the enclosure controller.

7. Engage the manual lock. This switches on the enclosure electromagnet and actuates the enclosure emergency stop buttons. This ensures that the electromagnet stays energized even if the PLC fails and that the PLC cannot attempt to open the enclosure.

   Move the manual lock switch inside the enclosure controller from OFF to ON. See Figure 11.5.

8. Close the enclosure controller.

9. Leave the enclosure controller mode selector switch to “LOCAL”.

Procedure for Starting-Up After the Winter Break

To prepare the enclosure after the winter break:

1. Go to the shed.

2. Switch off the enclosure controller.

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

3. Open the enclosure controller.

4. Disengage the manual lock.

   Move the manual lock switch inside the enclosure controller from ON to OFF. See Figure 11.5.

5. Close the enclosure controller.

6. Switch on the enclosure controller.

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

7. Move the enclosure controller mode selector switch to “REMOTE”.

11.2.8 Patching the Enclosure Roof

The enclosure roof is made from a heavy-duty fabric. Nevertheless, the COATLI roof in particular suffers from wear. Since the worst affected area is the south side of COATLI, we believe this is the result of exposure to the wind. Regardless, the roof needs patching about once per year.

Safety Considerations

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

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

Do not step on the elevated areas at the ends of the platform. If need be, you can put your weight on the beams, but not on the flat panel.

Requirements

You will need:

- Three persons, two to work in the enclosure and one to open and close the enclosure from the shed.
- A radio, for communication from the enclosure.
- The key to the shed (see §5.3).
- Spare fabric (in the ASTELCO chest).
- A roller (in the ASTELCO chest).
- The heat gun.
- Scissors
- To reach the higher parts of the enclosure, the light-weight step ladders from the 84-cm and 1.5-m telescopes are useful.

Procedure

We are not going to give a specific procedure, but instead some tips based our experience.

- The basic idea is to use the heat gun to weld the fabric patches to the roof.

- If you have no experience welding the fabric, we recommend that you start by practicing welding a patch to the spare fabric.
- We have found it much easier to work inside the closed enclosure and to apply patches from the inside. For this, two people should ascend to the enclosure and the third should open and close the enclosure from the shed.
- Cut the patches with round corners. See the existing patches.
- The fabric has a smooth side and a textured side. Weld the smooth side of the patch to the roof.
- Use the heat gun with the small round nossel and the temperature set to “Alta”.
- Warm the patch and the area to be patched first. Then place the patch in position. Fold back half of the patch and use the heat gun to weld a small area at a time. Heat both the patch and the roof. Once the plastic begins to melt, use the roller to push them together. After you have welded one half of the patch, continue with the other.
- For large patches, having two persons work together seems to be best. One holds the patch and heats an area with the heat gun. The other uses the roller to press the fabric together. With some practice, you can weld continuously.
- For small patches, working alone seems to be best. Hold the patch against the roof with the roller. Bend half of the patch back over the roller, heat the roof and patch, and then push them together with the roller. Then weld the other half.
- The pointed scraper that accompanies the heat gun is useful for lifting the edges of patches to finish welding them.
- When the fabric gets too hot, it begins to brown. Try to avoid this.
- To reach areas right above the telescope, it can be useful to partially open the enclosure to improve access.

11.3 Remote Interface

11.3.1 Lantronix EDS

The RS-232 interface to the enclosure controller is made available via the Lantronix EDS 4100 ethernet-to-serial converter. Specifically, it is connected to line 3 and configured as 9600/8-N-1 with a tunnel on TCP port 10003.

The Lantronix EDS is on the LAN at `serial`.

11.3.2 ADAM Modules

Remote control of the enclosure is through an ADAM-4055 digital input/output module. The input and output channels of the ADAM-4055 module are connected to the enclosure controller PLC.

The RS-485 serial interface of the ADAM-4055 is exposed via an ADAM-4520 RS-232 to RS-485 converter and isolator as RS-232 at 9600/8-N-1.

The state of the input and output channels can be determined either from the web interface (the “Input Channels” and “Output Channels” variables in the “Enclosure” tab) or by unscrewing the ADAM-4520 RS-232 to RS-485 converter on top of the ADAM-4055 to reveal LEDs which show the state of the channels.

The input channels are:

DI0 Open. 0 = not open and 1 = open. This channel is connected to terminal U3/Q5 (“Kuppel AUF”) on the PLC. Its value is determined by the PLC from the proximity switches on the platform.

DI1 Closed. 0 = not closed and 1 = closed. This channel is connected to terminal U3/Q6 (“Kuppel ZU”) on the PLC. Its value is determined by the PLC from the proximity switches on the platform.

DI2 Error. In remote mode, 1 = error and 0 = no error. In local mode, this follows the state of the red error button (constant 0 = not error, constant 1 = emergency stop button pressed, and intermittent at 1, 2, or 4 Hz for under-current, over-current, and safety rail errors). This channel is connected to U3/Q4 (“Störung”) on the PLC, which also control the red error button. Its value is determined by the PLC. Note that the behavior of this channel in local mode makes it only useful in remote mode.

DI3 Mode. 0 = local and 1 = remote. This channel is connected to terminal U4/I2 (“Hand/Auto”) of the PLC. Its value is directly determined by the mode switch.

DI4 Motor over-current error. 0 = no error and 1 = error. This channel is connected to terminal U3/I7 (“Motorschutz”) of the PLC. Its value is directly determined by the motor over-current relays K7 and K8.

DI5 Rain sensor. 0 = dry and 1 = wet. This channel is connected to terminal U3/Q8 (“Regensensor”) on the PLC. Its value is determined by the PLC from the rain sensor switch on the platform.

DI6 Safety strip. 0 = not pressed and 1 = pressed. This channel is connected to terminal U4/I1 (“Dichtlippe”) on the PLC. Its value is directly determined by the safety rail switch.

DI7 Emergency stop. 0 = not pressed and 1 = pressed. This channel is not connected to the PLC but rather to the emergency stop button circuit. Its value is determined directly by the emergency stop buttons.

The output channels are:

DO0 Open. In remote mode, set to 1 to open to the position specified by DO3, DO4, and DO5. This channel is connected to terminal U2/I3 (“AUF”) of the PLC via relay K11.

DO1 Close. In remote mode, set to 1 to close. This channel is connected to terminal U2/I4 (“ZU”) of the PLC via relay K12.

DO2 Reset. In remote mode, set to 1 to reset an error. This channel is connected to terminal U2/I8 (“Reset”) of the PLC via relay K13.

DO3 60 deg. Set to 1 to select 60 degrees. This channel is connected to terminal U4/I5 (“Auto 60-Grad”) of the PLC via relay K14.

DO4 90 deg. Set to 1 to select 90 degrees. This channel is connected to terminal U4/I6 (“Auto 90-Grad”) of the PLC via relay K15.

DO5 120 deg. Set to 1 to select 120 degrees. This channel is connected to terminal U4/I7 (“Auto 120-Grad”) of the PLC via relay K16.

DO6 Not used.

DO7 Not used.

If D03, D04, and D05 are all set to 0, opening will open to 180 degrees. The DDOTI enclosure has hardware to support opening to 60, 90, 120, and 180 degrees.

11.3.3 Diagnostics

To check communication with the Lantronix EDS, from a terminal run:

```
ping serial
```

To check communication with the ADAM modules, from a terminal on `control`, first stop the enclosure server so that it releases the enclosure TCP port on the Lantronix EDS:

```
sudo stopserver enclosure
```

Then connect to the enclosure TCP port on the Lantronix EDS using telnet:

```
telnet serial 10003
```

You can then send commands to the ADAM-4055. Some useful commands (which should be followed by ENTER) are:

Table 11.1: Enclosure Controller Components

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

- Command: `$01M`

  Response: `!014055`

  Read Module Name. The response shown above confirms that you are talking to an ADAM-4055.

- Command: `$016`

  Response: `!`$XXYY$`00`

  Digital Data In. The values of the output channels (in upper-case hexadecimal) are given by XX and the values of the input channels (in upper-case hexadecimal) are given by YY.

- Command: `#0100`XX

  Response: >

  Digital Data Out. The output channels are set to XX (in upper-case hexadecimal).

For more details of the commands, see the ADAM-4000 Manual.

You can exit from telnet by typing CTRL-] and then `quit`. Once you have done so, you should probably restart the enclosure server on `control` with:

```
sudo startserver enclosure
```

11.4 Control

The server for the enclosure runs on `control`.

The server starts automatically after `control` is boots, but if necessary can be stopped, started, or restarted explicitly by issuing the following shell 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 LAN. The following requests are supported:

Figure 11.11: 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 over-current relays; 220 VAC live and neutral distribution blocks; K10 is XXX; and K9 is XXX.

- `request enclosure initialize`

  Initialize the server and enclosure hardware. As part of the process of initializing, the enclosure will close.

  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`.

- `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`

  Show the status of the server.

  Obtain the values of the status data from the server and print them to stdout.

11.5 Bibliography

- "Technical Specifications: ASTELCO Remote Telescope Station (ARTS)", ASTELCO, Version V-1304-21.
- "Foldable Enclosure ENCL-ALTS-01 Technical Reference Manual", ASTELCO, Revision V-1.4.
  - The statement that the enclosure used 230 V 50 Hz is not applicable. The DDOTI and DDOTI/OAN enclosures use 220 V 60 Hz phase-phase.
  - The description of the ADAM input and output channels on page 19 is not applicable. The correct description is given in §11.3.2.
  - The DDOTI enclosure has hardware to support opening to 60, 90, 120, and 180 degrees.
- Electronic Schematics, ASTELCO, Revision A (in German).
- Drawing 0500 – Enclosure Platform, ASTELCO.
- Drawing 5772 – Enclosure Tower Base Plates, ASTELCO.
- Drawing 5798 – Enclosure Tower, ASTELCO.
- Drawing 6610 – Enclosure Tower on Columns, ASTELCO.
- Drawing 6658 – Enclosure Tower on Columns, ASTELCO.
- Drawing 6662 – Interface with Columns, ASTELCO.
- "Lantronix EDS Device Servers/Terminal Servers User Guide", Lantronix, Revision 1 April 2011.
- "ADAM-4000 Data Adquisition Modules User's Guide]", Advantech, Edition 10.5, 2007.

Part III

Telescope and Instrument

Chapter 12

Mount

12.1 Description

The mount is an ASTELCO NTM-500 German equatorial mount. For details, see the ASTELCO manual.

12.1.1 Mount

The mount itself is obviously located at the top of the telescope pier. Figure 12.1 shows the mount panel.

At DDOTI we pass 127 VAC and network connections through the mount HA axis up to Box D. The 127 VAC supply uses the “CUSTOM” connector. We also pass 127 VAC and network connections through the mount declination axis from Box D to Box E.

12.1.2 Mount Controller

The mount controller is a cream 4U box located in the rack in the shed. Figure 12.2 shows the controller front panel, with the connectors and the power, fan alarm reset, and factory reset buttons.

The mount controller is connected to the mount by two cables (one for the motors and another for the encoders) and a compressed air hose (for the brakes). It is also connected to a GPS receiver which is located on the south-east side of the shed.

The mount controller is connected to circuit B, through the 127 V UPS and iBootBar. (The mount controller should not be connected to 220 VAC.)

Figure 12.1: The mount panel showing the break release button.

Figure 12.2: The mount controller front panel showing the connectors and the power, fan alarm reset, and factory reset buttons.

12.2 Maintenance Procedures

12.2.1 Manually Moving the Mount

Press the BRAKE button on the panel on the south side of the mount. While this button is pressed, the brakes on both axes will be released and you can move the telescope by hand.

Sometimes, especially after an error, the mount takes a while to recover and you need to press and hold the button for up to a minute before the brakes are released.

12.2.2 Manually Switching Off

Press the power button on the front panel (shown in Figure 12.2). Do not confuse the power button with the factory reset button! The power button is in the lower right and the factory reset in the upper right.

12.2.3 Manually Switching On

Press the power button on the front panel (shown in Figure 12.2). Do not confuse the power button with the factory reset button! The power button is in the lower right and the factory reset in the upper right.

12.3 Bibliography

- "NTM Technical Reference Manual", ASTELCO, Version 3.7.
- "NTM Technical Description", ASTELCO, Version 3.7.
- "OpenTCI", ASTELCO, Version 2.5.
- "TPL2", ASTELCO, Version 2.0.
- "Drawing 5824 – Mount column interface", ASTELCO.
- "Drawing – NTM Base Plate", ASTELCO.
- "Drawing – NTM Dimensions", ASTELCO.
- "TCLM/TPL2 ASCOM Driver User Manual", Tau-tec, 2010

Chapter 13

Telescopes

13.1 Description

The DDOTI telescopes are six Celestron 11-inch Rowe-Ackermann Schmidt Astrograph (RASA) telescopes each equipped with a Starlight Instruments HandyMotor and FocusBoss II focuser and a custom-made detector adapter. The telescopes are mounted on the mount using a custom-made adapter.

The six telescopes are associated with six detector channels. Channels C0, C2, and C4 are mounted on one side of the mount and channels C1, C3, and C5 are mounted on the other.

The original two UNAM telescopes were installed in June 2017. The remaining four UMD telescopes were installed in February 2019. We also have a seventh telescope on site. This was dropped during installation of the UMD telescope and the corrector plate was destroyed. It is now used for spares. A replacement UNAM telescope was installed in March 2019.

Table 13.1 gives the serial and inventory numbers of the telescopes. The telescopes to have two serial numbers, one on a silver-colored label and one on a gold-colored label.

The telescope optical properties are shown in Table 13.2. The telescopes use the default filter window.

We have very little information on the transmission of the telescope. According to the RASA white paper, the primary mirror has a "Celestron StarBright XLT" coating and the corrector plate, corrector lenses, and filter have "broadband AR" coatings, but we have no quantitative information on the actual performance. Nevertheless, the telescope image quality was optimized for 400–700 nm and it makes sense that the coatings were also optimized for this range.

Table 13.1: Telescopes

Channel	Serial Numbers	Owner	Inventory Number
C0	985394/110780	UMD	243595
C1	985164/110661	UMD	243588
C2	980740/105806	UNAM	02480886
C3	/108014	UNAM	02333800
C4	985163/110200	UMD	243587
C5	984230/110102	UMD	243589
Spare		UNAM	

Table 13.2: Telescope Optical Properties

Property	Value
Diameter	279 mm (11 inches)
Central Obscuration Diameter (Telescope)	114 mm
Central Obscuration Diameter (Detector Adapter)	132 mm
Central Obscuration Ratio (Telescope)	0.41
Central Obscuration Ratio (Detector Adapter)	0.47
Focal Length	620 mm
Focal Ratio	$f/2.2$
Optimized Field Diameter	43.3 mm (4.0 degrees)

13.2 Mount Adapter

13.3 Optical Alignment

The telescopes have three optical groups: the corrector plate, the spherical mirror, and the four-element corrector lens group. The corrector plate and spherical mirror have no alignment mechanism. The corrector lenses have a three-point push-pull mechanism to allow collimation and the reduction of coma.

We aligned the corrector lenses in March 2019. We mounted a Sony α6000 camera using an E-to-T mount adapter and the Celestron-supplied T-mount RASA adapter. We observed out of focus stars at the center of the field using magnified live-view and adjusted the mechanism until the secondary obscuration was centered.

13.4 Hartmann Tests

13.5 Detector Adapter

13.6 Focusers

Bibliography

- "Celestron RASA Instruction Manual", 2014.
- "Celestron RASA White Paper", 2016.
- "Celestron RASA Recommendations for Camera Adapter", 2016.

Chapter 14

Instrument

14.1 Maintenance Procedures

14.1.1 Changing a Detector

The detectors are attached to an adapter which is in turn attached to a mounting ring on the telescope corrector plate. The mounting ring is held against rotation only by friction. Thus, care must be taken to avoid placing a torque on the mounting ring when manipulating the detector and adapter.

Safety Considerations

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

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

Requirements

You will need:

- Two persons.
- The key to the shed (see §5.3).
- Metric hex keys (specifically, 2 and 2.5 mm)
- Wire cutters
- Cable ties
- A spirit level

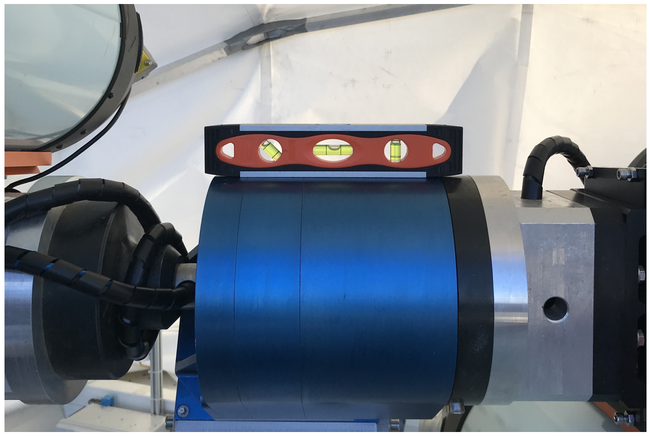

Figure 14.1: Using the spirit level to make sure that the declination axis is horizontal.

Procedure

1. Use appropriate safety equipment: harnesses, lines, and helmets. These are found in the shed.
2. Move the enclosure controller mode selector switch to “LOCAL”.
3. If the weather permits, open the enclosure to 60 deg.

   Set the angle selector switch to the 60 deg and then press and hold the “OPEN” button until the green light goes out.
4. Ascend to the platform.
5. Point the telescope to the northern horizon. Verify that the declination axis is horizontal using the spirit level. See Figure 14.1.

   While supporting the telescopes using one of the handles on the primary mirror cells, push the button on the mount to release the brake. Move the telescopes to point at the northern horizon. Then use the spirit level to make sure that the declination axis is horizontal.
6. Cut the cable ties on the detector to be replaced. See Figure 14.2.
7. Gently remove the USB and power cables. Support the detector to avoid placing a torque on the mounting ring. See Figure 14.3.
8. Using a 2 mm hex key, gently slacken the grub screw that stops the detector from rotating in its adapter. Support the detector to avoid placing a torque on the mounting ring. See Figure 14.4.
9. While one person holds the tip tilt adapter to prevent it from placing a torque on the mounting ring, the other should gently unscrew the detector. See Figure 14.5.

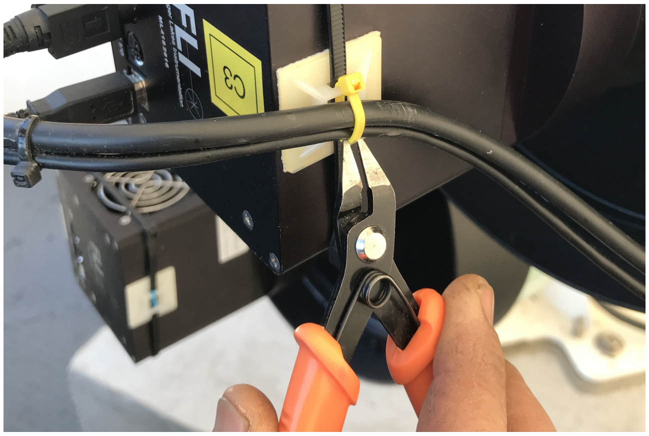

Figure 14.2: Cutting the cable ties of the detector to be replaced.

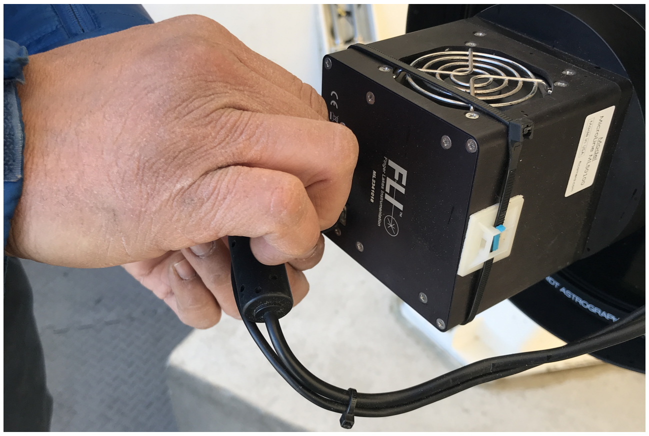

Figure 14.3: Removing the cables from the detector to be replaced. Be careful not to apply a torque on the detector.

Figure 14.4: Slackening the grub screw.

Figure 14.5: Removing the detector. One person should support the adapter against rotation while the other person unscrews the detector.

Figure 14.6: Removing the adapter. Support the adapter with one hand to avoid placing a torque on the mounting ring.

Figure 14.7: Attaching the new detector to the adapter.

10. Using a 2.5 mm hex key, gently slacken the screws that hold the adapter to the mounting ring. Support the adapter to prevent it from placing a torque on the mounting ring. See Figure 14.6.

11. Screw the new detector into the adapter and tighten the grub screw. See Figure 14.7.

12. Thread a small cable tie through the appropriate base.

    It is important to do this before you attach the adapter to the mounting ring, to avoid placing a torque on the mounting ring. See Figure 14.8.

13. Attach the adapter to the mounting ring.

    All of the detectors have the same orientation, so you can use the others as guides. You can select the appropriate set of holes in the mounting ring to give approximate alignment and then gently rotate the adapter in its slots for fine alignment. Use a level to guide you. Make sure the hex screws are adequately lose before turning the adapter, to avoid placing a torque on the mounting ring. See Figure 14.9.

14. Attach the cables to the detector and secure them with the cable tie. Support the detector to prevent it from placing a torque on the mounting ring.

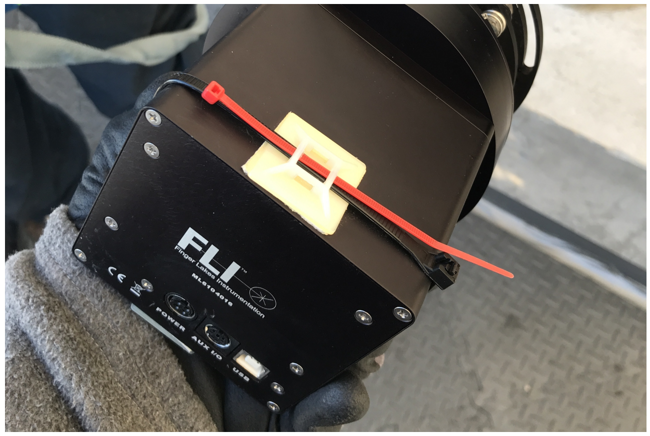

Figure 14.8: Attaching a cable tie to the detector prior to mounting it on the telescope.

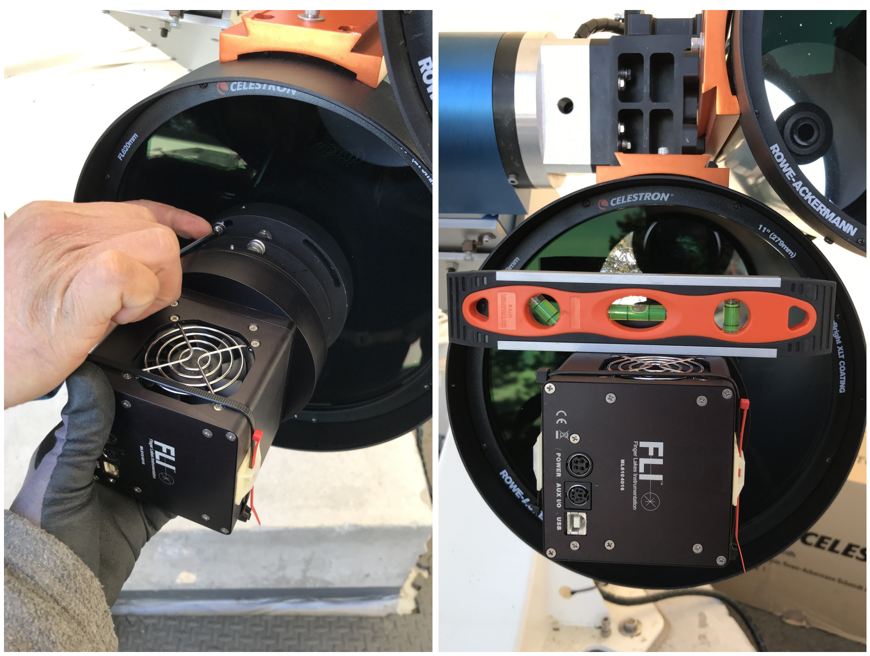

Figure 14.9: Attaching the adapter to the mounting ring. Be careful to avoid placing a torque on the mounting ring.

15. Descend from the platform.
16. Close the enclosure. If the red error button is lit or flashing, press it to clear the error. (Often you will activate the safety strip when entering or leaving the enclosure.) Press and hold the "CLOSE" button until the green light goes off.
17. Move the enclosure controller mode selector switch to "REMOTE".
18. Replace all tools and equipment in their correct places.
19. Communicate with the DDOTI team who will configure the new detector in the control system, restart the software, and verify that the detector is integrated correctly.

14.2 Calibration Data

14.2.1 Biases and Darks

14.2.2 Flats

14.2.3 Gain and Read Noise

The control system does not automatically take data for calibrating the gain and read-noise, but there are blocks that can be executed manually either in evening or morning twilight.

For best results, do this procedure either at the start of evening civil twilight or the start of morning nautical twilight.

The procedure is:

- Make sure the telescope is closed:

```
tcs request supervisor close
```

- Unpark the telescope and cool the instrument:

```
tcs request telescope unpark
tcs request instrument open
```

- Wait for the detector to cool to the operating temperature. Then run the morning or evening block, as appropriate:

```
tcs request executor execute block \
  /usr/local/var/tcs/blocks/0013-signal-chain-morning.json
tcs request executor execute block \
  /usr/local/var/tcs/blocks/0013-signal-chain-evening.json
```

The difference between the blocks is that in the morning the block takes biases and then flats, whereas in the evening it takes flats and then biases.

- One the block has finished, close the telescope again by running:

  ```
  tcs request executor close
  ```

For these data:

- The program identifier is 0013.
- The block identifier is 0 for the morning and 1 for the evening.
- The data are taken in visit 0.

The block takes 10 biases and attempts to obtain 10 flats with levels suitable for determining the gain. These flats will normally be the last 10 flats, as the block waits for the signal in the flat to be in a suitable range.

The dome lights should not be switched on during this process. If they are, then the biases might be contaminated with light and the flats will be saturated. Note that sometimes the technical staff switch the lights on in the morning to check that the enclosures have closed, so you should warn them in the chat that you are taking calibration data and that they should not do this.

Chapter 15

Calibrations

This chapter describes the routine calibrations procedures for DDOTI.

15.1 Twilight Flats

The control system takes twilight flats each evening that conditions permit.

The flats are taken with the telescope pointed to -3 hours of HA and +45 degrees of declination and with the tracking turned off. The detector uses a read mode of `default` (which is `16MHz`). The control system monitors the level in the flats, considers a flat to be good it its level is between 1000 and 3000 DN, and moves to the next filter either after acquiring a certain number of good flats (typically 7) or when the level is too low for the flat to be considered good.

Part IV

Control System

Chapter 16

Control System

TODO: What runs where.

TODO: Structure.

TODO: stopserver/startserver/restartserver

TODO: restartsoon (haltsoon and rebootsoon in network)

TODO: state and activity

TODO: basic requests: initialize, status, reset, stop

TODO: supervisor
request supervisor enable/disable/open/close/emergencyclose

TODO: Detectors:
expose <time> object/dark/bias/flat
setcooler on/off
movefilterwheel position/filter
movefocuser position
setfocuser position setwindow 1kx1k/2kx2k/6kx6k/default/full
setbinning 1/2/4
setreadmode mode
setsoftwaregain
focus TBD
analyze fwhm/levels

TODO: selector
request selector enable/disable
request select setunfocused

TODO: instrument
open/close

TODO: telescope
park
unpark
move HA dec

newtrack RA dec equinox
newtracktopocentric HA dec
01:23:45.67 +3h 60d
open/close

TODO: executor
open/close

TODO:
request telescope emergencyclose
sudo restartsoon
request supervisor enable

Chapter 17

JSON

JSON is used widely in TCS to represent data structures in configuration files, alert files, block files, and in inter-process communication. JSON has a simple and regular syntax that is fairly easy for humans to write, easy for computers to parse, and should be quite familiar to C, C++, and JavaScript programmers.

17.1 Dialect

The dialect of JSON used in TCS is both extended and restricted compared to standard JSON.

It is extended by the addition of comment lines that can appear wherever white-space can appear in standard JSON. A comment line is a line that begins with zero or more space and horizontal tab characters followed by two slash characters ("//"). Formally, the slash character is U+002F SOLIDUS. Other types of comments (e.g., block comments introduced by "/*" and terminated by "*/") are not allowed. Comment lines are treated as if they were empty lines. Our dialect of JSON can be converted to standard JSON by using a regular expression substitution to replace comment lines with empty lines.

It is restricted with respect to standard JSON in that it only uses array, object, and string values and does not use number, true, false, or null values. If a value represents a number, then the string representation should be used. This restriction ensures that value can be read and written without being changed.

The dialect of JSON is formally a very limited subset of JavaScript. Therefore, if you are editing data files manually, it might be useful to select an editing mode suitable for JavaScript.

17.2 Encoding

Data files should be encoded in UTF-8. ASCII is a subset of UTF-8, but ISO-8859-1 "Latin-1" is not.

17.3 Values

17.3.1 Value Types

Only array, object, and string values are used. Number and boolean values are represented by their string representation. For example, we do not write

```
0
true
false
```

but rather

```
"0"
"true"
"false"
```

Null values are not used.

17.3.2 Dates and Times

Dates and time values are written as strings containing an IS0-8601 basic date or basic combined date and time. The time zone is understood to be UTC; an explicit time zone must not be specified. The precision must not be specified more finely than seconds.

Examples of valid dates are:

`"20101117T223815"`	:	2010 Nov 17 22:38:15 UTC
`"20101117T2238"`	:	2010 Nov 17 22:38:00 UTC
`"20101117T22"`	:	2010 Nov 17 22:00:00 UTC
`"20101117"`	:	2010 Nov 17 00:00:00 UTC

17.3.3 Angles

A value representing an angle may be written as:

1. a string containing a decimal number (and interpreted as *radians* not *degrees*);
2. a string containing sexagesimal notation with colons as separators and no white space;
3. a strings containing a decimal number with a unit suffix (with no intermediate white space):
   (a) "r" for radians;

(b) "h" for hours;

(c) "m" for minutes;

(d) "s" for seconds;

(e) "ad" or "d" for degrees;

(f) "am" for arcminutes; and

(g) "as" for arcseconds.

For hour angles and right ascensions, sexagesimal notation indicates hours, minutes, and seconds. For all other angles, including offsets, it indicates degrees, arcminutes, and arcseconds.

Examples of valid angles are:

`"-22.5"`	: −22.5 *radians*
`"-22.5d"`	: −22.5 *degrees*
`"-01:30:00"`	: −1.5 hours or −1.5 degrees, depending on the context
`"0.5r"`	: 0.5 radians
`"-1.5h"`	: −1.5 hours
`"5am"`	: 5 arcminutes
`"+20as"`	: 20 arcseconds

17.3.4 Durations

A value representing a duration may be written as:

1. a string containing a decimal number (and interpreted as decimal seconds);
2. a string containing sexagesimal notation with colons as separators and no white space;
3. a string containing a decimal number with a unit suffix (with no intermediate white space):

   (a) "h" for hours;

   (b) "m" for minutes; and

   (c) "s" for seconds.

Sexagesimal notation indicates hours, minutes, and seconds.

Examples of valid durations are:

`"60"`	: 60 seconds
`"00:30:10"`	: 30 minutes and 10 second
`"60s"`	: 60 seconds
`"10m"`	: 10 minutes
`"1h"`	: 1 hour

17.3.5 Validation

JSON written by hand is prone to errors such as missing commas. For this reason, it is often worthwhile checking JSON with one of the many on-line validators. The following validator is especially useful, as it tolerates comments:

> https://jsonformatter.curiousconcept.com/#

17.4 Bibliography

- “Introducting JSON”, https://www.json.org/json-en.html

Chapter 18

Observing Blocks

18.1 Introduction

Observations are organized as *project*, *blocks*, and *visits*.

A project is associated with a successful observing proposal. It has a PI, a name, and an identifier. It consists of one or more blocks.

A block consists of a ordered set of visits associated with a set of constraints and a program. The selector and executor deal with blocks: the selector selects a block and the executor executes it. A block is only selectable if all of its visits satisfy all of the constraints. When a block is executed, its visits are carried out in order.

A visit is typically a logical operation with the telescope such as focusing, correcting the pointing, or observing an objects.

18.2 Block Files

A block file contains a JSON representation of a block.

It consists of a single JSON object with the following structure:

```
{
  "project": {
    "identifier": <project-identifier>,
    "name": <project-name>
  },
  "identifier": <block-identifier>,
  "name": <block-name>,
  "visits": <visits>,
  "constraints": <constraints>,
  "persistent": <persistent>
}
```

As for any JSON object, the order of the members is irrelevant.

The members and values are interpreted as follows:

- <project-identifier>: The project identifier.

  This is a four-digit non-negative integer represented as a string.

  By convention, calibration programs have identifiers from 0000 to 0999, alert science programs from 1000 to 1999, and non-alert science programs from 2000 to 2999. (The pipeline uses this convention to reduce alert observations immediately but delay reducing non-alert observations until the morning.)

  This member cannot be omitted.

- <project-name>: The project name.

  By convention, we use the surname of the PI followed by a brief description of the objects (e.g., `"Watson YSOs"`).

  If omitted, the default is `""`.

- <block-identifier>: The block identifier.

  This is a non-negative integer represented as a string.

  This member cannot be omitted.

- <block-name>: The block name.

  By convention, we briefly describe the main science target (e.g., `"HL Tau"`).

  If omitted, the default is `""`.

- <visits>: An array representing the visits. See below.

  If omitted, the default is an empty array.

- <constraints>: An object representing the constraints. See below.

  If omitted, the default is an empty object.

- <persistent>: Whether the block is persistent.

  Either `"true"` or `"false"`.

  If `"true"`, the block is persistent. Persistent blocks remain in the queue after they have been executed. Non-persistent blocks are removed after they have been executed.

  If omitted, the default is `"false"`.

18.3 Constraints

The <constraints> value specifies constraints which shall be satisfied by all of the visits in a block in order for the block to be selectable. If any constraint is not satisfied by any visit, the block will not be selectable.

For a block to be selectable:

- All time-based constraints (`mindate`, `maxdate`, `minfocusdelay`, and `maxfocusdelay`) must be satisfied at the start of the first visit.

- All condition-based constraints (e.g., on transparency) must be satisfied at the start of the first visit. (In the present version of the selector, there are no constraints on unpredictable properties, but this may change in future versions.)

- All other constraints must be satisfied at the start and end of *each* visit.

Syntactically, the <constraints> value is a JSON object with the following structure:

```
{
  "mindate": <date>,
  "maxdate": <date>,
  "minsunha": <ha>,
  "maxsunha": <ha>,
  "minsunzenithdistance": <distance>,
  "maxsunzenithdistance": <distance>,
  "minmoondistance": <distance>,
  "maxmoondistance": <distance>,
  "minha": <ha>,
  "maxha": <ha>,
  "mindelta": <delta>,
  "maxdelta": <delta>,
  "minairmass": <airmass>,
  "maxairmass": <airmass>,
  "minzenithdistance": <distance>,
  "maxzenithdistance": <distance>,
  "minskybrightness": <skybrightness>,
  "maxskybrightness": <skybrightness>,
  "minfocusdelay": <delay>,
  "maxfocusdelay": <delay>,
}
```

As for any JSON object, the order of the members is irrelevant.

The members and values are interpreted as follows:

- The <mindate> and <maxdate> values specify the earliest and latest date and time on which to the visit shall be executed.

  Valid values are dates.

- The <minsunha> and <maxsunha> values specify the minimum and maximum values of the HA of the Sun.

  Valid values are angles.

  These are of most interest to calibration blocks, where these can be used to determine whether it is morning or evening.

- The <minsunzenithdistance> and <maxsunzenithdistance> values specify the minimum and maximum values of the zenith distance of the Sun.

  Valid values are angles.

  These are of most interest to calibration blocks.

- The <minmoondistance> and <maxmoondistance> members specify the minimum and maximum values of the distance of the Moon from the visit targets.

  Valid values are angles.

- The <minha> and <maxha> values specify the minimum and maximum values of the HA of the visit targets.

  Valid values are angles.

  These can be used to program several blocks on the same target in the a given night by giving each a HA range disjoint from the others.

- The <mindelta> and <maxdelta> values specify the minimum and maximum values of the declination of the visit targets.

  Valid values are angles.

- The <minairmass> and <maxairmass> members specify the minimum and maximum values of the zenith distance of the visit targets.

  Valid values are numbers.

- The <minzenithdistance> and <maxzenithdistance> values specify the minimum and maximum values of the zenith distance of the visit targets.

  Valid values are angles.

- The <minskybrightness> and <maxskybrightness> values specify the minimum (faintest) and maximum (brightest) sky brightness in which the visit shall be executed.

  Valid values are: `"daylight"`, `"civiltwilight"`, `"nauticaltwilight"`, `"astronomicaltwilight"`, `"bright"`, `"grey"`, and `"dark"`.

  Daylight and the twilights are defined conventionally by the altitude of the Sun. Bright time is any time between twilights when the moon is above the horizon and is 50% illuminated or more. Grey time is s any time between twilights when the moon is above the horizon and is 50% illuminated or less. Dark time is any time between twilights when the moon is below the horizon.

- The <minfocusdelay> and <maxfocusdelay> values specify the minimum and maximum time since the telescope was last focused. So, for example specifying a <minfocusdelay> of `"1h"` will constrain the block to be run no sooner than 1 hour after focusing and specifying a maxfocusdelay of `"1h"` will constrain the block to be run no later than 1 hour after focusing.

  Valid values are durations.

  These are of most interest to focus blocks.

In addition to any explicit constraints, the scheduler requires that all visit targets are within the telescope pointing limits at the expected start and of the visit.

If no explicit constraints are given, the implicit telescope pointing limits are the only constraint and, for example, a block may be executed at very high airmass, close to the mount, or during twilight. Therefore, it is advisable to include at least minimal constraints, for example:

```
{
  "maxskybrightness": "astronomicaltwilight",
  "maxairmass": "2.0",
  "minmoondistance": "15d"
}
```

18.4 Visits

Syntactically, the <visits> value is a JSON array containing zero or more <visit> objects:

```
[
  <visit>,
  <visit>,
  <visit>,
  ...
  <visit>
]
```

Each <visit> value is a JSON object with the following structure:

```
{
  "identifier": <visit-identifier>,
  "name": <visit-name>,
  "targetcoordinates": <target-coordinates>,
  "estimatedduration": <estimated-duration>,
  "command": <command>
}
```

As for any JSON object, the order of the members is irrelevant.

The members and values are interpreted as follows:

- <visit-identifier>: The visit identifier.

  This is a non-negative integer represented as a string.

  By convention, science visits have identifiers from 0 to 999 and focusing, pointing correction, and other non-science visits from 1000 onward. (The pipeline uses this convention to avoid reducing non-science visits.)

- <visit-name>: The visit name.

  By convention, we used names that describe the activity generically, such as `"focussing"`, `"pointingcorrection"`, `"science"`.

  If omitted, the default is `""`.

- <target-coordinates>: The target coordinates. See below.

- <estimated-duration>: The estimated duration of the visit.

  Valid values are durations (e.g., `"10m"` for 10 minutes).

  This is used to by the selector to check the constraints at the estimated end of the visit.

- <command>: The command to execute the visit. See below.

18.5 Target Coordinates

The <target-coordinates> value is a JSON object with one of the following structures.

For equatorial coordinates, the structure is:

```
{
  "type": "equatorial",
  "alpha": <alpha>,
  "delta": <delta>,
  "equinox": <equinox>
}
```

The <alpha> and <delta> values are angles. The <equinox> value is a number.

For fixed topocentric coordinates, the structure is:

```
{
  "type": "fixed",
  "ha": <ha>,
  "delta": <delta>
}
```

The <ha> and <delta> values are angles.

For the zenith, the structure is:

```
{
  "type": "zenith"
}
```

For the idle position, the structure is:

```
{
  "type": "idle"
}
```

For a solar system body, the structure is:

```
{
  "type": "solarsystembody",
  "number": <number>
}
```

The <number> is a number and refers to the number part of the minor-planet designation. For example, for (388188) 2006 DP_{14}, it would be `388188`.

18.6 Commands

The <command> value is a string representing the Tcl command that will be run to execute the visit. Here we describe the three main commands of interest to science blocks and omit the other commands that are used in calibration blocks.

Many parameters of commands have default values.

18.6.1 Focus

The `focusvisit` command focuses the focuser of each channel C0 to C5.

The parameters are:

- `filter`: the filter in which to focus. The default is `i`.
- `exposuretime`: the exposure time in seconds. The default is `5`.

Examples:

```
"focusvisit"
"focusvisit z"
"focusvisit r 10"
```

18.6.2 Pointing Correction

The `pointingcorrectionvisit` command attempts to correct the pointing.

The parameters are:

- `filter`: the filter in which to expose. The default is `i`.
- `exposuretime`: the exposure time in seconds. The default is `15`.

Examples:

```
"pointingcorrectionvisit"
"pointingcorrectionvisit z"
"pointingcorrectionvisit z 5"
```

18.6.3 Grid

The `gridvisit` command takes exposures in possibly multiple filters over grid of dithers.

The parameters are:

- `gridrepeats`: The number of times the whole grid is repeated.
- `gridpoints`: The number of points in the grid.

  Valid values are 1 to 9.

  The grid points are distributed in a square that is 1 arcmin to a side. The grid points, in order, are the center, the four corners, and the four midpoints of the sides. So, for example, if a value of 5 is given, the grid will consist of the center and the four corners.
- `exposurerepeats`: The number of exposures taken in each grid repetition for each filter/dither combination.
- `exposuretime`: The exposure time of each exposure.
- `filters`: The filters.

  A list of filters in which to observe.

  Remember that lists in Tcl are surrounded by curly brackets. For example, `{g r i z}`.

  Filters can be repeated. So, for example, to do an ABBA sequence in *g* and *r*, you might use `{g r r g}`.
- `offsetfastest`: Whether to offset fastest (`true`) or change filters fastest (`false`).

  The default is `true`.

  If `offsetfastest` is `true`, the code will observe a whole grid in the first filter, then the observe a whole grid in the second filter, and so on.

  If `offsetfastest` is `false`, the code will observe in each filter at the first grid point, then observe in each filter at the second grid point, and so on.
- `readmode`: The read-mode.

  The default is `fastguidingmode`.

The total number of exposure is the value of `gridrepeats` multiplied by the value of `gridpoints` multiplied by the value of `exposurerepeats` multiplied by the number of `filters`. The total exposure time is this multiplied by the value of `exposuretime`.

Examples:

```
"gridvisit 4 9 1 30 {r}"
"gridvisit 1 5 1 60 {g r i z}"
"gridvisit 1 5 1 60 {640/10 656/3} false"
```

18.7 Managing the Block Queue

The telescope maintains an alert queue and a block queue. We will not discuss the alert queue here, except to note that observations are selected at a higher priority from the alert queue than from the block queue.

The block queue is maintained in a repository in GitHub:

This repository contains block files, shell scripts to generate block files, and a BLOCKS file to specify which block files are loaded, when, and with which priority.

At 00:00 UTC each day (16:00 PDT or 17:00 PST), the telescope control system fetches a copy of the repository from GitHub. At 00:01 UTC each day, it loads blocks from the copy of the repository into the queue. These actions are separate, so that even if the telescope is not able to fetch the latest version of the repository, it will still load the queue using a previous version of the repository.

The blocks that are loaded are specified in the BLOCKS file in the repository.

In the BLOCKS file, empty lines and lines beginning with `#` are ignored.

The remaining lines shall have four obligatory fields possibly followed by additional fields that give a time specification. Fields are separated by tabs or spaces.

The fields are:

1. Action. Either the the word `load` or the word `unload`. This specifies whether the block will be loaded or unloaded.
2. Priority. A letter, with a being highest priority and z being lowest priority.
3. Duplicates. The number of copies of the block file that are loaded or unloaded. This is useful when breaking long observations into shorter blocks; simply set this field to the number times you want to run the shorter block.
4. Block file. This can be a file name or a shell glob pattern to match a set of file names. Omit the trailing `.json`.

After the first four columns, additional optional fields can give a time specification. If no time specification is given, the block files are loaded or unloaded every day. Valid time specifications are:

- Load or unload the blocks on a fixed UTC date.

  In this case, the 5th field is the word `date` and the 6th field specifies the date as YYYYMMDD.

  This is useful when you only want to add blocks to the queue once.

- Load or unload the blocks every N days.

  In the case, the 5th field is the word `day`, the 6th field is a number M, and the 7th field is another number N. The blocks are loaded into the queue when the day of year D (1 to 366) satisfies $M = D \bmod N$.

  Note that by choosing different values of M you can cycle through a set of blocks.

Example BLOCKS file:

```
load   a 1 0004-initial-focus-*
load   b 1 0004-focus-*
load   f 1 2001-smith-*
load   g 1 2000-jones-0      day 0 2
load   g 1 2000-jones-1      day 1 2
load   h 3 2003-harris-0     date 20220218
unload h 3 2003-harris-0     date 20220318
load   i 1 2002-bloggs-0
load   x 1 0001-twilight-flats-evening-0
```

Chapter 19

Archive

19.1 Introduction

The control system generates many data files during operations.

Most of the data files are organized by first date and then component. For example, all files for the UTC date YYYYMMDD generated by the sensors component are located in

```
/usr/local/var/tcs/YYYYMMDD/sensors/
```

Some components have subdirectories at the top level for data files that are applicable to more than one night. For example, the selector maintains the alert files in

```
/usr/local/var/tcs/selector/alerts/
```

These files are copied from the control system computers at the telescope to the archive. This is a central NAS on the private transients subnetwork at the OAN. Public access is via SSH, RSYNC, HTTP access to `transients.astrossp.unam.mx`. The NAS is shared by the control system computers and the data pipelines for RATIR, COATLI, DDOTI.

The archive volume on the NAS is mounted on other computers on the transients network at:

```
/nas/archive-ddoti/
```

The data files on the control system computers are copied by rsync to the subdirectory `raw` in the archive volume. The log files are copied every minute, the FITS data and header files every five minutes, and the other files every hour.

19.2 Logs

The log files are created under

```
/usr/local/var/tcs/YYYYMMDD/log/
```

They are mainly of interest to the engineering and operations team.

19.3 Image Files

The image files are created under

```
/usr/local/var/tcs/YYYYMMDD/executor/images/
```

The files are created below this directory in subdirectories whose names are the program, block, and visit identifiers. For example, the files for program 2022A-2001, block 10, visit 0 are created in

```
/usr/local/var/tcs/YYYYMMDD/executor/images/2022A-2001/10/0/
```

The base name of each image created by the executor is the UTC time in ISO 8601 basic combined format followed by the channel name (e.g., `C0`, `C1`, `C2`, . . .), followed by a letter indicating the type of exposure (`o` for object, `f` for flat, `b` for bias, and `d` for dark). For example,

```
20220405T072311C0o
20220405T072341C0b
20220405T072351C0f
20220405T072411C0d
```

For each image there are two files: the full FITS image compressed losslessly with fpack (with suffix `.fz`) and a text version of the header (with suffix `.fits.txt`). In the text version, each record is separated with a newline character.

19.4 FITS Header Records

The FITS header records are largely self-documented by comments. However, these are the most relevant header records for searching for particular data:

- `DATE-OBS`: The UTC date of the start of the exposure.
- `CCD_NAME`: The channel (e.g., `C0`, `C1`, `C2`, . . .).
- `EXPTIME`: The exposure time (seconds).

- `EXPTYPE`: The exposure type (e.g., `object`, `flat`, `bias`, `dark`).
- `FILTER`: The selected filter name.
- `BINNING`: The detected binning (pixels).
- `READMODE`: The detector read mode.
- `PRPID`: The proposal identifier (integer).
- `BLKID`: The block identifier (integer).
- `VSTID`: The visit identifier (integer).
- `STRSTRA`: The J2000 RA of the target at the start of the exposure (degrees).
- `STRSTDE`: The J2000 declination of the target at the start of the exposure (degrees).
- `STROBHA`: The observed HA of the target at the start of the exposure (degrees).
- `STROBDE`: The observed declination of the target at the start of the exposure (degrees).
- `STROBAZ`: The observed azimuth of the target at the start of the exposure (degrees).
- `STROBZ`: The observed zenith distance of the target at the start of the exposure (degrees).
- `STROBAM`: The observed airmass of the target at the start of the exposure.
- `SMNZD`: The observed zenith distance of the Moon at the start of the exposure (degrees).
- `SMNIL`: The illuminated fraction of the Moon at the start of the exposure.
- `SMNTD`: The distance between the target and the Moon at the start of the exposure (degrees).
- `SSNZD`: The observed zenith distance of the Sun at the start of the exposure (degrees).

For all of the records that begin with `S` and refer to the start of the exposure, there is another record that begins with `E` and refers to the end of the exposure. So, for example, `STROBAM` gives the airmass at the start of the exposure and `ETROBAM` gives the airmass at the end of the exposure.