Red Buttes Observatory Manual

July 19, 2022

1 On-Site Manual Observations

1.1 Before You Travel to the Telescope

1. Check the local weather station, which can be accessed at *www.ambientweather.net*, a quality Radar and Satellite map, such as *www.weather.gov* and *radar.weather.gov*, and any other appropriate forecast to assess the viability of observing. Observing is only viable if there is no precipitation, humidity is at or below 85%, and the wind speed is at or below 50 km hr^{-1}.

2. Obtain the key (#955) to the observatory. This is stored in PS 213 — the Dale Computer Lab. Alternatively, a key is stored at the observatory in a keybox, which can be accessed with code *0127*.

1.2 Setup

1. Enable power at the observatory.

   (a) Log into *RBO_1*.

   (b) Log into the PDU webpage, 10.214.214.205, from any web browser.

   (c) On the PDU webpage, in the *Actions* tab, select *Control* from the side.

   (d) Select *Start Ramp Sequence* from the *Control Command* drop down menu.

   (e) Select *Execute Command*.

   (f) Log into *RBOTCS* computer

   The PDU webpage can operate very slowly with a delay of ten seconds for an action to occur and a delay of one minute for the webpage to reflect the actions performed.

2. Check the local weather station, which can be accessed at *www.ambientweather.net*, a quality Radar and Satellite map, such as *www.weather.gov* and *radar.weather.gov*, and any other appropriate forecast to assess the viability of observing. Observing is only viable if there is no precipitation, humidity is at or below 85%, and the wind speed is at or below 50 km hr^{-1}.

3. Camera Setup

   (a) Launch MaxIm DL from the desktop shortcut.

   (b) Use the keyboard shortcut *Ctrl+W* or select *Camera Control Window* from the *View* menu.

   (c) In the *Setup* sub-menu of the *Camera Control Window*, select *Connect*.

   (d) Once connected to the camera, select the *Cooler* button under *Camera 1* and choose an appropriate setpoint, usually -15° C. Note that the camera can achieve a temperature at maximum 35° C below ambient.

4. Open the in-dome web camera webpages, 10.214.214.220 and 10.214.214.221, and turn on *Night Mode*. Remember to disable *Night Mode* when imaging begins.

5. Telescope Setup

   (a) Open the DFMTCS shortcut from the desktop. This program tends to minimize itself and cannot be refocused normally. This is fixed by opening the *On-Screen Keyboard* and using the shortcut *Windows+↑* with the DFM program active.

   (b) Open the *Miscellaneous* window from the *Telescope* menu.

   (c) Under the *Switches/Mirror Door* tab, select the two red Dome boxes to turn the dome on and enable tracking.

   (d) Under the *Display Epoch/Dome Shutter* tab, select *Shutter Open*, if it is safe to do so. Check the *Disable Cloud Sensor Input* box.

   (e) Under the *Switches/Mirror Door* tab, select the *Open Mirror Door* once the dome shutter has finished opening and the *Activity Message* window is clear.

   (f) In the *Rates* window under the *Telescope* menu, set the *R.A. Rate* to $15.029'' \text{ s}^{-1}$.

1.3 Observation

1. In the *Movement* window under the *Telescope* menu, enter the coordinates and epoch of the target in the *Slew Position* tab.

2. Select apply and ensure that the coordinates and epoch have populated the *Next Object* line in the main window.

3. If the *Operating Mode* does not read *TARGET OUT OF RANGE*, then it is safe to select *Start Slew*. The telescope will slew to the target and begin tracking.

4. Imaging

   (a) In MaxIm DL, under the *Exposure* tab in the *Camera Control* window, set the exposure type to *Single* on the right hand side.

   (b) The filter can be selected in the bottom left of the *Expose* tab.

(c) Typically a 10^{th} magnitude star reaches an acceptable signal to noise with a 45 s exposure. Adjust exposure time accordingly and take a sample exposure. That is to say:

$$t \approx 45\,(2.5)^{m-10}$$

(d) Photometry can be checked using the *Ctrl+I* keyboard shortcut.

(e) If the exposure looks acceptable, then select the *Autosave* bubble and button.

(f) In the *Options* arrow menu, select *Set Image Save Path*.

(g) Set the Autosave Filename, exposure slots, filters, filename suffix, exposure length, and repetitions.

(h) Review the exposure sequences, then select *Apply* and *OK*.

(i) To start the the exposure sequences, select *Start*.

5. Repeat the above *Observation* steps for all targets until all targets have been imaged.

1.4 Shutdown

1. Set the camera's cooler to *Warm Up*.
2. Close the mirror doors.
3. Close the dome shutters, once the mirror doors are closed.
4. Set the dome to go *Home*, but leave the dome *On* until it has reached an azimuth of 270° and the *Activity Message* is clear. Once the dome has stopped moving, turn it *Off*.
5. Slew the telescope to zenith (i.e. α: local sidereal time, δ: 41:19:00).
6. Set the *R.A. Tracking Rate* to $0''$ s^{-1}.
7. Close the DFMTCS program.
8. Once the camera has reached less than 5% power, it is safe to disable the cooler.
9. Disconnect the camera and close MaxIm DL.
10. Turn the computer off.
11. On the PDU webpage, in the *Actions* tab, select *Control* from the side.
12. Select *Start Shed Sequence* from the *Control Command* drop down menu.
13. Select *Execute Command*.
14. Return the key to where it was obtained.

2 Remote Manual Observations

2.1 VNC Installation

1. Install an X-Windows system on your laptop. Mac already has one installed. For windows, use *Cygwin*.

2. Inside the X-Windows system, create and cd to your $\sim$*/.ssh* directory.

3. Create a text file called *config* and type these two lines:

   Host zem.uwyo.edu
     ProxyCommand ssh -e none chip@zulu.uwyo.edu exec nc %h %p

4. Replace *zem* with your department computer name, and *chip* by your username.

5. In your home directory, create a file called *tozem.com*. Inside, type this line:

   ssh -L 1208:zem.uwyo.edu:5908 chip@zem.uwyo.edu

6. The 8 can be replaced by 2, 3, or 4, as long as the same is done in later steps.

7. Replace *zem* with your department computer name, and *chip* by your username.

8. Make the file executable by running *chmod +x tozem.com*.

9. In a terminal execute *./tozem.com*. You will be prompted for you system password twice, once for zulu and once for your desktop. You may get a warning the first time you do this prompting if you want to continue. Do so only once to allow your computer to store the host key for zulu. Subsequent prompts may be a virtual attack and should be regarded as suspicious.

10. If your computer fails to connect because it does not have the needed host keys, create a file inside the $\sim$*./ssh* folder called *known_hosts*.

11. From someone else in the department, acquire a list of known hosts and copy the host keys into this file.

12. Leaving this ssh connection open, download and install *VNCViewer* from *RealVNC*.

13. While installing, run *vncpasswd* in the same terminal that is connected to your department computer. This is where you will set your VNC password, which *cannot* be the same as your department password.

14. Launch the VNC client. In the top bar, type *localhost:1208*. It should prompt you for your VNC password. Once signed in, you should see the lock screen for you department computer.

2.2 Setup

1. Log into Dra using the *rboremote* user. All usernames and passwords for computers on the RBO network are located in Appendix **??**, Table **??**.

2. Enable power at the observatory.

   (a) Log into the PDU webpage, 10.214.214.205, from any web browser.

   (b) On the PDU webpage, in the *Actions* tab, select *Control* from the side.

   (c) Select *Start Ramp Sequence* from the *Control Command* drop down menu.

   (d) Select *Execute Command*.

   The PDU webpage can operate very slowly with a delay of ten seconds for an action to occur and a delay of one minute for the webpage to reflect the actions performed.

3. Open a VNC session to the *RBOTCS* computer, 10.214.214.222. This can be done with the *vncviewer* terminal command, *vncviewer 10.214.214.222 -shared &*, or TigerVNC.

2.3 Initiation of Observation Software

1. Check the local weather station, which can be accessed at *www.ambientweather.net*, a quality Radar and Satellite map, such as *www.weather.gov* and *radar.weather.gov*, and any other appropriate forecast to assess the viability of observing. Observing is only viable if there is no precipitation, humidity is at or below 85%, and the wind speed is at or below 50 km hr^{-1}.

2. Camera Setup

   (a) Launch MaxIm DL from the desktop shortcut.

   (b) Use the keyboard shortcut *Ctrl+W* or select *Camera Control Window* from the *View* menu.

   (c) In the *Setup* sub-menu of the *Camera Control Window*, select *Connect*.

   (d) Once connected to the camera, select the *Cooler* button under *Camera 1* and choose an appropriate setpoint, usually -15° C. Note that the camera can achieve a temperature at maximum 35° C below ambient.

3. Open the in-dome camera webpages and turn on *Night Mode*. Remember to disable *Night Mode* when imaging begins.

4. Telescope Setup

   (a) Open the DFMTCS shortcut from the desktop. This program tends to minimize itself and cannot be refocused normally. This is fixed by opening the *On-Screen Keyboard* and using the shortcut *Windows+↑* with the DFM program active.

   (b) Open the *Miscellaneous* window from the *Telescope* menu.

(c) Under the *Switches/Mirror Door* tab, select the two red Dome boxes to turn the dome on and enable tracking.

(d) Under the *Display Epoch/Dome Shutter* tab, select *Shutter Open*, if it is safe to do so. Check the *Disable Cloud Sensor Input* box.

(e) Under the *Switches/Mirror Door* tab, select the *Open Mirror Door* once the dome shutter has finished opening and the *Activity Message* window is clear.

(f) In the *Rates* window under the *Telescope* menu, set the *R.A. Rate* to $15.029'' \text{ s}^{-1}$.

2.4 Observation

1. In the *Movement* window under the *Telescope* menu, enter the coordinates and epoch of the target in the *Slew Position* tab.

2. Select apply and ensure that the coordinates and epoch have populated the *Next Object* line in the main window.

3. If the *Operating Mode* does not read *TARGET OUT OF RANGE*, then it is safe to select *Start Slew*. The telescope will slew to the target and begin tracking.

4. Imaging

   (a) In MaxIm DL, under the *Exposure* tab in the *Camera Control* window, set the exposure type to *Single* on the right hand side.

   (b) The filter can be selected in the bottom left of the *Expose* tab.

   (c) Typically a 10^{th} magnitude star reaches an acceptable signal to noise with a 45 s exposure. Adjust exposure time accordingly and take a sample exposure. That is to say:
   $$t \approx 45\,(2.5)^{m-10}$$

   (d) Photometry can be checked using the *Ctrl+I* keyboard shortcut.

   (e) If the exposure looks acceptable, then select the *Autosave* bubble and button.

   (f) In the *Options* arrow menu, select *Set Image Save Path*.

   (g) Set the Autosave Filename, exposure slots, filters, filename suffix, exposure length, and repetitions.

   (h) Review the exposure sequences, then select *Apply* and *OK*.

   (i) To start the the exposure sequences, select *Start*.

5. Repeat the above *Observation* steps for all targets until all targets have been imaged.

6. Data stored in *E:\Data* is automatically transfered by a WinSCP script to */dra2/RBO/* that starts 15 minutes after the user has logged in. To manually backup data, double-click the file on the desktop named *WinSCP Autosync*.

2.5 Shutdown

1. Set the camera's cooler to *Warm Up*.
2. Close the mirror doors.
3. Close the dome shutters, once the mirror doors are closed.
4. Set the dome to go *Home*, but leave the dome *On* until it has reached an azimuth of 270° and the *Activity Message* is clear. Once the dome has stopped moving, turn it *Off*.
5. Slew the telescope to zenith (i.e. α: local sidereal time, δ: 41:19:00).
6. Set the *R.A. Tracking Rate* to $0''$ s^{-1}.
7. Close the DFMTCS program.
8. Once the camera has reached 0° C, it is safe to disable the cooler.
9. Disconnect the camera and close MaxIm DL.
10. Turn *DFMTCS* off from the Start menu.
11. On the PDU webpage, in the *Actions* tab, select *Control* from the side.
12. Select *Start Shed Sequence* from the *Control Command* drop down menu.
13. Select *Execute Command*.

3 Automated Observations

3.1 Setup

1. Log into Dra using the *rboremote* user. All usernames and passwords for computers on the RBO network are located in Appendix **??**, Table **??**.

2. Enable power at the observatory.

   (a) Log into the PDU webpage, 10.214.214.205, from any web browser.

   (b) On the PDU webpage, in the *Actions* tab, select *Control* from the side.

   (c) Select *Start Ramp Sequence* from the *Control Command* drop down menu.

   (d) Select *Execute Command*.

   The PDU webpage can operate very slowly with a delay of ten seconds for an action to occur and a delay of one minute for the webpage to reflect the actions performed.

3. Open a VNC session to the *RBOTCS* computer, 10.214.214.222. This can be done with the *vncviewer* terminal command, *vncviewer 10.214.214.222 -shared &*, or TigerVNC.

3.2 Initiation of Observation Software

1. Open MaxIm DL and minimize it.

2. Open DFMTCS and minimize it.

3. Open the *RBO Automated Observing* shortcut and enter in the details of your target.

4. Verify, using airmass plots and observation charts, the target is visible for the time specified (i.e. Airmass less than 2.75 and Hour Angle between 10 and -10).

5. Make sure to follow the given legend for using the appropriate filter. E.g. if you would like to observe in R, you would enter 2 in the field that says filter.

6. Click on *SAVE* once and then click on *RUN*.

7. A dialog box will appear asking for the destination to save all the observations. Enter the appropriate directory path in the window. After that, a terminal will pop up.

8. Once information is printing to the terminal, the setup is complete and the VNC session can be closed.

3.3 In the Morning

1. Check your data and ensure the telescope was shut down correctly.
2. Close all open tabs, and verify the dome is in the correct home position.
3. Shut down the *RBOTCS* Computer.
4. On the PDU webpage, in the *Actions* tab, select *Control* from the side.
5. Select *Start Shed Sequence* from the *Control Command* drop down menu.
6. Select *Execute Command*.

4 Taking Calibration Images

4.1 Setup

1. Check the local weather station, which can be accessed at *www.ambientweather.net*, a quality Radar and Satellite map, such as *www.weather.gov* and *radar.weather.gov*, and any other appropriate forecast to assess the viability of observing. Observing is only viable if there is no precipitation, humidity is at or below 85%, and the wind speed is at or below 50 km hr^{-1}.

2. Setup the Telescope as you would for manual observations. Refer to the Operations Manual for this.

4.2 Taking Calibration Images - Flats

1. In MaxIm DL, select *Autosave* under the *Exposure* tab in the *Camera Control window*.

2. Change the filename under *Autosave Filename* to "f-".

3. Set *Delay First* to 0 and *Delay Between* to 0.

4. In *Slot* 1, set *Type* to Flat, *Filter* to the filter you wish to take your flats in, *Exposure* to whatever is appropriate based on current twilight, but no less than 10 seconds, *Readout Mode* as Monochrome and *Repeat* is set to 1. Make sure *Binning* is set to 2.

5. Select the arrow button next to *Options* and select *Set Image Save Path* and select the appropriate directory.

6. Review the exposure sequences, then select *Apply* and *OK*.

7. In the DFMTCS window, select the *Slew Position* tab under the *Movement* window in the *Telescope* menu.

8. Slew the telescope to an acceptable clear sky location, preferably near zenith e.g. *RA* within 2 hours of zenith and *Dec* within 10 degrees of zenith.

9. In the same window, select *Zenith/Offset*.

10. Set an appropriate offset for both *RA* and *Dec*, between 100' and 1000'.

11. Select *Start* in the *Camera Control window* in MaxIm DL.

12. During the delay between the images, press *Apply* underneath the offsets, and then *Start Slew*, in order to avoid taking images of the same patch of the sky.

13. Continue this until the image taking process has been completed.

4.3 Taking Calibration Images - Darks

1. In MaxIm DL, select *Autosave* under the *Exposure* tab in the *Camera Control window*.
2. Change the filename under *Autosave Filename* to "d-".
3. Set *Delay First* to 0 and *Delay Between* to 2.
4. In *Slot* 1, set *Type* to Dark, *Exposure* to whatever is appropriate based on your exposure time of your targets, *Readout Mode* as Monochrome and *Repeat* is set to usually around 5. Make sure *Binning* is set to 2.
5. Select the arrow button next to *Options* and select *Set Image Save Path* and select the appropriate directory.
6. Review the exposure sequences, then select *Apply* and *OK*.
7. Make sure both the Mirror doors and the Dome Shutters are closed.
8. Select *Start* in the *Camera Control window* in MaxIm DL.

4.4 Taking Calibration Images - Biases

1. In MaxIm DL, select *Autosave* under the *Exposure* tab in the *Camera Control window*.
2. Change the filename under *Autosave Filename* to "b-".
3. Set *Delay First* to 0 and *Delay Between* to 2.
4. In *Slot* 1, set *Type* to Bias, *Readout Mode* as Monochrome and *Repeat* is set to usually around 30. Make sure *Binning* is set to 2.
5. Select the arrow button next to *Options* and select *Set Image Save Path* and select the appropriate directory.
6. Review the exposure sequences, then select *Apply* and *OK*.
7. Make sure both the Mirror doors and the Dome Shutters are closed.
8. Select *Start* in the *Camera Control window* in MaxIm DL.

5 Troubleshooting

The dome continuously rotates in a circle.

In the TCS software in the *Miscellaneous* menu under *Telescope*, turn the dome tracking to Home and then turn the Dome off. After this, turn the dome power back on and then enable tracking. If the dome does not recognize Home it may have lost contact with the Home foot switch. Check the switch position onsite and make sure it is in contact with the dome railing. Flip the switch back up if the dome has pushed it into the wrong position.

The dome is pointing in the wrong direction.

Move the telescope back to zenith and the dome back to home. If the dome fails to return to the corrent location, turn the dome tracking to Home and turn the dome off in the TCS software in the *Miscellaneous* menu under *Telescope*. Use the *Dome Left*, *Dome Right*, and *Dome Stop* buttons in the *Display Epoch/Dome Shutter* tab to manually move the dome to the correct dome location (i.e. the two black strips are aligned). Close the Mirror Doors and Dome Shutter, and when it is safe to do so close and reopen the TCS software. The dome should be at home and read an azimuth of 270.

Sidereal tracking is too fast or too slow.

Adjust the rate in the *Rates* menu under *Telescope* until the RA remains constant or nearly so. Once an appropriate rate has been found navigate to the Job778TCS directory on the desktop and open "WinPNTM_With4x.exe". Select "RBO1.pat". Select the *Adjust XMTR*. The desired tracking rate is 15 and the observed rate is the rate experimentally found earlier. Once the program has calculated the new XMTR value, substitute it for the current value and select *Save Initialization File*.

Pointing Offset Errors.

1. Move to a bright star using the DFM TCS software's *Telescope* under *Movement* tab. Be sure to input correct Epoch as well as RA/Dec. (Make sure the telescope is tracking before continuing).

2. Find the bright star in the sky and center it on the instrument field by using hand-paddle controls. This is most easily done by going to the observatory and using the small telescopes mounted on the North side of the main telescope housing. With very bright stars (1-3 mag) centering can also be achieved by following defraction spikes back to their source directly on the imager if the star is nearby to begin with.

3. Reset the location of the telescope in the DFM TCS software's *Initialization* under *Telescope Position* tab. Again input the RA/DEC and Epoch of the bright star you have now centered the instrument on. (Be sure NOT to click the 'use next position' button as your correcting slews will be counted).

4. Once you have saved the position on the bright star in the *Initialization*, try to slew to another bright star following step 1. If the method was successful your new star should be centered on the instrument.

5. Alternatively, the telescope can be manually set to zenith by using the level attached onsite and leveling the telescope in all directions. That position can then be set as zenith in *Telescope Position* in *Initialization*.

Telescope is pointed at the ground and will not move.

At the observatory, manually shut down TCS as specified in steps 1-9 in the shutdown procedure. Once the telescope no longer responds to hand paddle actions, head into the dome and physically move the telescope back into position. This will take a bit of force. If the telescope moves itself back, shut down the observatory completely. Once the telescope is near zenith, reinitialize the TCS software and verify the telescope thinks it is near zenith. If not, follow the above guide to the reset the pointing.

Images are blank or there are no stars.

Verify both Dome Shutters and Mirror Doors are open, in addition to all lights being off.

1. If the images are uniformly 65000 counts, which will appear completely black, there is too much light from either the sun or dome lights. Turn off all lights and try images again. Wait 5 minutes to try flats again.

2. If the images are spotty, yet there are no stars, there is likely clouds. Images with clouds will always have higher counts than images with the Mirror Doors or Dome Shutters Closed. For flats, move to a clear spot of the sky. For science images, verify the weather is acceptable and wait.

3. If the images have large white or black portions, verify *Night Mode* is off for both cameras. Other causes may be moonlight if the target is near the bright moon, or rarely, condensation on the mirror when the humidity is too hight. If humidity is suspected, shutdown the telescope until weather conditions are acceptable.

The weather station is not reading properly in the automated script.

If the weather station reads correctly on *ambientweather.net*, but will not load properly at its IP address or in the automated script, it likely needs a firmware update. On the *RBOTCS*

computer, launch the program titled *IP Tools*. Enter the IP address of the *RBOTCS* computer and press *OK*, then press *Search*. You should see the weather station information listed in a row. Click on the row, and select *Upgrade*. Select *Upgrade Firmware* and follow the rest of the steps as given in the program. If the weather station still does not read properly or reads too slowly, verify the information update delay is set to one minute at *10.214.214.207/livedata* under the *Settings* tab.

The internet is slow or the the PDU webpage is unresponsive.

Often, the problem can be fixed by manually resetting the internet at the observatory. Onsite, unplug and replug both ends of the cable going into the small box on the outside of the observatory on the south wall. You may need a ladder to reach it. Inside, unplug and replug both the power and the internet to the rooftop satellite, located in the back of the server rack. Finally, unplug and replug the power for the router, which will interrupt all connections to the telescope for a few minutes. If the internet has still not improved, contact IT and wait. Weather can often affect internet connectivity.

The telescope focus is stuck.

Occasionally, the focus can reach one of the limits and become stuck. Using the handpaddle onsite, move the telescope to zenith if the focus is too high, and as close to the horizion as possible if the focus is too low. Again using the handpaddle, manually adjust the focus back into limits. If needed, reset the focus to acceptable limits. In the *Initilization* window under the *Telescope* menu in the *Other Positions* tab, reset the focus position to approximately 36.5 while in the middle of the focus range.

The lower shutter will not open.

In order for the lower shutter to open, the upper shutter must be open enough to release the switch loctated near the bottom of the shutter. Rarely, this switch can become stuck in the depressed position. Onsite, carefully climb and locate the black switch near the bottom of the upper shutter and depress it a few times. Use the manual dome shutter controls located over the door to the dome to verify the proper actuation of the shutters. If no attempts to clean or fix the switch are successful, a new switch may need to be ordered, and is the same as the rest of the switches in the dome.

A Usernames and Passwords

RBO uses the 10.214.214.0/24 IP address block. A notable exception is the *Dra* computer which hosts the data for reduction. This computer is located at 10.212.212.214.

Table 1: Relevant network locations, usernames, and passwords for observation.

IP address	Device	Username	Password
200	RBO_1	Observer	iii2skY
205	PDU	admin	78Vista
206	UPS	apc	78VistaGrande
207	Ambient Weather Station	jrothenb@uwyo.edu	weather_rbo
220	In-dome Webcam 1	admin	78Vista
221	In-dome Webcam 2	admin	78Vista
222	RBOTCS	DFM Engineering	add_@stra!
222	TCS VPN		78Vista!

On the local computer network there are two users which are commonly used:

Table 2: Local network users.

Username	Password
RBO	iii2skY
rboremote	78Vista!

The Ambient Weather weather station can be accessed through www.ambientweather.net using the username *jrothenb@uwyo.edu* with password *weather_rbo*. Lastly, the RBO webpage is managed by the RBO account. The login to password protected pages is *iii2skY*

B File Locations

1. All observation plans are located at *C://Users/RBO/Desktop/Observation/Plans/*, and are saved as *yyyymmdd.txt*.

2. All Python files, including the automated script, are stored at *C://Users/RBO/Desktop/Observation/*.

3. All data is stored on the external hard drive, currently listed as *E://Data/*.

4. The nigtly backup script is stored at *C://ProgramFiles/WinSCP/syncrbo.bat*, and runs as a startup program with a 15 minute delay. A shortcut to the backup scrip is stored on the desktop as *WinSCP Autosync*.

5. For sharing data externally, cd to */d/dra2/RBO/* and run the following command, with the proper file locations and dates:
tar -cvf /d/www/RBO/public_html/PennSt/20211223_RBO.tar 20211223.

C Helpful Websites

The following is a list of helpful websites for planning observations.

1. For checking weather and radar, *www.weather.gov* and *radar.weather.gov*.
2. For checking observation conditions, *www.cleardarksky.com/c/RdBtsObWYkey.html*.
3. For finding transits, *astro.swarthmore.edu/transits/transits.cgi*.
4. For finding targets in the night sky, *aladin.u-strasbg.fr/AladinLite/*. Note that for TESS targets, the TIC number must be entered, rather than the TOI number.
5. For checking the visibility of targets, *catserver.ing.iac.es/staralt/*.
6. For converting UTC to JD and vice versa, *www.aavso.org/jd-calculator*.

D Miscellaneous Information

The currently equipped weather station is an Ambient Weather *WS-1550-IP*. The currently equipped camera is an Apogee Alta F16M. With 2x2 on-chip binning, the camera has a gain of 1.39 e-/ADU, read noise of 15.3 e-, dark current of 0.139 e-/s/pix, and plate scale of 0.731"/pix.

As of writing, these are the approximate focuses for RBO at different temperatures. For transits, the focus will need to be set slightly higher as to spread the light out. Alternatively, for very bright targets, the diffuser in the filter wheel can be used. Notably, the diffuser replaces the filters, meaning it uses white light.

Table 3: Focus at different temperatures.

Temperature	Approximate Focus
-10° C	N/A
-5° C	N/A
0° C	44.25
5° C	N/A
10° C	N/A
15° C	N/A
20° C	N/A
25° C	N/A
30° C	N/A

The field at RBO is oriented like any other astronomical field, with North to the top, South to the bottom, East to the left, and West to the right.

Table 4: PDU Loads.

Load	Connection
1	Dome Lights
2	Base Plate Power
3	N/A
4	N/A
5	PDU 2
6	CCD Power Bar
7	CCD
8	N/A
9	N/A
10	N/A
11	N/A
12	N/A
13	N/A
14	N/A
15	N/A
16	Ambient Weather Station

As of writing, the needed loads on the PDU are 2, 3, 5, 6, 7, 9, 13, and 16.

Table 5: Filter Locations.

Location	Filter
0	B
1	V
2	I
3	R
4	Empty
5	Empty
6	Diffuser
7	U

E Picking Targets

The following selection criteria apply for transiting exoplanets.

1. For transiting exoplanet candidates, RBO time is most useful verifying timings, rather than following up already known planets. As such, the most recent unconfirmed candidates are the recommended targets. For TESS objects these are the 3xxx and 4xxx TOIs.

2. In order to balance signal to noise and timing precision, it is recommended to select targets brighter than 14^{th} magnitude and limit images to under 240 seconds.

3. The precision of RBO is approximately 2ppt, and as such all targets selected should have transit depths larger than 2ppt.

4. Ideally, all transit observations should have at least half an hour of out of transit time on either side of the transit, such that data reductions are more accurate.

5. Additionally, the entirety of the transit and out of transit should be visible (i.e. Airmass less than 2.75 and Hour Angle between 10 and -10).

6. If using the Swarthmore Transit Finder, verify the target is a Planetary Candidate, not an Ambiguous Planetary Candidate or False Positive. (Priority 3 and above).