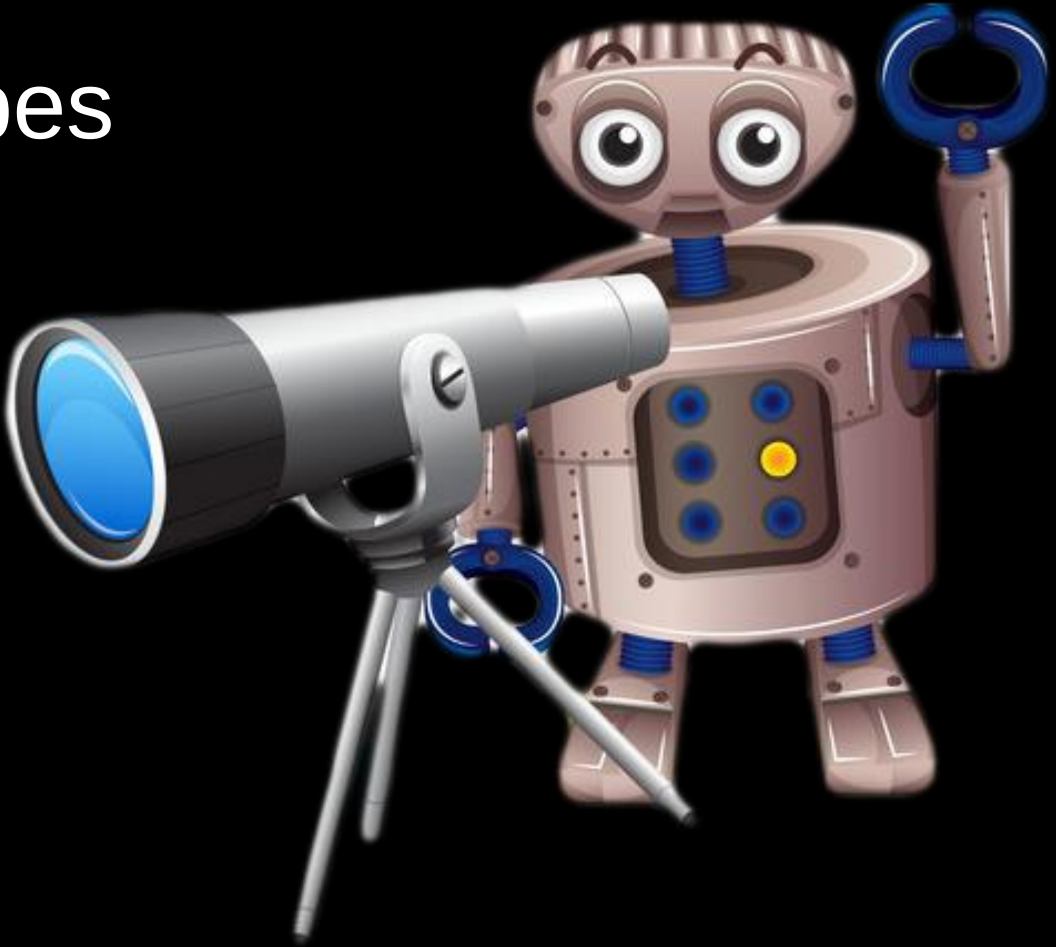
Robotic Telescopes



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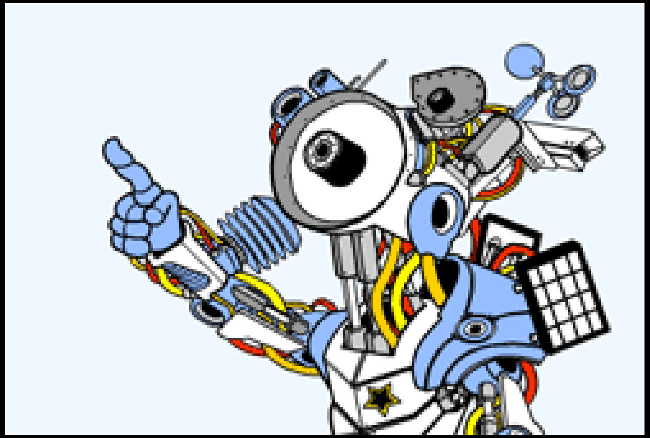
Robotic Telescopes – What and Why?

Simply a robotic telescope is a telescope system that can operate autonomously. It is principally a system used for imaging whether this is for capture of data for images of objects or scientific use.

This could be as simple as something at the bottom of the garden or a system on the other side of the world.

Robotic systems are useful because they allow you to capture data automatically. You can be doing something else during unsociable hours like sleeping!

Systems such as this also allow you to capture data in more favourable locations for seeing, darkness and objects.



What is Needed? – The Basics

The basic components for a robotic system are just a telescope system that can be controlled by computer. Robotic does not necessarily mean ‘Remote System’. It is just a system that can operate on its own.

For more advanced systems that are to be left unattended, then you also need secondary equipment that can control power, monitor the weather and react when conditions deemed as unsuitable or unsafe are met. Typically this also includes an observatory whose roof is motorised.

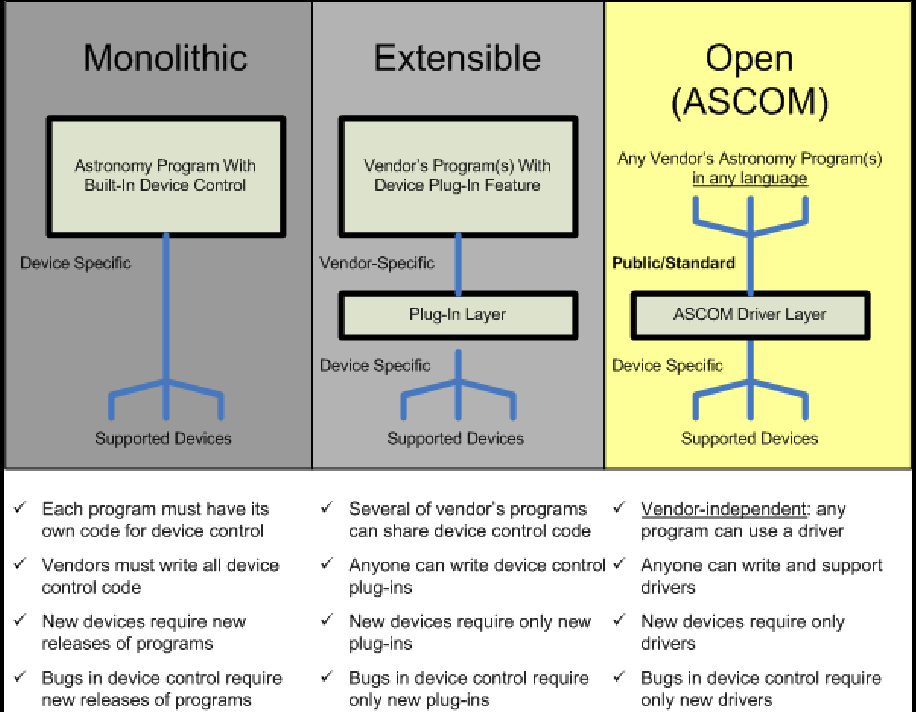
For remotely accessed systems a good internet connection is also needed, although low latency rather than speed is preferable.

The Telescope Control System

Any type of telescope system can be used as long as it can be controlled by computer and supports either ASCOM (for Windows) or INDI (for Linux) Drivers. Some devices, like DSLR cameras have dedicated drivers and can be used, but compatibility should be checked.

These drivers basically act as translators. For example they allow an application like capture software to control different brands of camera. The different cameras might all use different control languages or protocols. The driver converts the language the control application speaks to one which the hardware understands.

Drivers for a wide range of devices are now available.



The Telescope Control System

Choosing components for a robotic system needs to be done with some care. What will work depends on what you want to achieve. If you are going to remain close to your system and will turn it on / off etc manually less thought is needed.

There are products that suggest a simple route to full unattended operation, like the Primaluce Eagle. However these do not offer the full connectivity or power management needed for true remote operation but do allow unattended operation. They simply replace your PC. A better solution is actually the Astrel Smart Camera, but that also is not a complete solution on its own.

Primaluce Eagle

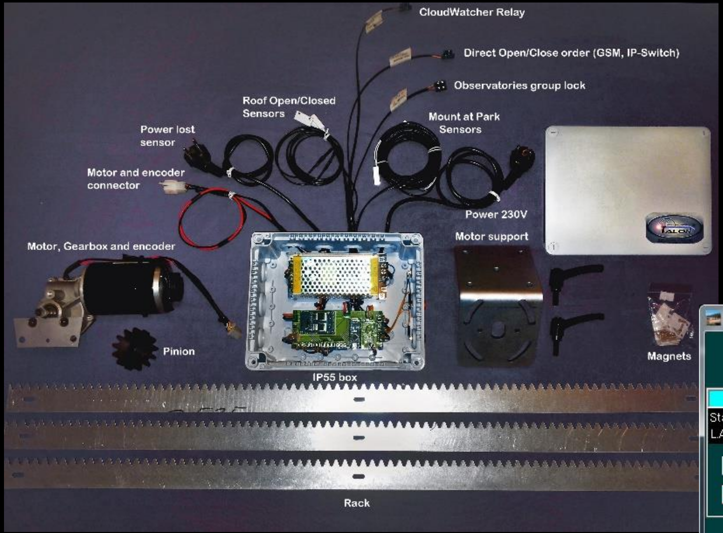
Astrel Smart Camera

The Automated Observatory

For true remote operation you need an observatory with a motorised roof (a simple Roll Off Roof type or Dome) but this needs to be controllable. Motorising a roof is simple and no different to any other system that uses a motor to open and close something. Roller blinds, windows, gates and garage doors are common examples.

Ideally the roof system should be computer controlled as this will allow integration with other Astronomy software.

If using a dome, a second level of control is needed as not only must you open the dome, this must track with the telescope. This also requires your telescope to be installed correctly.



Talon Roof Controller

This system can react to events and also command a mount to park safely

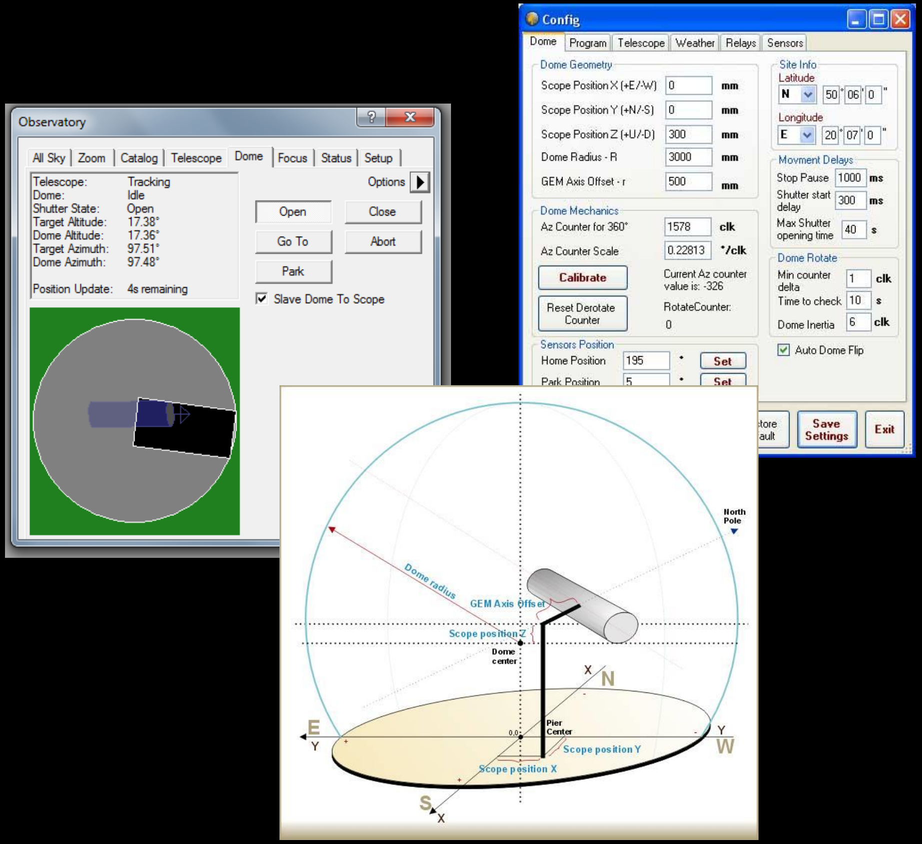
The Automated Observatory - Domes

Telescopes on a fork mount with an equatorial wedge or a normal EQ Mount need to be *offset* because the centre of the telescope *axis* needs to be in the middle of the dome, not the pier.

Get this wrong and the opening of the dome will not remain synchronised with the mount when both are moving. An Alt-Azimuth mount can be placed centrally as its rotational centre is the same as the centre of the dome.

Dome automation requires accurate placement of the telescope and then configuration of the dome drive system to keep the dome slit inline with the telescope axis.

Dome control software then synchronises telescope and dome rotation.

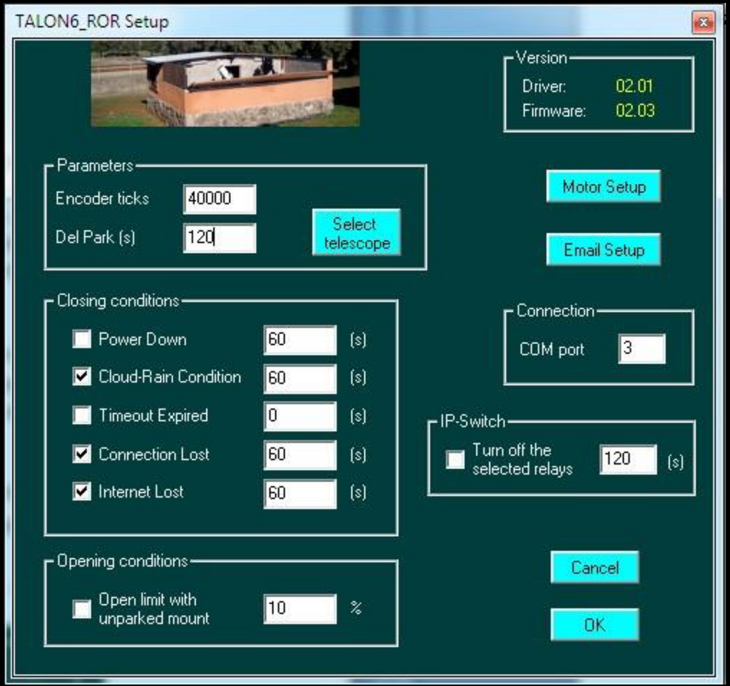


The Automated Observatory

With a computer controlled observatory, other functionality becomes possible.

- If, when in use, your telescope protrudes above the roof line, then it must be parked before the roof can be closed. This is possible with a computerised roof and it also does not necessarily rely on a PC. Domes do not have this problem as the telescope is always within the ‘roof’.

- With a system such as a Talon Roof controller, this will close the roof *after* the mount is parked when an unsafe condition is met. It can do this autonomously as it is only reliant on seeing a contact closure relay activate. It knows the mount is parked because of small magnetic sensors that are placed on the mount axis. As this system is computerised and has an ASCOM driver, it can also be told to close by the capture software.

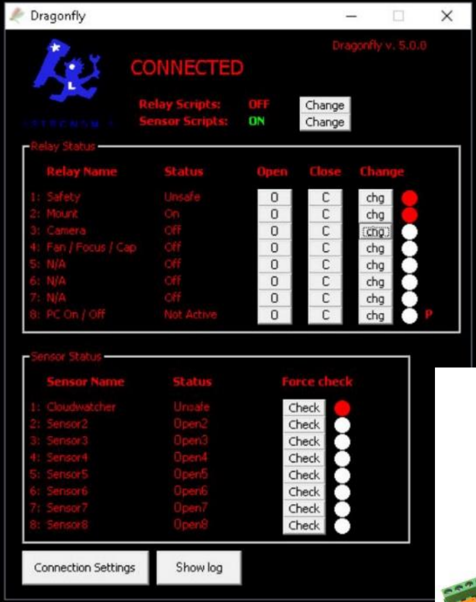


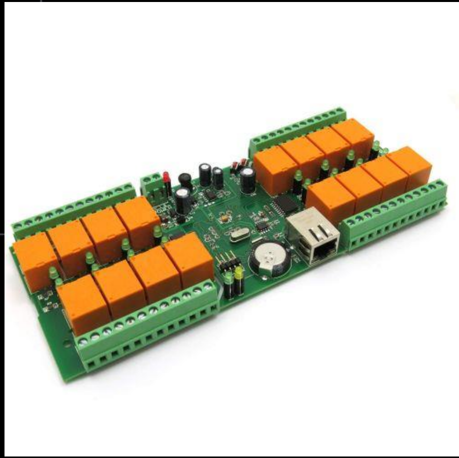
Full System Control

The next level of control is to have full remote control of power and automate responses to events.

Control of power and the ability to turn things on and off remotely is important. You *could* leave everything turned on. However that won't do a dew heater much good or a camera. A PC might eventually crash as operating systems are not designed for 24/7 365 operation. Also, in the event of a power cut, things usually default to an off state so if you don't have a way to turn components on and off, your sunk!

The simplest way to control power is via a relay that can be computer controlled. Many such relays are available. Using such a device allows you to control low voltage and also mains voltage, although the latter should be left alone. Relays can also be pulsed, rather than be maintained. This allows you to mimic actions like the pressing of the power button on a PC.



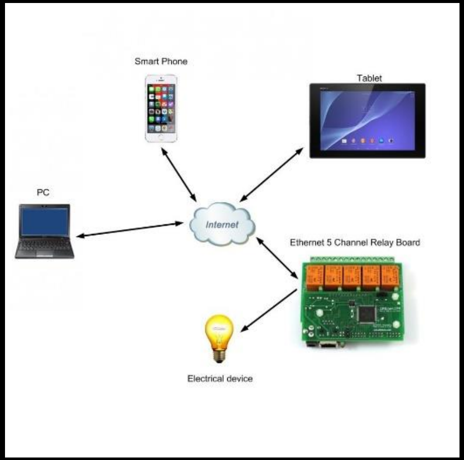


Full System Control

More advanced relay based systems also allow sensing using a contact closure input and conditional logic. This means they can react to external events. Such events might be loss of mains power, temperature, unsafe weather conditions or even a security event.

A modern network enabled relay allows you to access it over the internet directly. You don't need a computer, even a mobile phone can be used.

Opposite is an example of an Astronomy optimised relay, called the Dragonfly, but really any network enabled relay can be used.



Keeping an eye on things

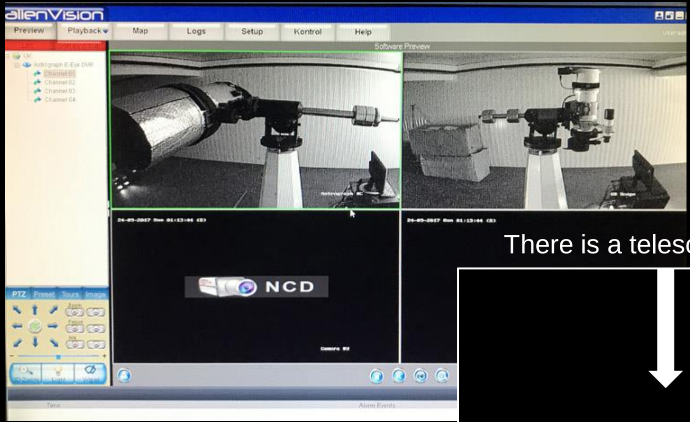
One final and essential piece of equipment needed for any remote system is a CCTV camera. It is important (and comforting) to know that things are actually behaving.

Many types of camera are available for this purpose from simple webcams to exotic specialist CCTV. The two main considerations are;

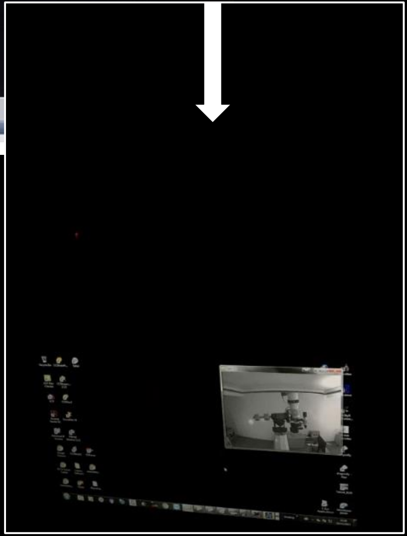
- How to you access the images
- How well they see in low light

The best cameras are analogue types with ‘Sensor Up’ options. These have sensitivity below the level of light provided by starlight without using IR Illumination.

IR Lights are not ideal because they can cause interference to imaging systems



There is a telescope here!



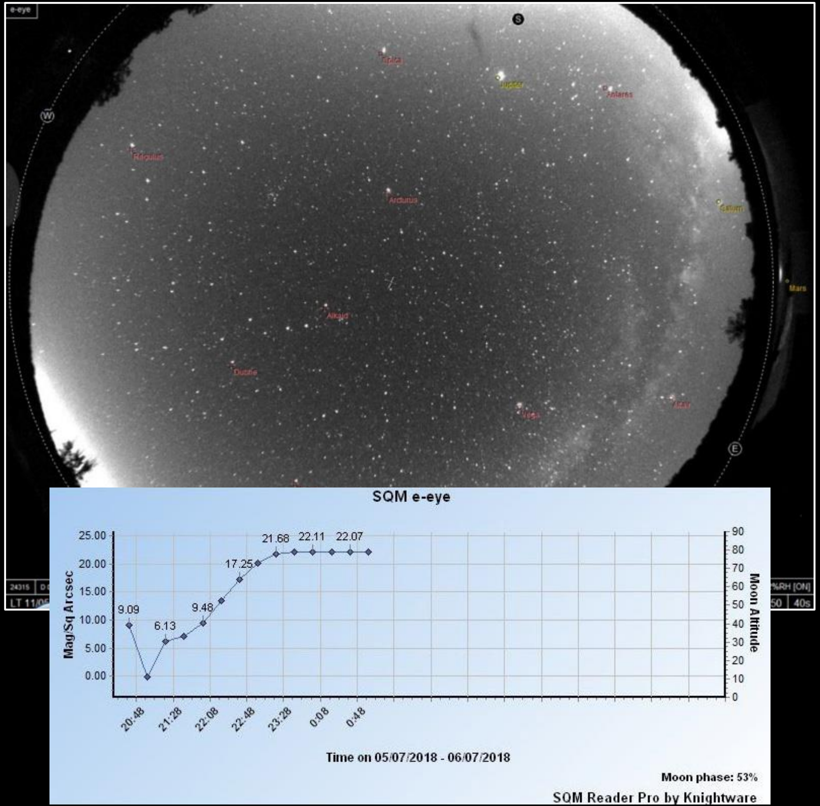
Keeping an eye on things

It is also worth being able to see the sky your telescope system is under.

Despite looking at the weather forecast and having your Cloudwatcher to keep your equipment safe, an All-Sky camera can be helpful in confirming the actual conditions. The image on the right shows a beautiful clear sky. The SQM was 22 and the Milky Way is visible. The weather forecast said cloud!

If your telescope is ‘hosted’ then often the facility will have its own all-sky camera you can log on to, but they are simple to make.

Another useful tool is being able to check darkness levels with an SQM. This can allow you to see when the optimum time for imaging is.



Safety

With an unattended, remote system, two criteria must be met.

The first is that everything must work! That sounds obvious but if your system is not local and you ‘assume’ it is all working you might be in for a nasty surprise.

The second is keeping your system safe from possible damage. This is likely to be caused by either weather or loss of power. There is however the question of how to protect the optics as you won’t be around to remove the cap!

A solution for this is a motorised cover. The example on the right is a Gemini Snap-Cap. This also incorporates a flat field so calibrations files can be made remotely.

Safety

Power (and PC’s)

This is pretty fundamental! So what happens if you get a power cut? Some components are not manageable in the event of a power failure so consideration must be given to choices. For example the worst PC to use is an Apple Mac Mini. Why?

- It has no easily accessible BIOS. Many BIOS has a ‘Resume last state after AC Power Loss. This effectively allows the computer to restart as soon as it sees power.
- You cannot get inside the case so attaching a cable to the on/off switch to mimic a pressing the on button via a relay is not possible

Basically with a Mac, you need a friendly local finger to get it working again!

One way to turn on a PC remotely is using WOL (Wake on LAN). This is a BIOS setting that allows the computer to be started if the network port is sent what is called a magic packet. Unfortunately this only works when the PC is in a particular power state. After a complete power loss the network controller is dead so WOL does not work.

I recommend a small industrial PC. These are fanless and designed for continued use. They run solid state drives and have lots of connectivity including COM ports. It is easy to wire in remote on/off switches. They are also 12V devices.

Safety

Power (Back Up)

Some overseas countries are prone to power cuts. This may because of unreliable supply or working practice. In Spain for instance, utilities companies will cut power without notice.

For reasons such as this, both your system and the observatory roof should be connected to a UPS (Uninterruptable Power Supply), which is basically an inline battery. These come in different sizes but one that offers about 30 minutes of life after a power cut is normally sufficient to get everything shut down safely before the battery goes flat.

A simple relay that closes when mains power is lost can notify your system of the problem and let it begin a controlled shut down. If using a Roof controlled by Talon, this will sense a loss of power (and is also on a UPS) and park the mount / close the roof.

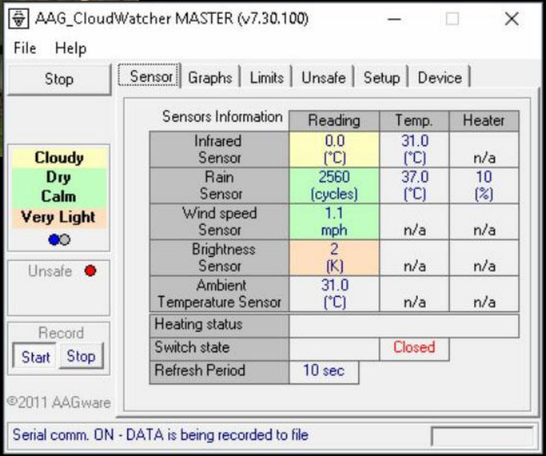
Safety - Weather

Obviously this is another area where action must be taken to protect the telescope system. High winds and rain can very cause many thousands of pounds worth of damage.

In addition to conditions likely to cause physical damage, different weather conditions also make it impractical to use a system. For instance, excessive cloud or light.

To react to these different states, a specialised weather monitoring system is needed. This will measure light, rain, temperature, humidity and wind speed. Parameters can be set and when outside of these the system will go ‘unsafe’, both in software and also be triggering a physical relay.

One of the most popular weather solutions is the ‘Cloudwatcher’ made by Lunatico.

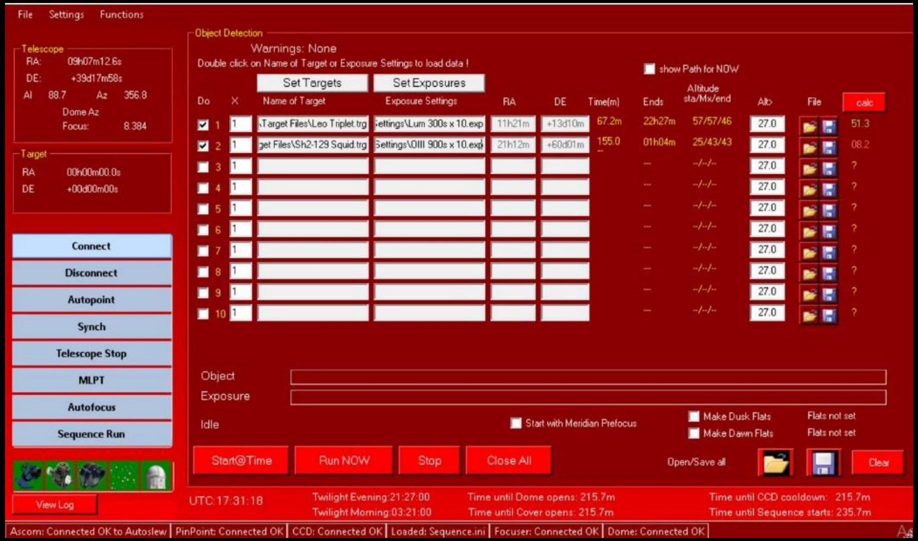


Software

The software used for robotic telescopes is slightly different to normal capture software.

Most capture software allows an image sequence to be taken. i.e. Take x number of exposures with different filters. These applications can also integrate with a motorised focuser and guide system.

However what they don't usually do is also slew the telescope to the target or incorporate Dome / Roof control to start and end the session. There is also no safety monitor to respond to issues like power and weather. This type of software are more accurately described as Sequence Scheduling applications. In addition to control of devices they will also allow for the taking of calibration files and warm up of the camera. They may also include plate solving and be aware of imaging parameters like altitude, twilight hours etc. Therefore they can stop imaging a target when it becomes unfavourable and move on to another.



Software

Scheduling applications can also capture mosaics and the most sophisticated can also ‘Re-Task’ the whole schedule based on information received. Therefore if in the middle of a session, news about a new Supernova was released, the schedule could be interrupted and the scope would retarget on the new object.

Some common examples of Scheduling Software are;

SGP (Sequence Generator Pro) http://mainsequencesoftware.com/Products/SGPro

CCD Autopilot http://www.ccdware.com/products/ccdap5/

ACP Observatory Control Software http://acp.dc3.com/index2.html

ASA Sequence (only supplied with ASA mounts) http://www.astrosysteme.com

Access – Remote Control

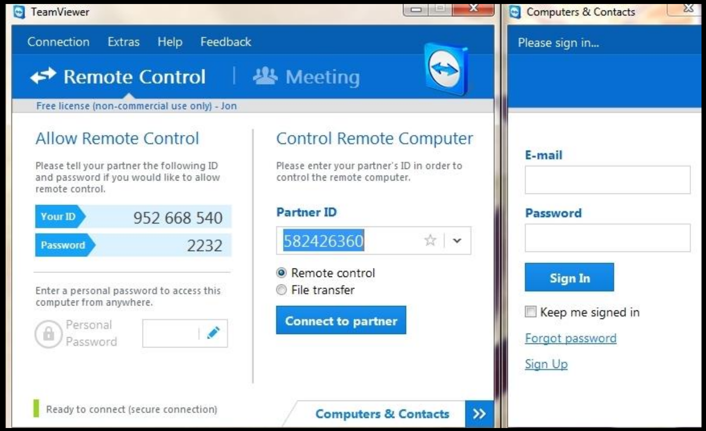
So you have all the equipment and the software but how do you use it remotely?

What is needed is something called a remote desktop. This allows you to create a virtual desktop on a local PC (or tablet), giving you the same control as if you are in front of the remote PC. Tablets are not ideal because touchscreens can't really replace all the functionality of a mouse.

The simplest way to remote access is to use the remote desktop functionality built into Windows. However this is really intended to be used on an internal network and as such its not ideal for internet based control.

Specific, internet compatible remote desktop software is now freely available. A common choice is Teamviewer (www.teamviewer.com) and another is AnyDesk (www.anydesk.com). These are free for private use and very easy to setup. They work by connecting the two computers through a central server. One advantage of this is that because the software dials in to a known location, it can be used with Internet Services that use DHCP.

Another popular remote control application is Radmin (https://www.radmin.com/). This is a direct peer to peer system which allow it to have less latency. However you really need a fixed (static) IP address at the remote system location. Personally I use both so as to provide a means of back up.



Access – PC Monitor

In addition to having remote access to your PC you might also want to consider the way your 'remote' PC screen is displayed locally. A PC needs to have a monitor plugged into it in order to load a display driver. You can leave the monitor turned off but it must be connected or you will see nothing. The resolution of that monitor is what you will be able to use remotely.

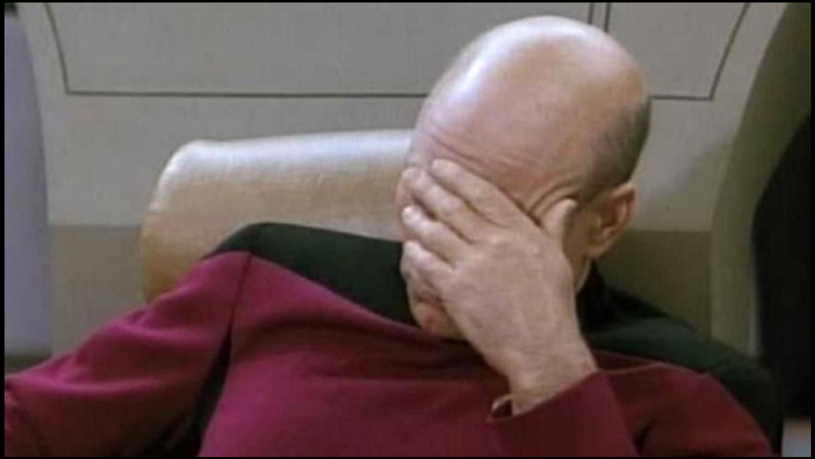
An alternative to leaving a monitor connected is to use a display emulator. These simply plug into the PC. Not only do these simplify your install but they can also be hi-resolution.

Test, Test and Test again!

Now that you have everything to get a robotic telescope system up and running what's next? Well next is you test it. Then test it again!

Before you leave a system to operate unattended you must test properly that everything works as intended, particularly the safety aspects. If your telescope is truly remote from you then you are not going to be able to fix anything that requires you to be physically at the system.

Ignore this at your peril!



Reliability

Any automated, unattended system needs to be reliable. Apart from using quality components, the system should be installed carefully. There is no excuse for poor install, it is just laziness and it will cause problems and potentially be unsafe.

If your system is located overseas where a third party has to maintain it then poor install is also likely to cost you money because it will take much longer to find the cause of a problem, which are likely to be more frequent anyway.

The images on the right are of ‘DIY’ installs I have come across. This is chaos and there is 240v unprotected on screw terminals so also dangerous.

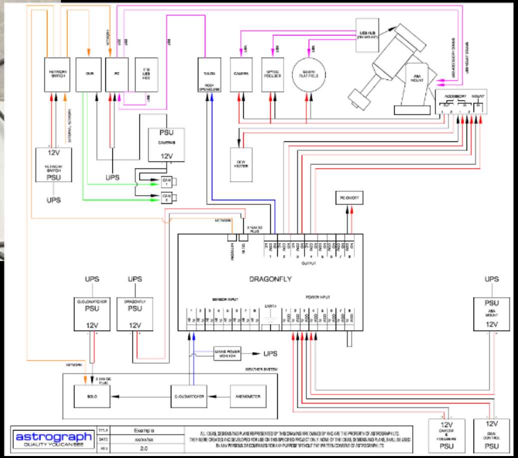
When it goes wrong. Don’t call me!

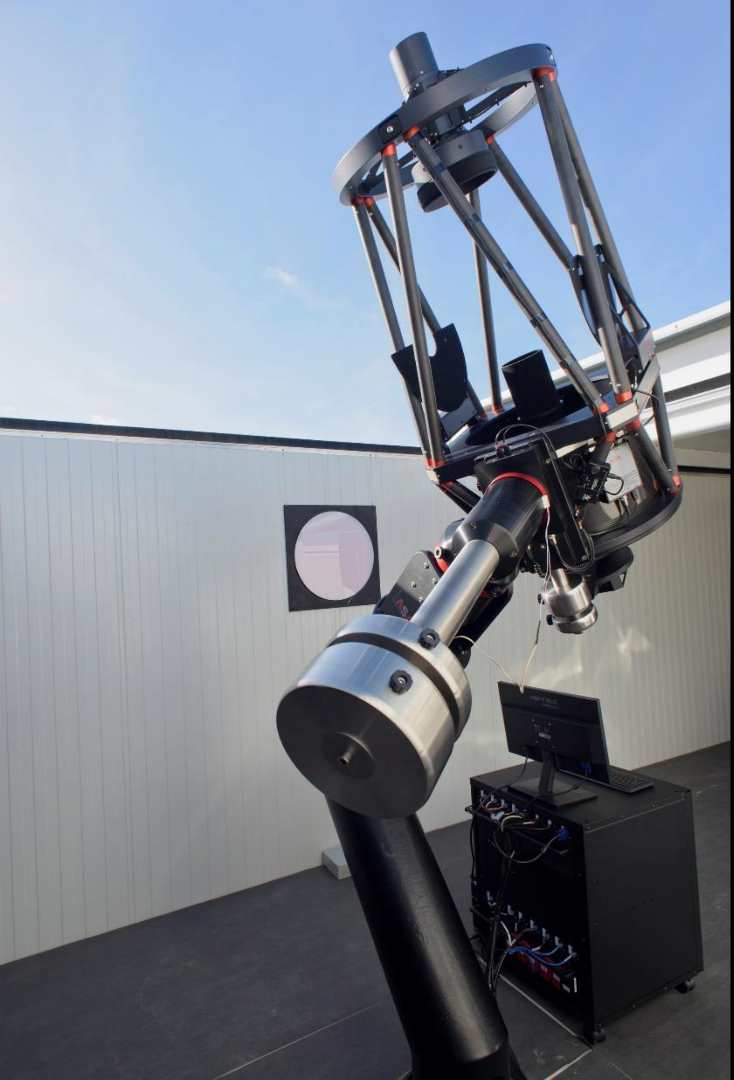
Reliability

Careful Install is important. Plan the system and have details of the setup. If a third party needs to perform maintenance then it helps them and saves a lot of time (and hence your money) if they can easily identify where all the wires go!

On the left is an example of our normal installation. In addition we supply documentation covering the wiring and details (like IP addresses, passwords etc) that allow for easy maintenance.

I cannot overstress how important taking time with installation and wiring is.





Remember why you do it

Robotic systems don’t take the fun out of imaging. You still pick the targets, compose them, decide on the exposure, the quantity and type of images you will take.

What a Robotic System allows is for you to make the most of your time. They let you take images at unsociable hours from optimum locations and with the knowledge that the system will look after itself.