**Paramount MyT – Part 3 – Image Link & Closed Loop Slew**
Ken Sturrock

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*A map is the greatest of all epic poems. Its lines and colors show the realization of great dreams.*
*-Gilbert Grosvenor*

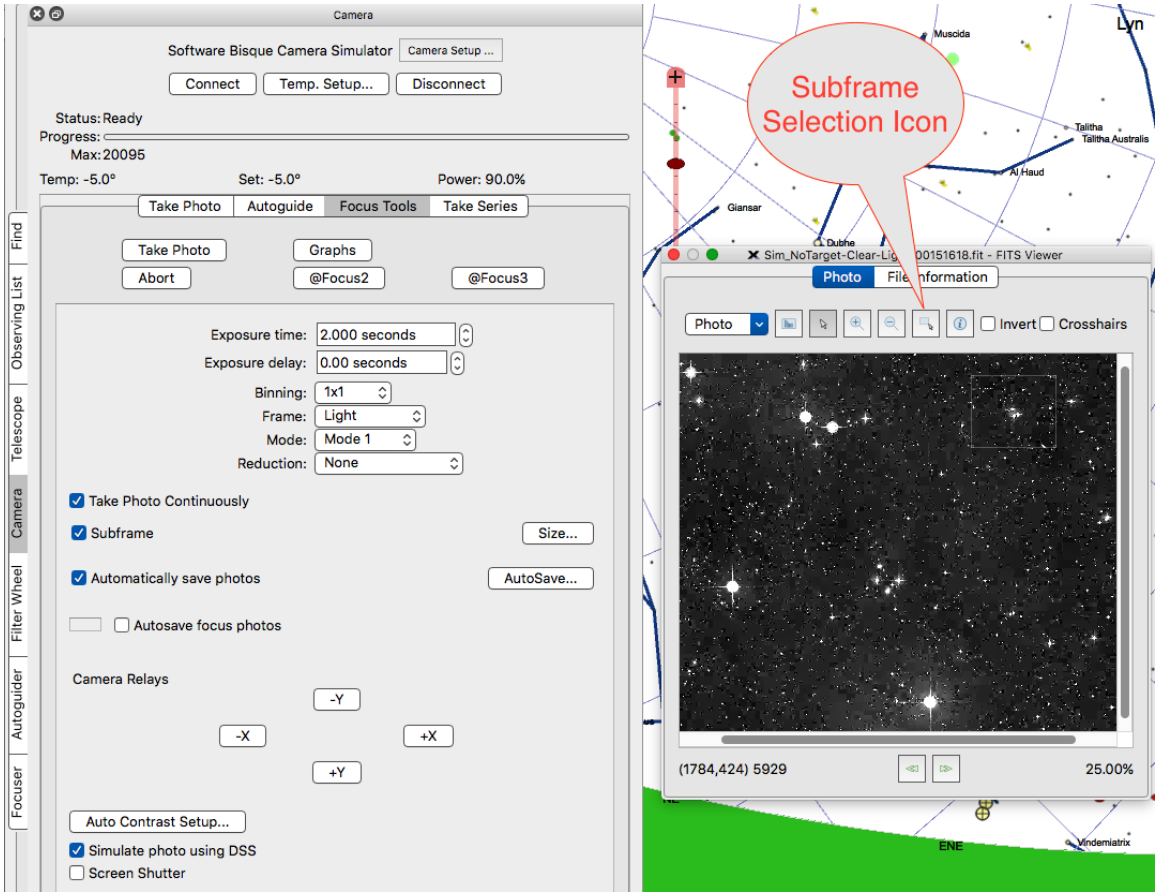
## A word about focusing

Before you can use Image Link, or really anything with a camera, it is important to focus the telescope. Hopefully, anyone reading this has an idea how to focus their camera but, just in case, here are a few tips:

Sure, @Focus3 is absolutely awesome and some evangelists may have even told you that it can cure baldness. Although much maligned, @Focus2 also remains a very effective focusing tool. Regardless of the rhetoric, however, both techniques require that the focuser be somewhat in focus to start. In other words, you need at least a rough focus to get started.

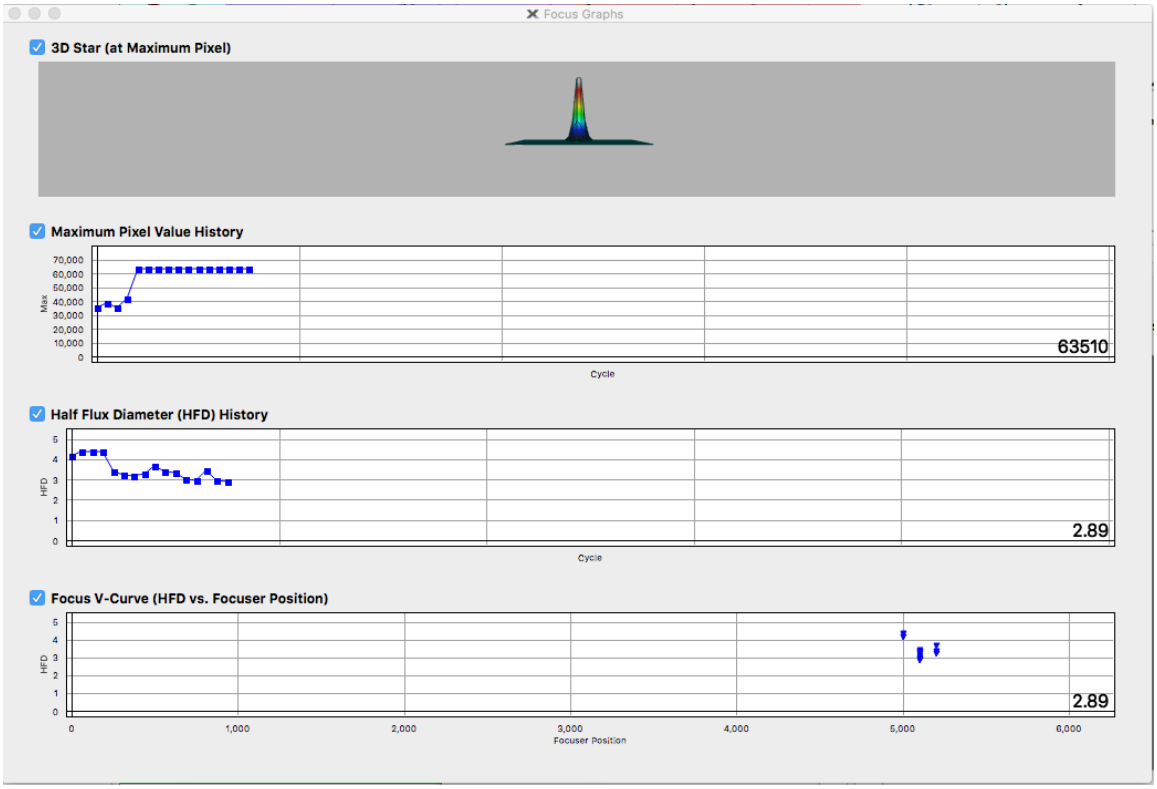
The first step is to take a several-seconds long image while the mount is sidereal tracking. Do you see stars? If you do not see any stars then you'll have more work to do. Assuming that your telescope is reasonably wide-field and your lens cap is off, then the view should show you at least something. If you don't see any stars then the focuser is probably grossly off. Move the focuser all the way out (don't go all the way on an SCT, rather move about ten twists – you'll have to further experiment) and then inward about a centimeter.

Now, switch over to the "Focusing Tools" tab on the camera control panel and start taking images of the same duration with the "Continuous" check-box ticked. Keep moving inward until you see large dim circles. Once you see the dim circles, abort the imaging cycle and use the sub-frame tool in the FITS image viewer window to draw a large box around the circle. You can now resume the imaging cycle on that subframe.




Finally, Press the “Graphs” button.

Switch over to the focuser controller panel (assuming you have a motorized focuser) and move the focuser in & out so that you maximize the ADU (Maximum Value – the top plot) and minimize the Half Flux Diameter (HFD – middle plot). HFD represents the sharpness of the star and is a value similar in concept to Full Width Half Maximum (FWHM). Also note the bottom plot which shows the focuser’s reported position compared to HFD. As you approach focus, you should see the line descend at a diagonal. As you pass through best focus, the line will start to climb again. The lowest spot should represent the best focus position. You can verify this by watching the star profile plot at the top of the frame.




This is the origin of the term “V curve”. Although, Richard Wright would want me to remind you that it’s not a “V”, but is actually a parabola. Once you’ve found that center/low point position on the graph and moved the drawtube to that position, you’re focused. You could now run @Focus3 (or @Focus2 assuming that @Focus2 has been setup) if you wanted to, but it’s probably not necessary because you should have a decent focus. Of course, if you have not yet setup and tested @Focus3, this would be a good time to try it.

## Image Link

“Plate Solving” is a generic term for a technique that compares the stars in an image (a “film plate” in old terminology) to a known set of star patterns and, from that comparison, determines where the image is located in the night sky. For example, if you look at an image on the WWW site AstroBin you can pass your cursor over the image and the site will show you an annotated version. You can also try to upload your own images to astrometry.net and let that site plate solve an image. This is useful because it not only determines where the image was taken and what objects are in the image, it will also tell you the positional angle of the picture as well as the image scale. Plate Solving is also built into the image-processing program PixInsight. In PixInsight, you can find it under Script -> Image Analysis -> Image Solver.

Software Bisque's implementation of Plate Solving, which is built into The SkyX Professional, is called "Image Link". Image Link comes in two forms: "Traditional" Image Link & "All Sky" Image Link. The traditional form of Image Link uses coordinates embedded in the image's FITS header, as well as image scale and "mirror" information supplied by you, to compare your picture to the built-in star catalogs.

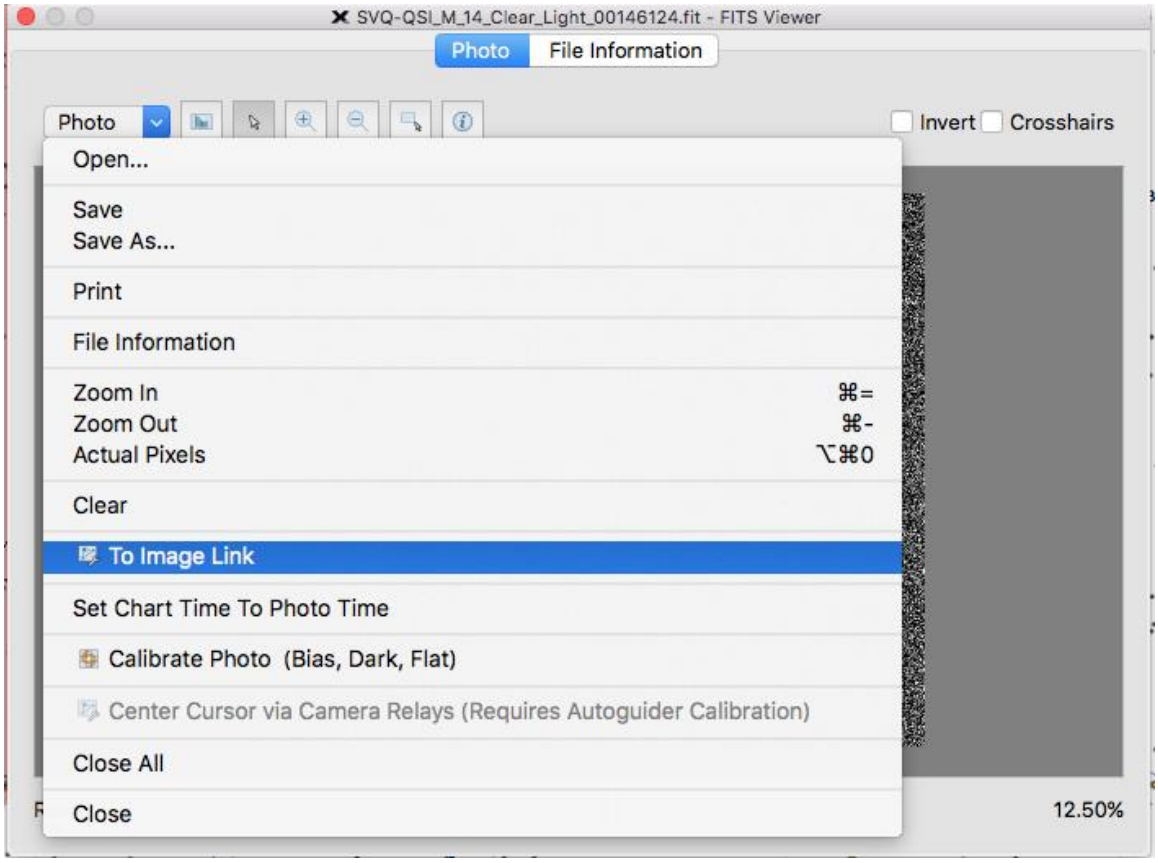
All Sky Image Link does not require any location information – it relies entirely on the pattern of stars in the image. Moreover, with the "Blind" option, All Sky Image Link does not even need the image scale or mirroring information. As expected, the more information that is provided, the faster the routine will work. Here is a video, by Mike Miller, showing Steve Bisque's explanation of the process. In order to work its magic, All Sky Image Link also requires that you download and install a large (2 gigabyte) database from the Bisque WWW site. You should go ahead and download this database and follow the instructions about placing the database within the astrometry sub-folder beneath the Application Support Folder (ASF).

Image Link is a core SkyX technology and it is used in a variety of ways. For example, it allows TPoint's automated sample collection system to verify where the mount is really pointing during a run. Image Link is also the heart of the Closed Loop Slew (CLS) procedure. With CLS, the mount will move to where the target should be, takes a picture, uses Image Link on that image to learn where the mount is actually pointing and then adjusts the mount appropriately. Regardless of TPoint, CLS will allow a mount to point with extraordinary accuracy. You can, for example, make use of an image from a previous night, or that you just happen to like, and slew the mount to the exact same location. Finally, Image Link is useful for synchronizing a mount's position to the SkyX's star chart without having to hunt down specific alignment stars.

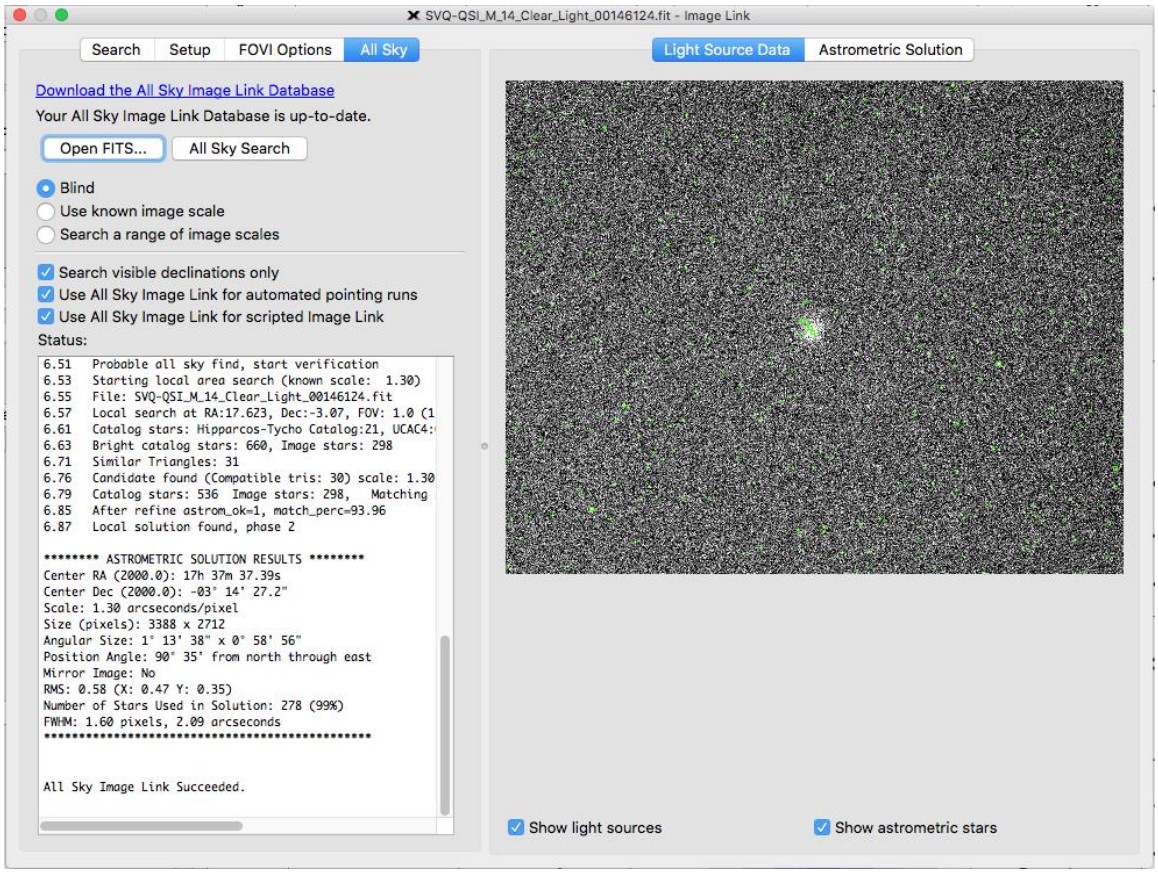
While there are some efficiency benefits from using the traditional Image Link technique - For the purpose of getting you up & running we're going to concentrate on the "blind" variant of All Sky Image Link. It is easier to setup, more reliable to use and plenty fast for normal activities.

In order to use any variation of Image Link, you'll have to take a reasonably focused image of sufficient FOV to get enough stars for a plate solve. For example, you may have noticed that the large All Sky database linked above is named "10-180". It is named this because it is optimized to work with camera FOVs that range from ten arc-minutes up to 180 arc-minutes (3 degrees).

Once you have succeeded in taking an image, the easiest way to start up Image Link is to evoke it from the Photo drop-down menu:




You can also find Image Link under the Tools menu. Once Image Link has opened, you will be faced with the usual SkyX multiple-tab interface and it helps to know a bit about what you want to do. In this document, we will confine ourselves to the All Sky functions found on that tab. The screen shot below shows the results of a successful image link, but you'll have to click a few buttons to get to that stage.




1.) Click on the “All Sky” tab.

2.) Confirm the text below the tab bar that says “Your All Sky Image Link Database is up-to-date.”

3.) Click the radio button that says “Blind”.

4.) For work at the telescope under the stars, check the box that says “Search visible declinations only”.

5.) Click the large button that says “All Sky Search”.

If all goes well, the Status window will show you the progress of the search and it will, hopefully, conclude with a success message. If it succeeds, take a look at the statistics and appreciate the wealth of information provided about the image. While you’re in the Image Link window, go ahead and check the boxes for “automated pointing runs” and “scripted Image Link”. You can always adjust these later, if needed.

Although All Sky Image Link is quite reliable, it can fail. Failures are often caused by the following problems:

1.) Poor Focus
2.) Not enough stars
3.) Poor SNR

The solution for poor focus is to try to focus the system better. The solution for an inadequate number of stars is to expose the image longer or use 2x2 binning. Poor signal-to-noise leads to a situation where the software cannot distinguish between stars and background noise. Similar to insufficient stars, SNR issues can often be fixed by increasing exposure or binning 2x2 but also by using dark frame calibration.

There are some special situations, however, that may apply to your camera:

1.) Cameras with large numbers of small pixels: In order to make Image Link run faster, an automatic "crop" is applied to reduce the FOV of cameras with large numbers of pixels. This is effective on cameras with large numbers of larger pixels because they have large sensors and will still have an adequate FOV for Image Link purposes after the crop. Unfortunately, many modern cameras have large numbers of small pixels on a small-to-moderate size chip. When these smaller-chip cameras have their FOV cropped, the resulting FOV may be too small for a successful Image Link. If you have such a camera and Image Link tends to fail, you should reduce the crop percentage setting found under Preferences -> Advanced.

2.) One Shot Color Cameras and DSLRs: Due to the Bayer Matrix found on these cameras, you should probably run Image Link with the camera binned 2x2.

3.) Rectangular pixels: Some cameras, such as the Starlight Xpress Lodestar, use rectangular pixels that can prevent a successful Image Link. Both the ASCOM and X2 Lodestar driver have an option to "square the pixels" which may help these cameras. Moreover, many people have their camera mounted OAG and this edge-of-field light passed to the camera may be distorted enough to prevent a successful Image Link.

Although the above summary will be sufficient to carry out an Image Link for many users, there is a lot of depth to the procedures. Please consult the SkyX manual section on Image Link and Automated Astrometry (Page 312 in the December 2017 edition).

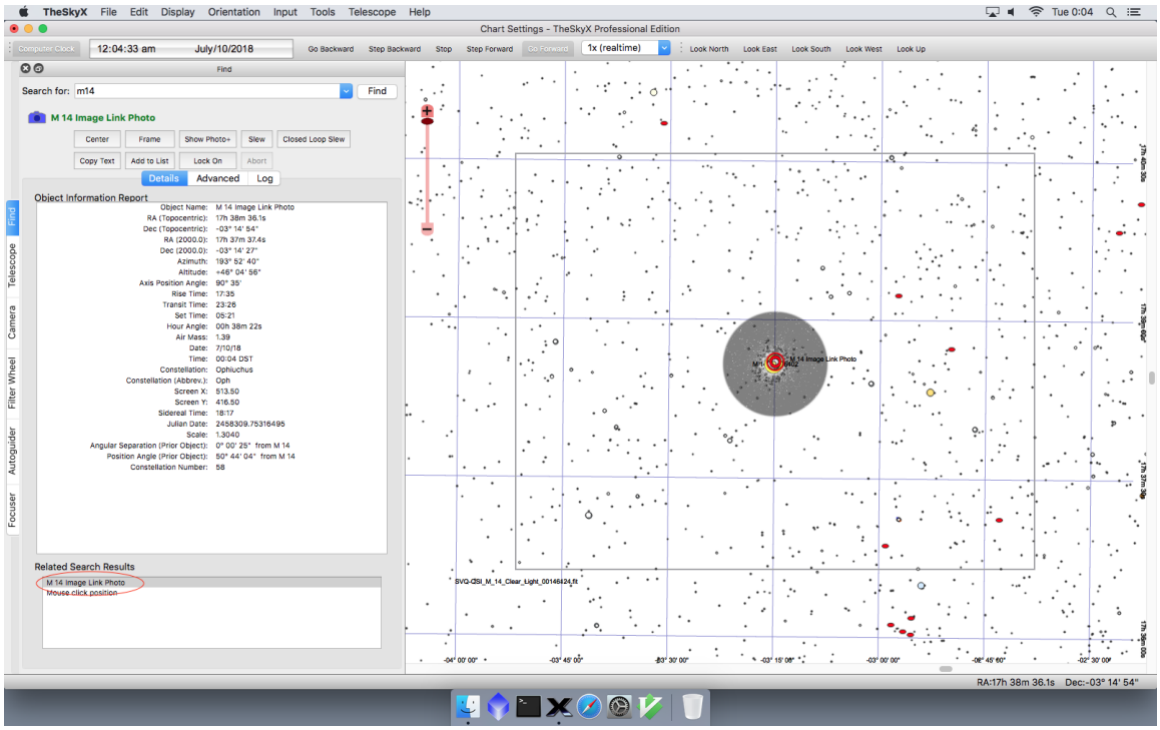
You can watch William Shaheen walk us through the very similar "traditional" Image Link process in a video, here.

## Synchronizing the Star Chart

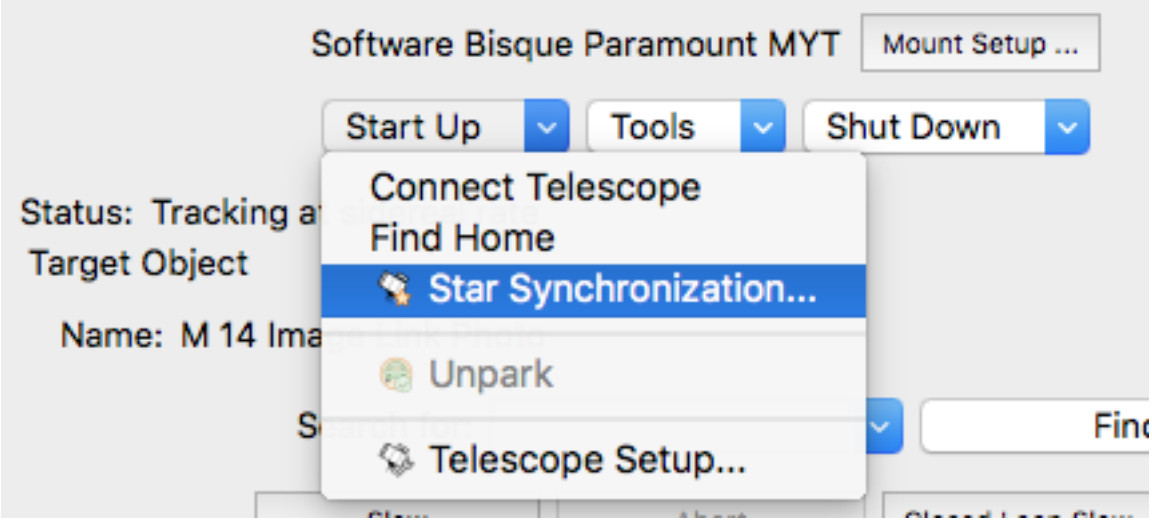
After you have successfully solved the photo with Image Link, you can now use that solved image to synchronize the telescope to the sky chart.

If you were visually synchronizing the mount, you would slew the mount to a known star and then center the star in an eyepiece. You could then select the star on the star chart and synchronize the chart to the mount. In this case, however, we are going to take a picture wherever the mount happens to be pointing and then synchronize the star chart to the center of the photo.

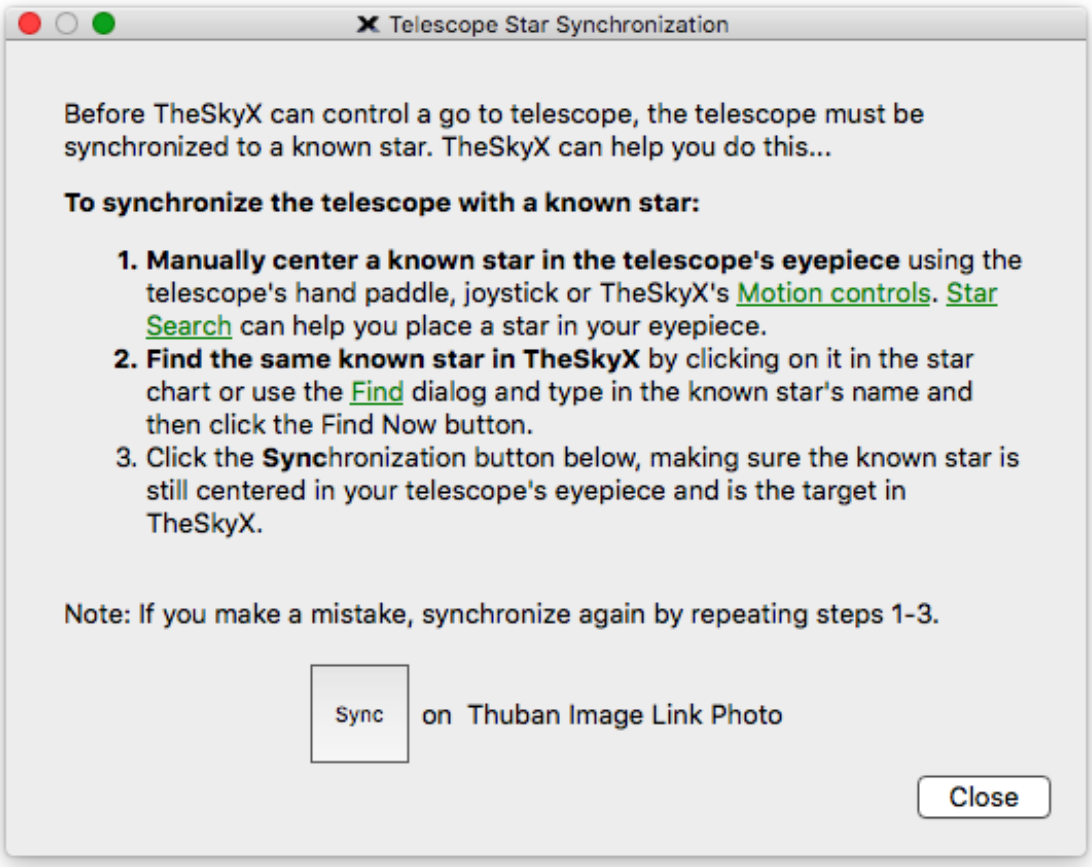
Once the image has successfully solved, you can close the Image Link window. You will notice that the image, or an outline depicting the image depending on settings, has been placed on the appropriate location on the star chart. You can then select the center of the solved photo by clicking on this image, or choosing the Image Link Photo under the results list in the bottom left corner.




At this point, the red bull's eye will snap to the center of the photo. It can be interesting to compare where the mount thinks that it pointing (yellow bull's eye) to where it actually is pointing (red bulls' eye). Once you have selected the image (or image outline) you can switch over to the telescope control pane and choose "Star Synchronization" from the "Start Up" menu.




You will then be asked to confirm that you wish to synchronize the star chart to the mount's position.



Because you have not yet created a TPoint model, synchronizing the MyT is a simple yes/no question. If, however, you had a TPoint model in place you would be faced with several options. Because the Paramount automatically moves to its home position and synchronizes after startup, you would seldom use this process with a permanently mounted Paramount running a TPoint model. For field work, however, this technique can come in handy. On mounts that point poorly, re-synchronizing the mount to the chart may be a regular occurrence.

Now that you know the steps to "manually" Image Link and synchronize, you can appreciate the magic of an automated TPoint calibration run as the SkyX commands the mount to slew across the sky at high speed, snapping pictures and Image Linking as it goes.

**Closed Loop Slew**

The next step beyond Image Linking & Synchronizing the mount is to use Image Linking to precisely point the mount. While virtually all Paramount owners will eventually utilize a TPoint model to refine pointing, there are times when it can be incredibly useful to guarantee almost exact target placement: Small FOVs, imaging targets over multiple-sessions or matching the framing of colleagues. Of course, you may also be using a mount without TPoint or are experimenting and don't wish to setup a model.

Closed Loop Slew is a function that:

1.) Slews to where the mount thinks the target should be.
2.) Takes an image.
3.) Image Links the Image.
4.) Calculates the difference between where the mount thinks that it is pointing and where it really is pointing.
5.) Moves the mount to the new location.
6.) Takes a confirmatory image for display purposes.

Once your camera is running and focused, using Closed Loop Slew couldn't be easier. Instead of clicking the "Slew" button to move the mount to a target, simply click the "Closed Loop Slew" button.

Now that you understand Image Link & Closed Loop Slew, you can GoTo align and precisely point your mount quite easily. You also have the knowledge of how this fundamental technology works so that you can better appreciate it later when you use the Precise Polar Alignment tool and TPoint. Finally, you no longer have a regular reason to remove your camera from your OTA which will allow you to reuse both guider calibration (for OAG-mounted guiders) as well as flat frames.

You can thank Software Bisque in the morning.