## Overview

Often times, due to the size of the chip in our cameras, focal length of our scopes, or simply the sheer size of the objects we are imaging, we are unable to capture an object in a single image and must capture a series of images later pieced together to form a mosaic in order to get the entire object we are after. While the capture portion of this operation is fairly straight forward, the combining of these images later into a single picture is not so. There are several applications out there for image processing today that can do some of this for us but for those of us that either don't have those applications or choose to manually build the mosaic images ourselves, the process can be tedious and frustrating. In this article, my goal is to provide you with the steps, tools, and few tips on how you can put together your own mosaic images using just PhotoShop.

I must state up front that this article is not a "how to" on the actual capture process, as stated before, that is a fairly straight forward process. I will however give you a couple ideas to consider when capturing your mosaic images which will make things far easier once you get into processing them later on. This is not to be a tutorial on the capture process but just a few hints and tips that should help the final processing be a bit easier.

The first thing that should definitely be considered is the amount of overlap between each of the images in the mosaic. When we stack and then process the individual images into a final single image, we will need to have features on those images which we can match up, stars and craters, etc, that must be present in both images being combined. Having a good overlap will give us as many points as possible to ensure all areas of the mosaic are perfectly aligned with each other.   Another reason for having good overlap is because we will most likely be trimming the edges of our individual images during the mosaic process and you will want to ensure that during that trimming process there is still plenty of image remaining for alignment. Just as a rule of thumb, I generally try to put at least 10% overlap in my mosaic images.

The second tip I will offer, and one that may save you a lot of grief later on, is to actually take a series of single images of the entire mosaic area and piece it together ahead of the actual imaging processes. This will help you get an idea of not only where to move the scope for each successive image but will give you a better understanding of how much overlap you are really getting, how many images it will actually require, etc. There are several applications out there such as TheSky and others which will do some of this for you and can help to lay out your mosaic ahead of time taking into consideration the size of the chip on your camera, the focal length of your scope, etc. The image on the following page shows how TheSky has defined a mosaic for me using my equipment to capture an image of M31:
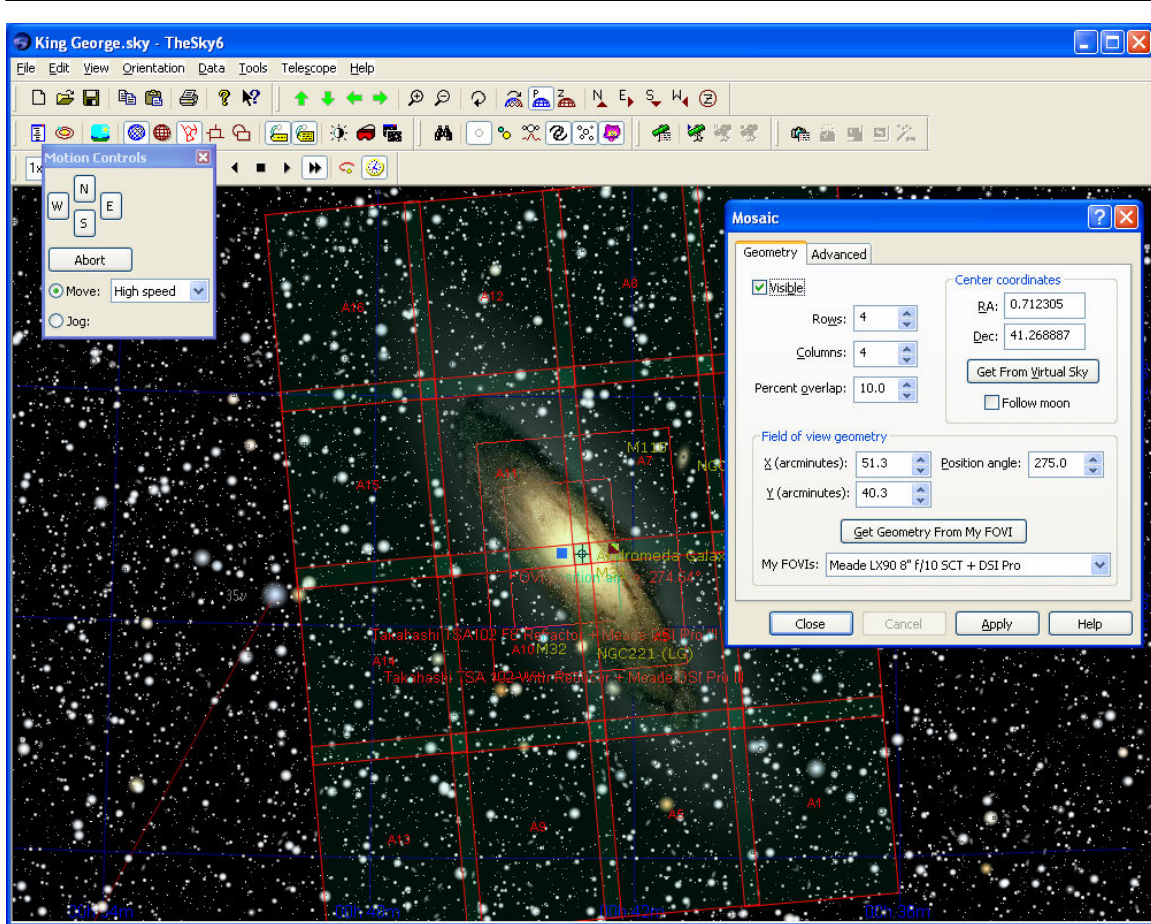
As you can see, it has taken into account the size of the chip, the scope being used, and the amount of overlap I have between images. If you are controlling your scope thru one of these applications they will also move the scope according to the mosaic designed to help put it in the right place for each piece of the mosaic.

Just a couple of final thoughts here before we jump into the actual processing portion of this article. If this is your first mosaic image, start small till you get the hang of it. I would suggest a 2 or possibly 4 image mosaic to begin with at the most. You might also consider something like the moon instead of an LRGB image of some large galaxy. The basic principles between processing lunar mosaics and Deep Space mosaics are the same but with out the complexities of long exposures, greater field rotation, etc. Secondly, have fun, that is why we are all doing this anyway right? There are some things about putting together mosaic images that can be tedious and frustrating at times but in the end you will be able to do these in your sleep.

The remainder of this article assumes that you have captured your images for the mosaic and are ready to begin processing them into a final image. For this tutorial I will be putting together a mosaic of the moon though the final section will step you thru the differences between lunar mosaics and deep space mosaics and provide a few tips on how to perform mosaic combines on LRGB images.

OK, let's get started…

Assembling the Mosaic

The first step after acquiring your images for a mosaic is to assemble them in PhotoShop in their initial configuration. I generally open all the images at the same time and do an initial arrangement to make sure everything is going to fit correctly and nothing is missing. The image below shows 3 frames of a Moon image I have taken as they have been initially dropped onto the canvas for processing. This is the image we will work thru in this tutorial.
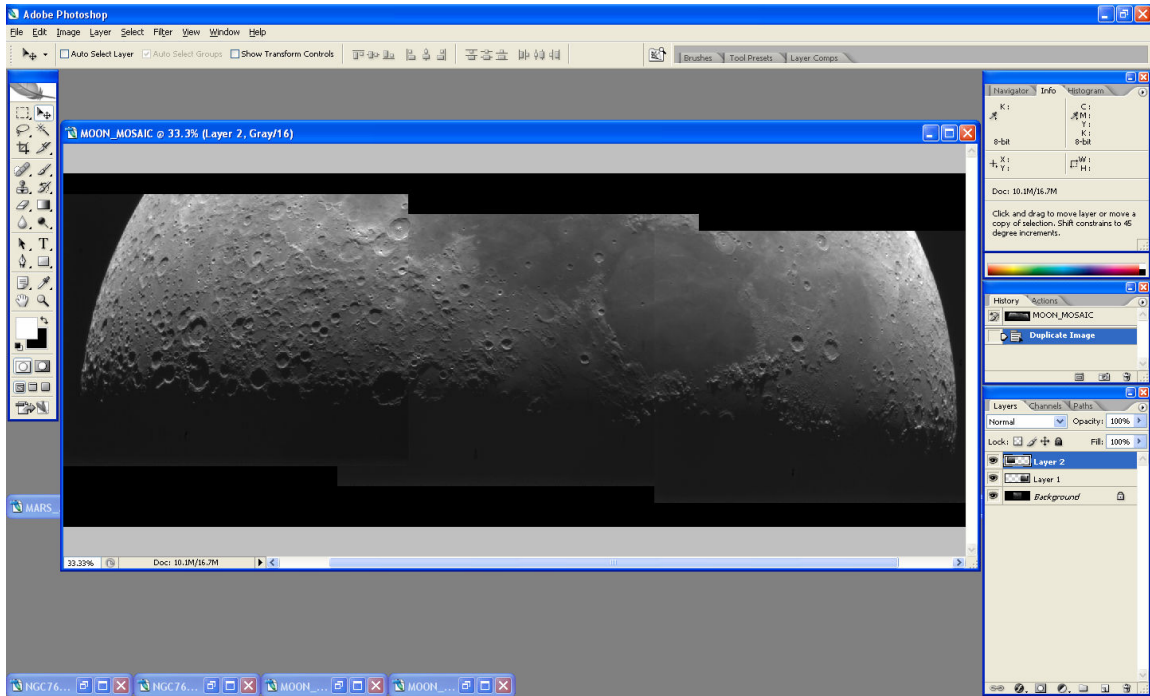
As can be seen, there are three layers in the image that have been added to the canvas and roughly aligned. It is obvious from this image that they cannot simply be flattened and turned into the final image as there are differences in brightness, hard edges, etc, that must all be taken care of.

The first step is to properly align the images. So long as there is no rotation between the images this is a fairly simple task. But as there often happens to be some rotation, I will step thru how to handle that as well. Thankfully, PhotoShop provides all the tools we need to accomplish these tasks and they are all very simple to use after a bit of practice.

The first thing to do in aligning your images is to select the anchor image, that layer which will be the base for which all other images are aligned. Since I happen to have three images here, I am using the center image as the anchor image for this demonstration. This layer doesn't necessarily have to be the layer with the brightness you are going to finally have, we will get to that later, just the position for which all other layers will be aligned. Later we will select a base brightness layer for that part of the exercise.

Next, select the layer which you will be aligning by clicking that layer in the Layers pallet (in the pervious image it is on the right hand side of the screen). Just above the layer

tab there is an Opacity adjustment box. The Opacity sets how transparent the current layer is with 0 being completely transparent and 100 being not transparent at all. Since we need to be able to see both layers at the same time in order to align them, we need to set the opacity of the layer we are aligning down to about 60 or so. You may have to go as low as 50 but somewhere in that range will allow you to sufficiently see both layers for alignment. The image below shows how this would look on the screen.
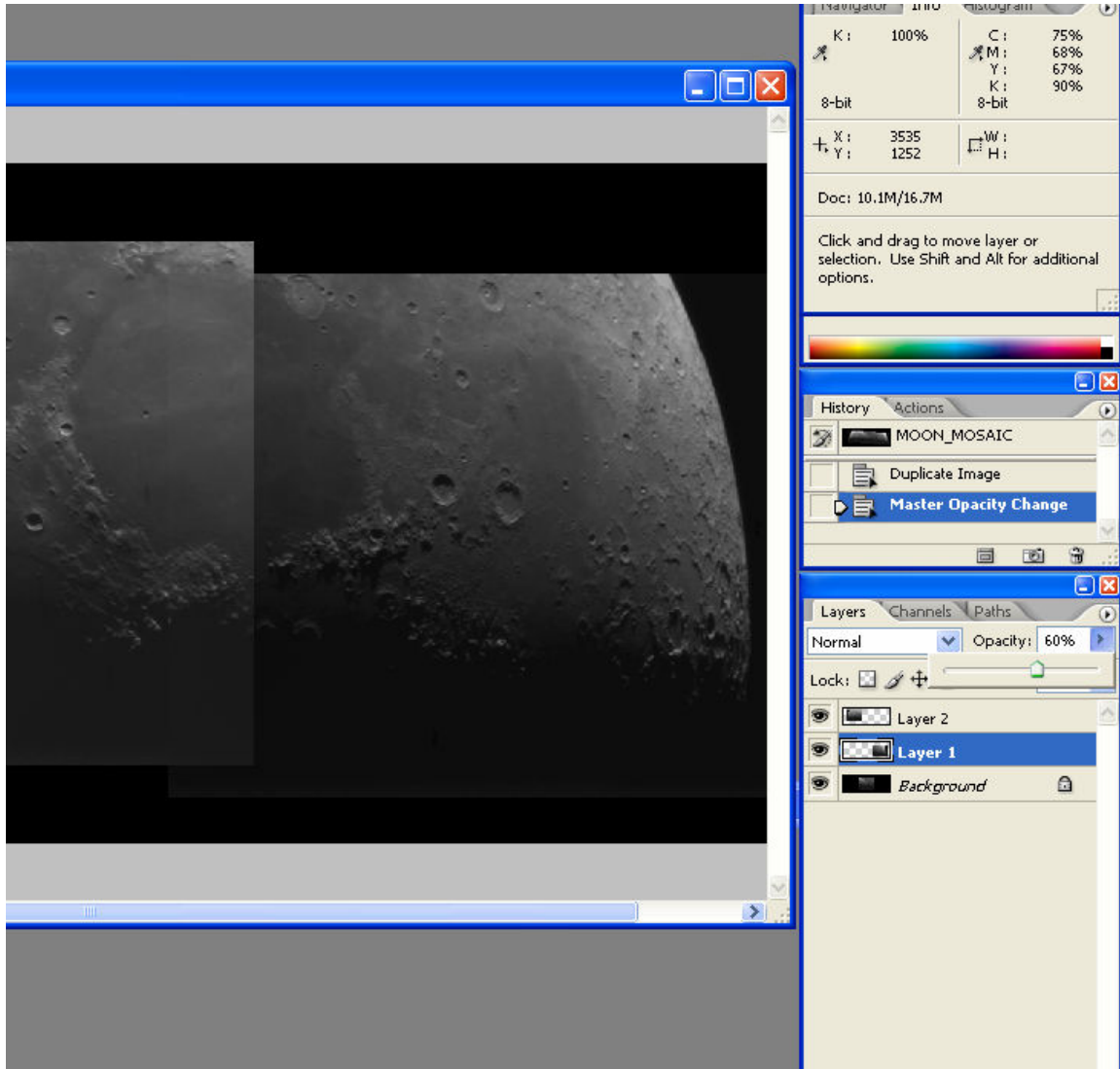
Next, zoom in on the image to at least 200% so you can easily see the difference in the placement of the two images as can be seen below. Notice the edges of the craters and mountains are slightly offset from each other in the two images.
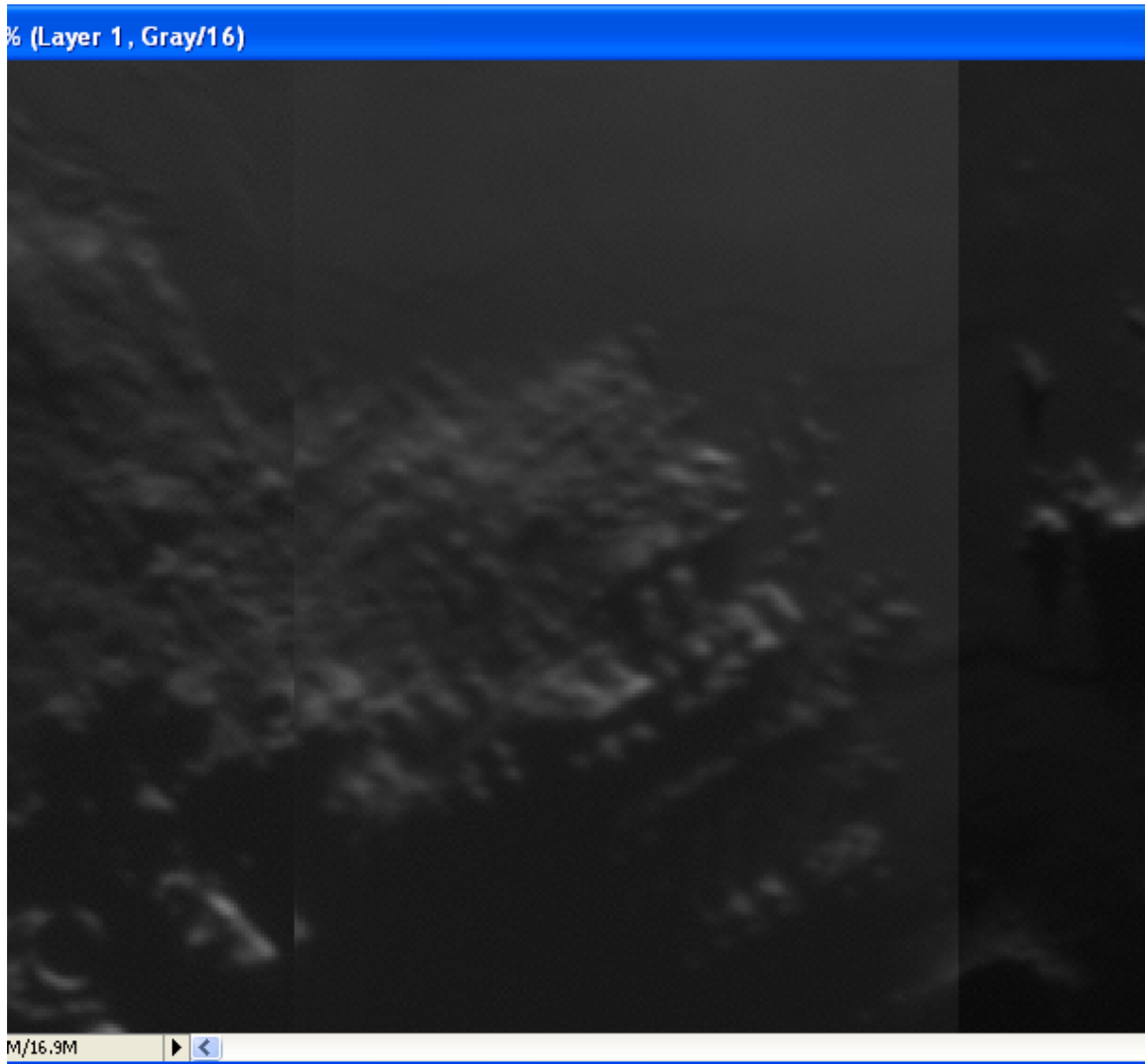

On the Tools pallet, select the Arrow tool in the top right side:

Next, you can do a rough alignment with the mouse by simply clicking on the image (remember to make sure you still have that layer selected) and moving it close to its final placement. This will get you close but generally you will need to stop using the mouse after a while and simply use the arrow buttons on the computer keyboard. The arrow buttons will move the image one pixel at a time. Once you think it is close, slide the Opacity up to 100 and back down to 60 a few times and watch the image to see if it appears to move. This little trick will help you see slight differences in reference that you might not see while simply moving the image around. The image below shows the two layers well aligned with each other.
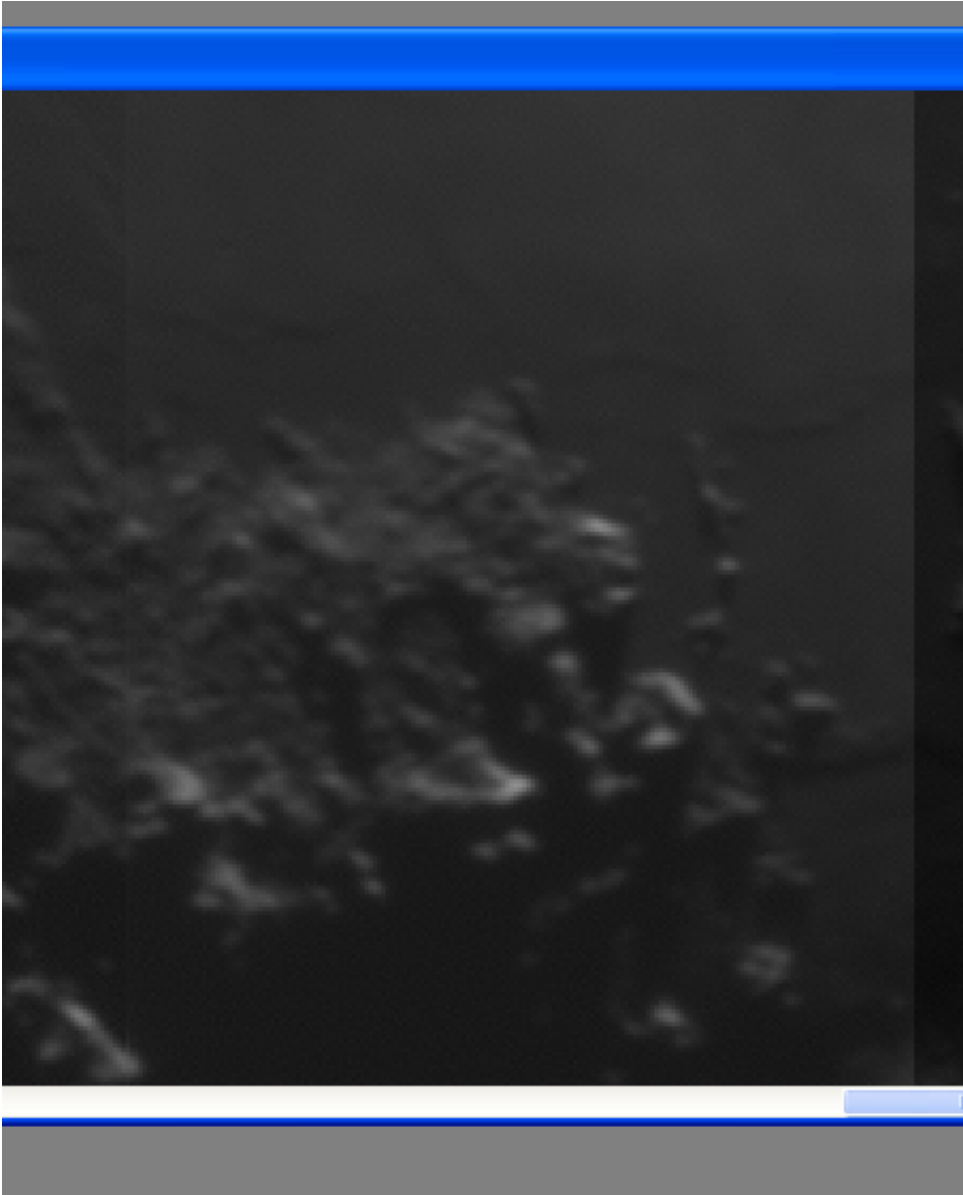
Once you are happy with the alignment, bring the opacity back up to 100% for that layer and repeat the same process for all the remaining layers. The image below shows how the image looks once all layers have been aligned.
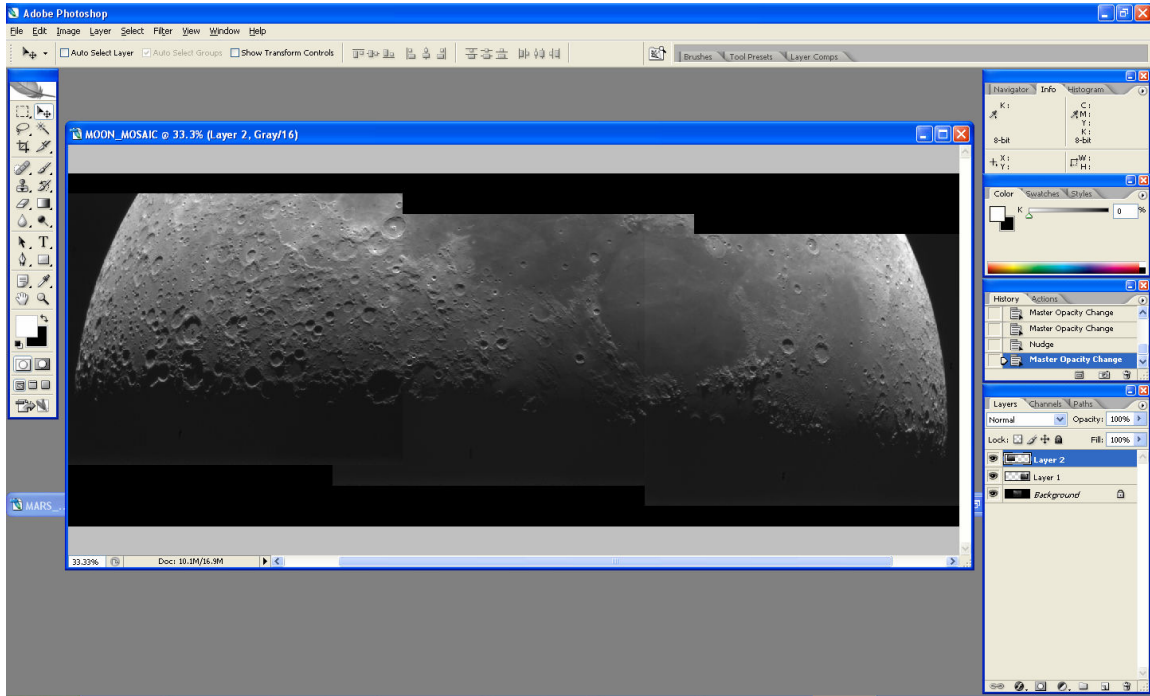

Notice that we have done nothing yet concerning the brightness differences, edges, etc, that will come next.

Advanced Alignment – De-Rotation

Many times you will find that your images may have some rotation between them, This can be caused by a poor polar alignment or if you are taking your images with a scope that is Alt-Az mounted. De-Rotating these images is a bit more complex then the simple alignment we have done thus far but is still fairly straight forward and with some practice you will be able to easily perform these tasks as well.

The first step is to get the images as closely aligned as possible in the same way we did in the previous section. The only difference here is that you will not be able to align the entire layer but only a part of it. Generally, once you get a portion of it aligned it will be fairly simple to see where the center of rotation is. This is very important because the center of ration for your image will generally not be the center of the image. The image below shows how one layer is rotated off of the layer below it. Notice that the center of the rotation appears to be near the lower right of the layer.
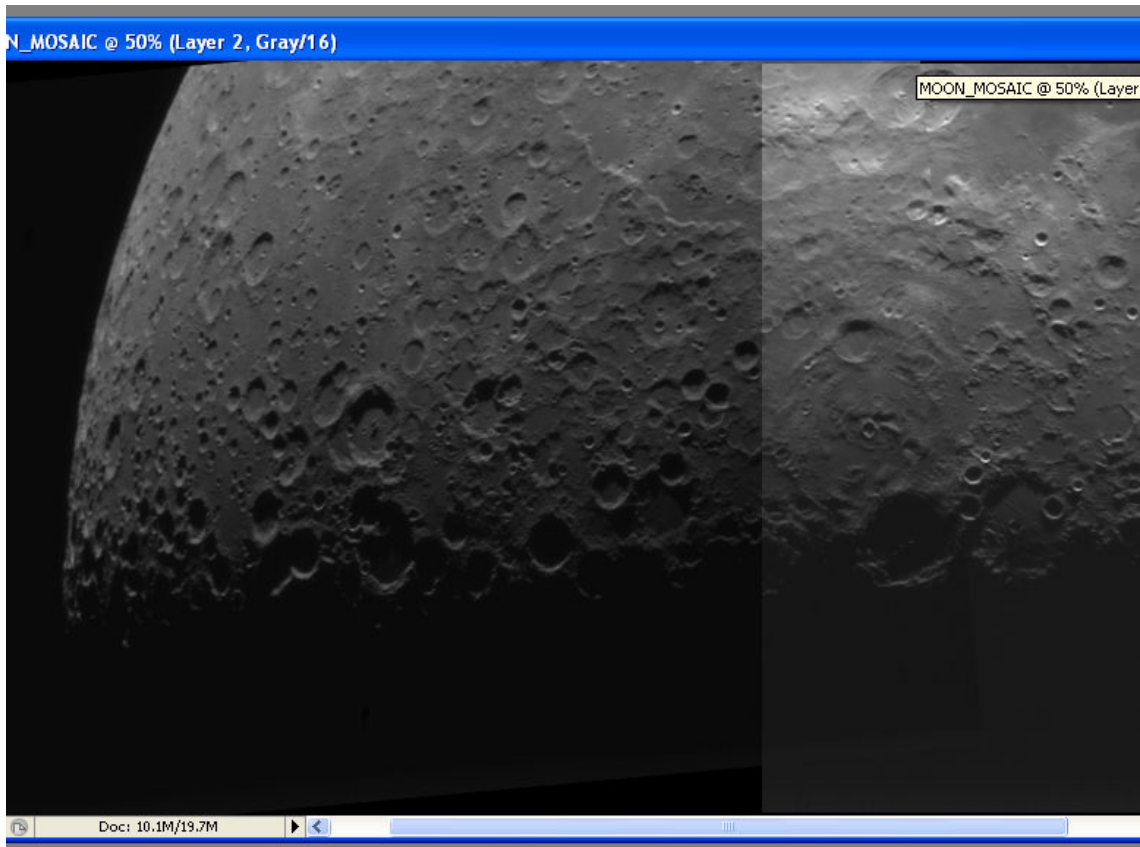

To correct for this rotation, we will utilize the Free Transform tool found under the Edit menu. To get this tool, click the Edit Menu, then Free Transform (about half way down) or simply click CTRL-T (ensure that you still have the correct layer selected first). After selecting the Free Transform tool, you will notice a dashed line surrounding the layer you are working with and a small reticule in the middle of the layer.

The first thing to do is to move the reticule to the correct location on the image as this is the point about which the actual rotation will take place. In our image it is on the lower right side. Using your mouse, simply click on the reticule and while holding down the left

mouse button, drag it to the location that appears to be the center of rotation for that layer. The image below shows how this would look for our moon mosaic.
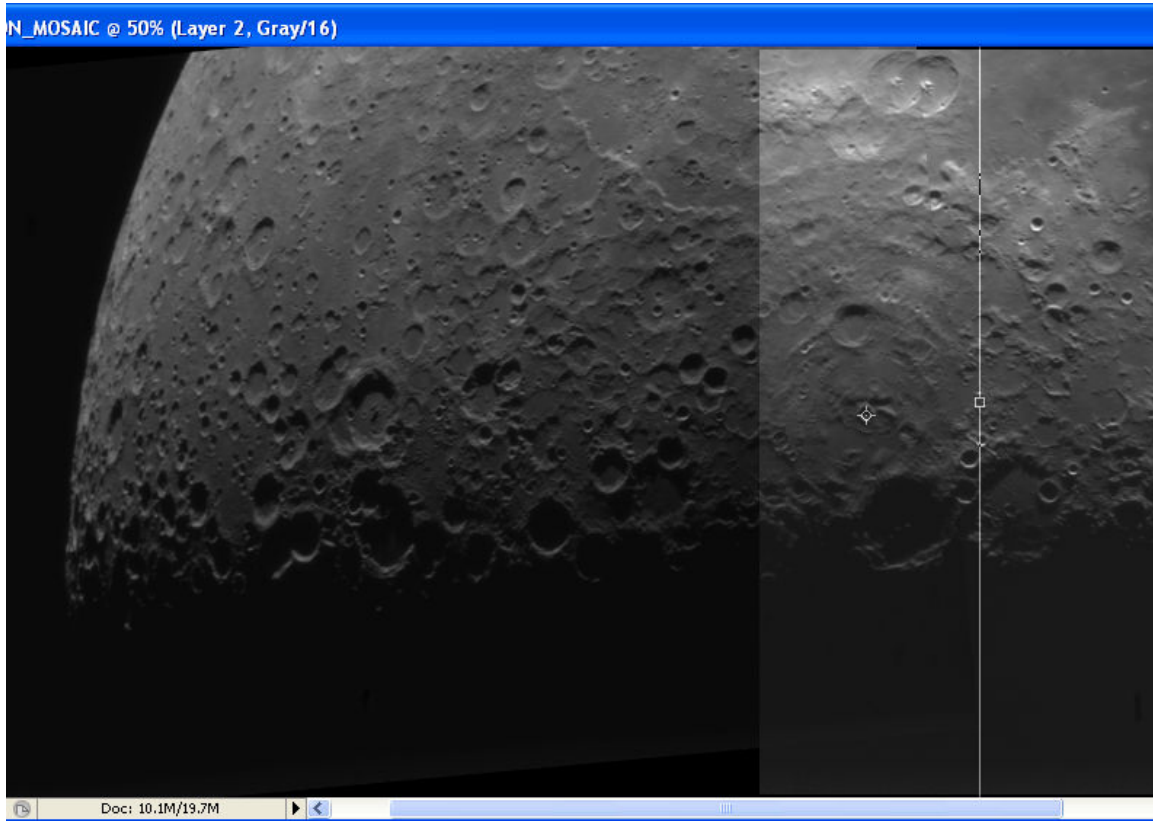
The next step once our reticule is aligned is to actually rotate the layer. The simplest way to do this is with your mouse but you may need to zoom out a bit in order to see the entire layer to do this. You will need to be able to see the corners of the layer to accomplish this with the mouse. Once you are zoomed out enough to see the corners, simply move your mouse over one of the corner nodes (little squares) and you will notice that the arrow becomes a curved arrow. Select the corner you wish to rotate and while holding down the left mouse button, move the mouse such that the image begins to rotate the direction you need it to in order to get the images aligned.

It is likely that in the same way as the initial alignment, the mouse will get you only so far and you must resort to another method to complete the task. At this point, you should zoom back in on the layer so you can see the smaller details. Next, look at the top of the PhotoShop screen in the toolbar and you will see several small square text boxes that display information about the rotation you are performing on this layer as seen in the image below:
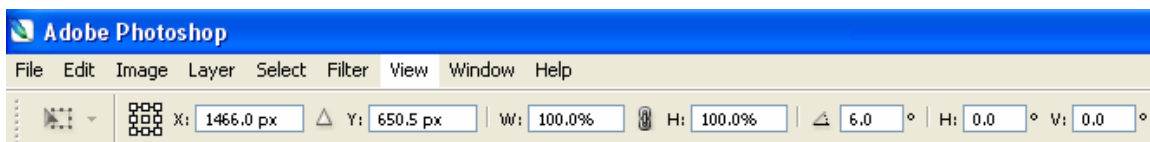
Notice that the little text box third from the right in the toolbar (the one with a little angle next to it) now has a number in it indicating the number of degrees we have rotated the image. This has changed thus far based on the inputs from the mouse but to ensure we are completely de-rotated, we will enter values in this text box manually at this point to complete the operation.

While zoomed in on the image at least 100% or greater (you might want at least 200% or so eventually), begin to change the number by increasing or decreasing it a bit at a time and noting how the image is rotating as you do so. Generally you should not have to change the number before the decimal if you have gotten close enough but should try to make changes to the 10ths or even hundredths of a degree to get it right.

Once you are happy with the rotation of the layer, simply hit the enter button on your keyboard to accept the changes you have made. If at any time you don't want to make the changes permanent, simply start over by hitting the escape key and begin the process again.

One thing to note here is that sometimes this is an iterative process. In other words, you may find that after de-rotating the image, you may need to re-align the image again as done in the initial alignment. This is ok, you may end up doing small alignment and rotations several times before getting the image exactly where you feel it needs to be. Once again, this may take a little time to learn but once you have done it a few times it will become second nature to you.

Brightness Balancing

As can be seen in our lunar image, the three layers each have different brightness levels from each other and make them stand out as distinct images rather then the smooth mosaic we are ultimately after. In this section we will work with the individual layers to bring them in line with each other from a brightness standpoint. This is a multi-step process and may be repeated multiple times to get to the final image we are after. Also, when making these changes, I would recommend that you make small changes with each iteration so as to not overcompensate and then have to undo or fix a problem that wasn't there before.

The first step though will be to get rid of the jagged edges on each of the top layer images. These will ultimately have to be removed anyway and at this point they will only make comparing pixels side by side that much tougher. To do this, select the Rectangular Marquee Tool form the tools pallet and ensure that the Feather is set to 0 in the Feather selection text box at the top of the screen as seen in the image below:

Next, we want to select the first layer we are going to remove the edge from in the Layers Pallet. Then, zoomed in to a point where you are able to see the entire layer edge you will be removing, carefully select a portion of that layer with the Rectangular Marquee Tool that is just enough to cover the jagged edge. The image below shows how this would look in my image.
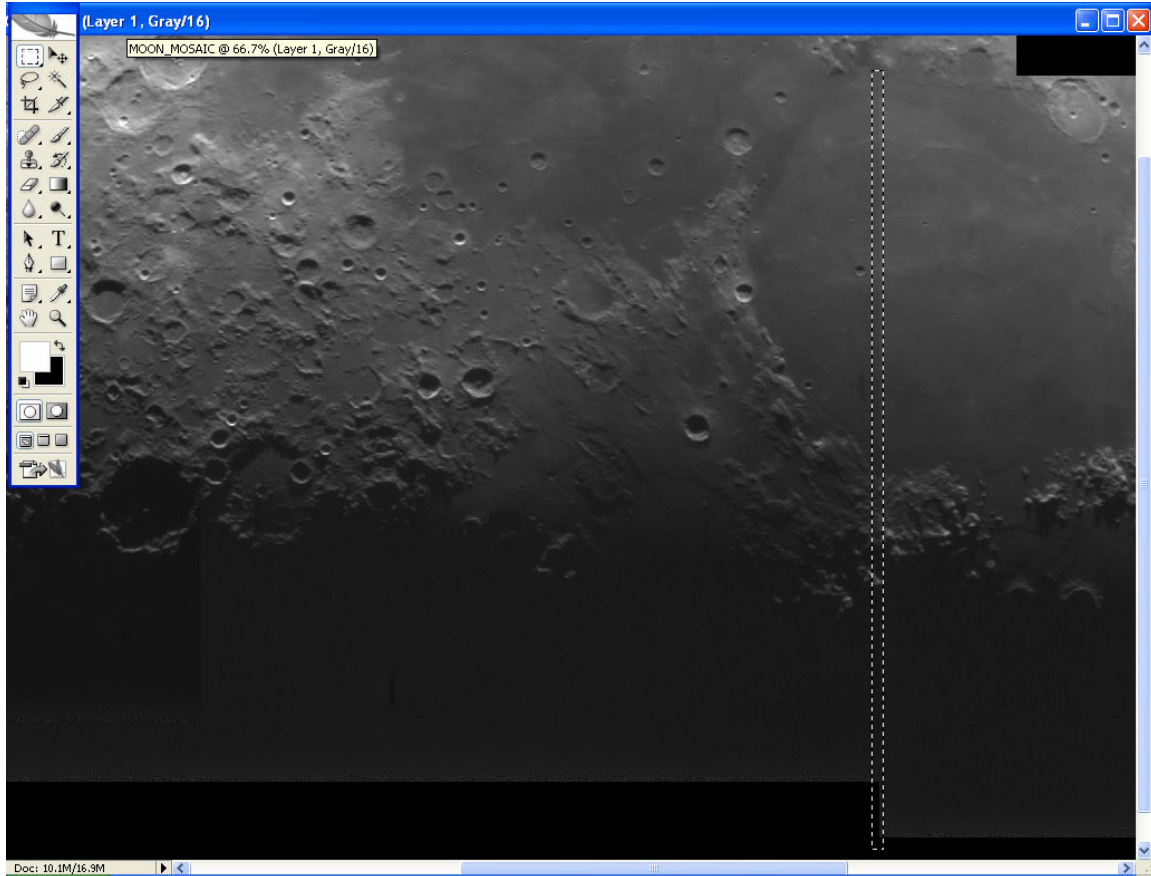

It might help to zoom in even tighter then I have shown it here so as to ensure you are only removing a few pixels from the image. Once you have selected the pixels you wish to remove from your layer, click the "Edit" Menu, then the "Clear" menu button. The selected area should be removes and you can simply click anywhere else in the image to deselect the selected area. Just a note here, don't be concerned that the selected area overlaps a portion of another layer, only the layer you have clicked on in the layers pallet will be effected by this change.

Repeat this process for all the remaining edges you wish to remove. Remember that there may be overlap at the top and bottom as well as the sides so ensure that you get those areas as well.

Once all of your areas to be clipped are complete, your image should look something like the one seen below:
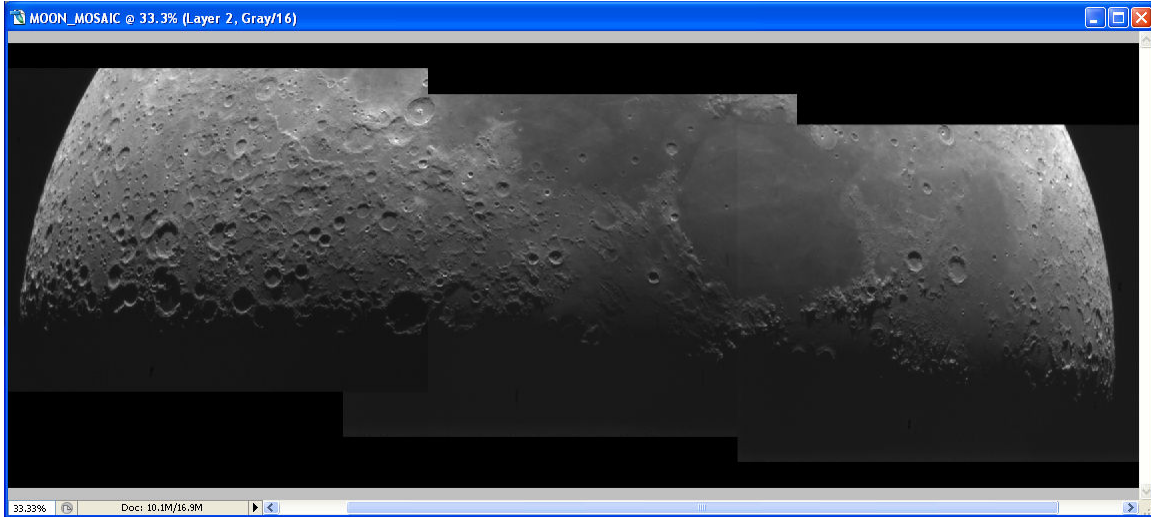

Now that we have our edges trimmed a bit, the next step is to select our base layer that we will use as the basis for determining the brightness levels of the remaining layers. As with the initial alignment, this layer will generally be left untouched for the most part though there may be occasion to make small changes to it also. In general, I try to select a layer that has a more or less medium brightness level as compared to the other levels. This will ensure that no single layer has to have major changes made to it but rather smaller changes. One thing to remember here is that the base layer selected may not be the final brightness we want for the entire image, that is ok, we will take care of that later once the image is flattened into a single layer. For this image, I have selected the center layer as my base layer for brightness balancing. It just happens to be the same layer I used for alignment but that may not always be so.

The primary Tool we will be using for adjusting the brightness of our images is the Levels Tool. Within the levels tool, we will also primarily be utilizing the center adjustment or the Gamma adjustment on our images. To do this, begin by selecting the layer you are going to work on initially and zoom in so you can see the entire edge of that layer and the edge of the corresponding base layer. In general, if you have layers that do not actually touch the base layer you will want to start with those layers which do connect to the base layer and then work outward from those images. For example, if our lunar image was a 5 image mosaic straight across and we had selected the center layer as our base layer, we would first process the two inside images adjoining the base layer and then process the two outside images. This is very important since if you simply start somewhere else, you may very well end up having to make multiple changes across the entire image several times.

Once you have selected the layer you are going to adjust, open the Levels Dialogue under the Image / Adjustments / Levels Menu. Notice that there are three little adjusters at the bottom of the curve, as noted, we will be primarily adjusting the middle section or gamma. While looking at both layers, the one we will be adjusting and the base layer, begin to make small adjustments with your mouse using the gamma adjuster in the levels pallet. As you do, you should be able to see the brightness of your layer

changing. Carefully move the slider until the images appear to be the same brightness at the edges. One thing you will probably notice is that while part of the image can be seen to match the base image, other parts of the image may still be too bright or too dim and the line between the two images can still clearly bee seen due to the brightness differences. This is ok, we will do more work on it later to ensure the entire image matches. For now, simply try to get the greatest amount of the image possible to match the base image and then click OK. The image below shows how this might look:
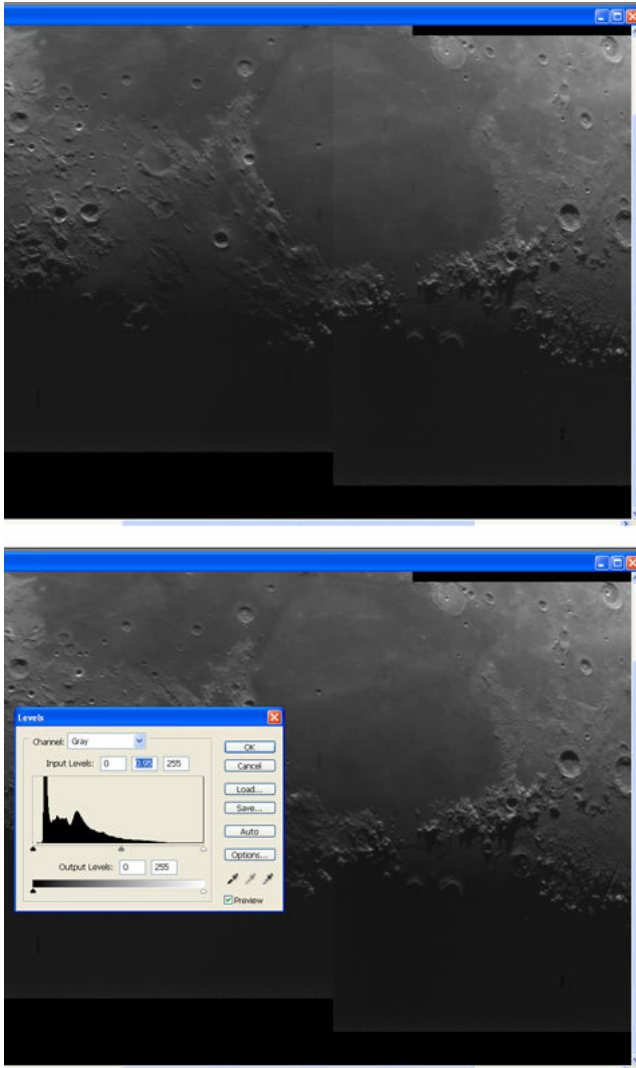

In this before and after image, you can see that the large area at the top of the image is now fairly well balanced against the base image to the left but that the lower section is still somewhat darker then the base image.   Since our goal is to get them simply as close as possible in this step, this difference is ok, we will be able to take care of this steps now.

Sometimes, due to light pollution, the angle of the object you are imaging changing over time during the night, or any other reasons, the brightness of any single image may be different then the one taken right before it not only in total brightness but also as a gradient. Because of this, we may end up with the situation seen in the previous image where a single iteration of the levels dialogue is not enough to get the entire layer matched up. While there are tools out there that may help with specific gradient issues, we will not use those here and will simply use the built in tools in PhotoShop to accomplish the same thing.

To do this, we are going to use the Lasso tool on the tool pallet. We also want to have a very large feather for this action so that no hard lines are created. After clicking the lasso tool, select a large area of the layer around which the layer is still darker or lighter then the base layer. It is important that the first time you do this you select as much of the image as possible. For example, in our example, the lower portion of the image is darker then the upper portion so I will select the lower third for this image for this operation. Next, using the Levels dialogue again, make small changes to the image to bring it closer in brightness to the base image. The image below shows how I did this for the example image. Notice that I did make some small adjustments in both the white points and black points for this adjustment. You may have to play with different levels to see what works best for your image.
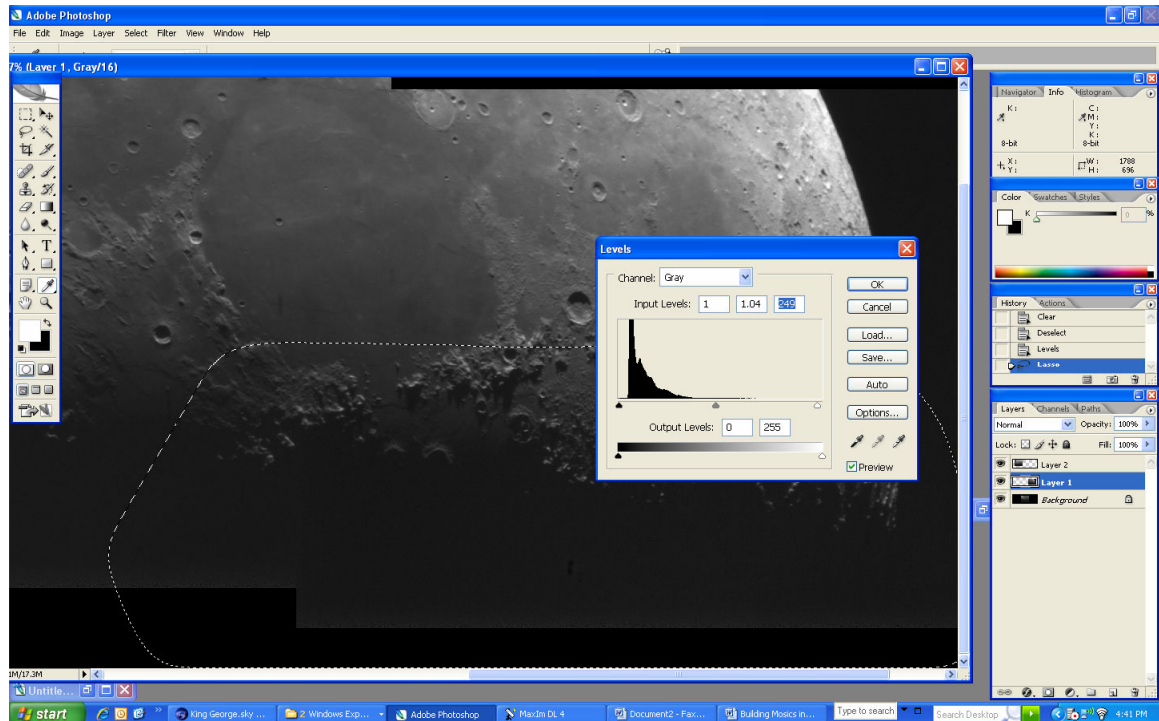
As can be seen, they are much closer now but there is still a small area at the very bottom that may need a bit more attention. This is not unusual and to accomplish this, we will simply repeat the above process only this time we will work on a much smaller area. Once again, using the lasso tool, select that area that you wish to change but since we are not working on the entire section of the layer this time, we will only select a small area near the actual place where the difference can be seen.

The image below shows how I have once again used the lasso tool to select a smaller area and also have made adjustments to the image using the levels dialogue to achieve our goal.
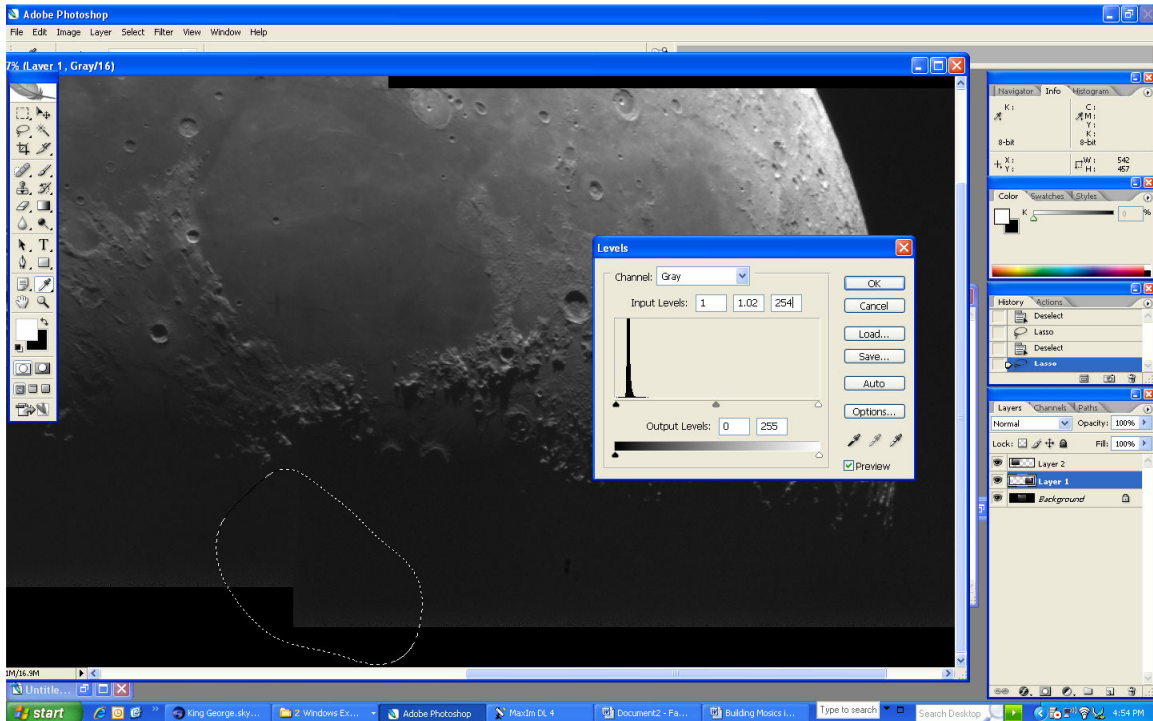

As can be seen, there are sometimes when an area just can't be correctly matched up without really making some drastic changes. In this case, there is an obvious bright band at the lower section of our base image and ultimately we will probably simply remove this from the final image. The goal here is to get the two images as closely matched as possible understanding that there may be areas that you will still have to change later on.

The images below show how our example now looks (lower image) with this portion of the processing completed vs how the image looked before we began this section.
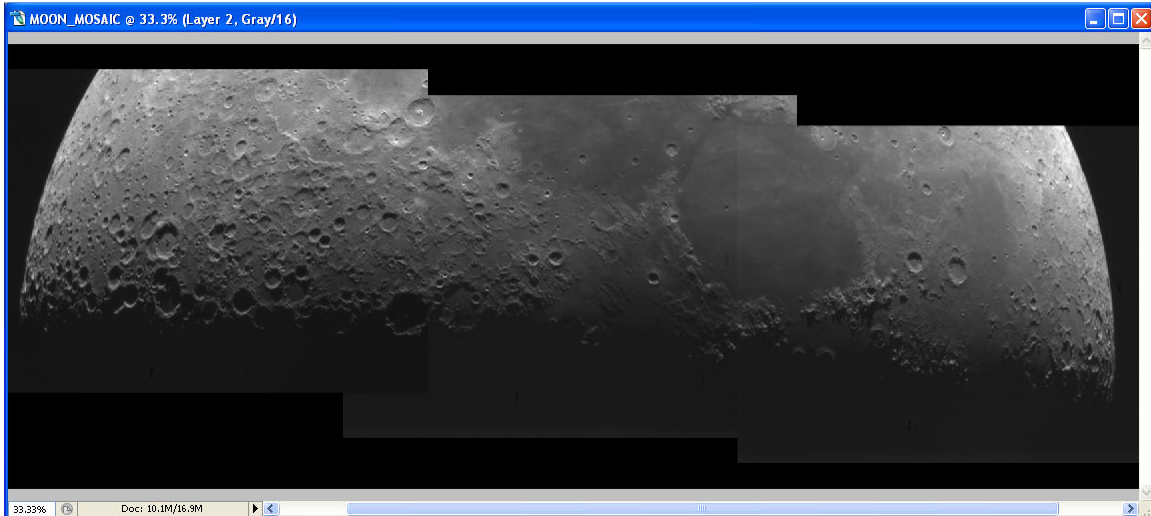

Before Balancing
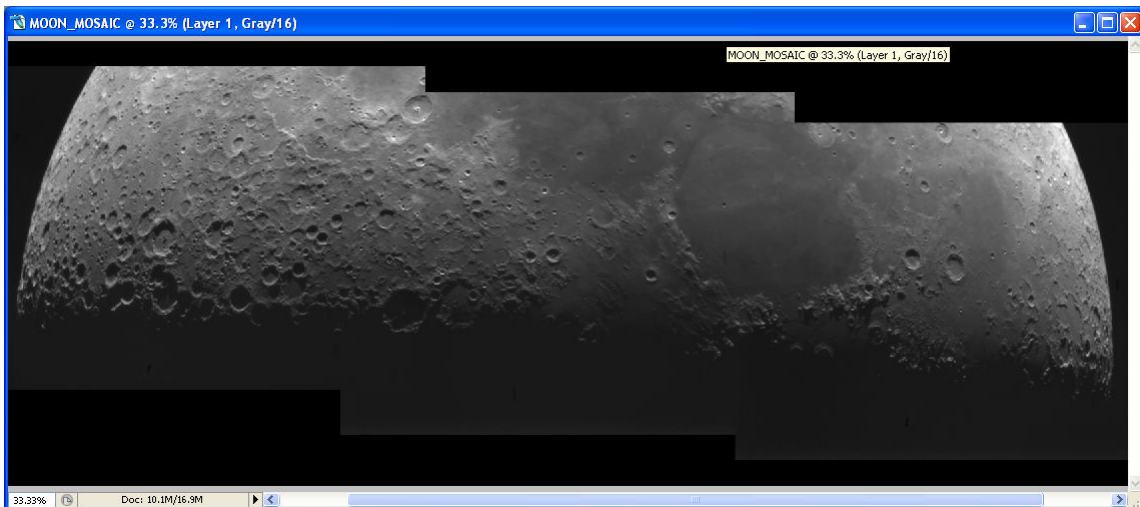
After Balancing

Edge Finishing

Prior to flattening the image for further processing, we still have one more small task to take care of. Even though we have gotten our layers fairly well balanced with each other, you may still find that if you look closely enough, you can still barely see the lines form the mosaic. As out intention is to have the final image look completely clean of lines, we will need to remove these. However, if we were to simply cut the edges the way we did before we will simply move the visible line back in the image and we don't want to do this.

Once again, our handy lasso tool comes to our rescue. Just as we did in balancing, we now want to select the layer we are going to process and also select the lasso tool as we did before, again, with a feather setting of about 30 or so pixels. The trick we will use here is to cut away the edges a little using a feather so the cut away portion is a gradual removal rather then a clear cut allowing the two layers to naturally blend into each other.

To accomplish this, use the lasso tool to select an area along the edge of layer you wish to clip the edges on. There is no need to go too far into the image, just enough to clean up the edges making sure that you stay within the area of overlap between the two layers as seen in the image below;
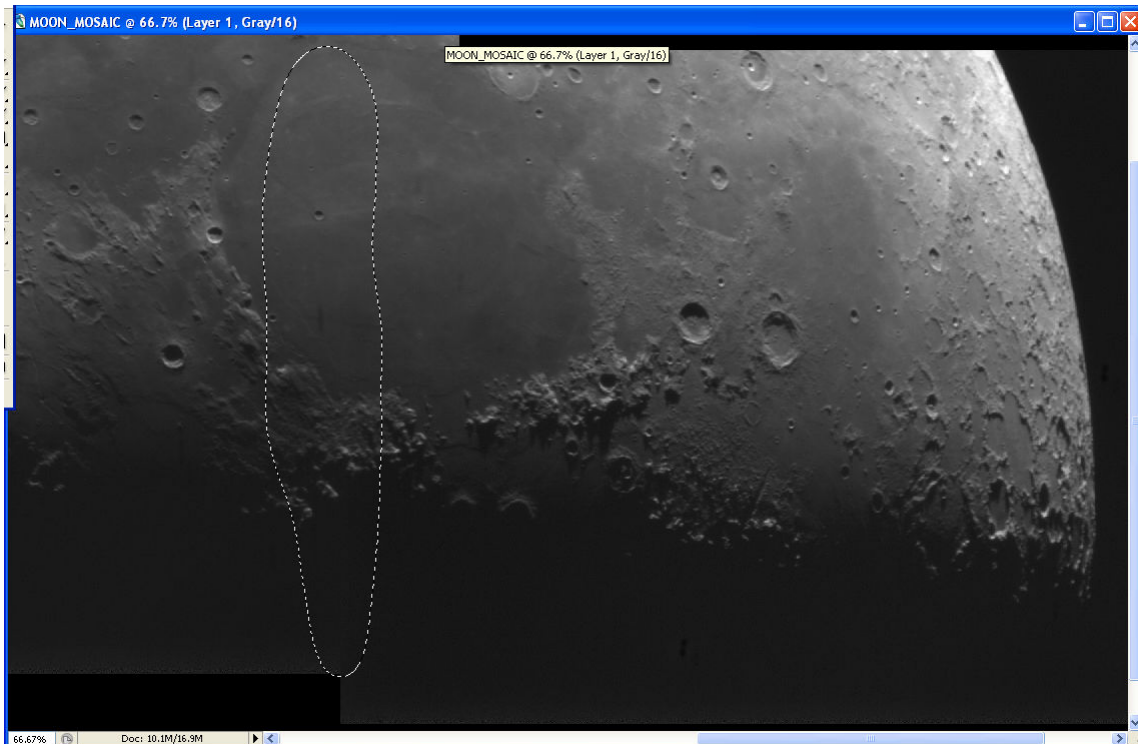
Next, from the Edit Menu, select the Clear menu item. This will clear away the selected area from the image and should leave your image with no lines. Note, sometimes you may get to close the edge of your image and may remove to much. If so, simply delete that action from the history menu and repeat the process using a smaller area. You may also find that in the smaller areas, a feather setting of 30 is too large and you may need to lower it some in order to complete the task.

Completing the Mosaic

At this point, we are nearly finished with the composition of our mosaic. It is generally helpful now to simply look over the image as a whole and note any areas that may still need a little work. Once you are happy with all the areas of the image, you should then flatten the layers into a single layer and continue with your normal processing such as levels and curve adjustments, sharpening or blurring, rotating, etc.   The image below shows the final image created with all 6 panels added once al processing was complete:

You can see the final version of this image here:
http://autostarsuite.net/photos/dsi_iii/images/14024/original.aspx

Advanced Mosaics – LRGB Images

Since most of our Deep Space images are taken using color filters to create our final color image, building a mosaic of those images adds a certain level of complexity to the situation not encountered when simply putting together a mosaic of something like the moon. While the basic principles are the same, we have the added task of not only making sure the individual channels have their layers aligned and balanced correctly, but all of the channels, L, R, G, and B, must also be aligned correctly with each other.

Thankfully, this is not a huge an undertaking as it may seem as we have a simple trick we can use to accomplish this.   That trick is to use one of our completed mosaics as the base layer for the other three mosaics we will build, generally, I use the LUM as the base layer.

To accomplish this, you must ensure that certain things have been taken care of ahead of time. First, process and stack all of your individual sub-frames as you normally would. Secondly, and this is very important, register (or align) each of the stacked images with their respective layers before bringing them into PhotoShop for processing. In other words, you might have L1, L2, L3, and L4 along with B1, B2, B3, B4, G1, R1 etc. for a 4 panel mosaic. In this case you would register or align each of the layers that will belong together with each other ahead of time such as L1, B1, G1, and R1, and L2, B2, G2, and R2, etc. This will ensure that from a starting point in PhotoShop, all rotation between the individual layers has been removed and the size of the layers correctly matches. This will save a lot of time and frustration later on.

Next, starting with the Luminance layer, bring your images into PhotoShop and follow all of the steps previously outlined here to create a single LUM image. Next, create 3 copies or duplicates of this image naming one RED, one GREEN, and one BLUE.   In each of those duplicated image, flatten the image so that it is now only one single layer. These new images will become the base layer for each of your color channels as you go along.

The next steps are fairly simple.   For each of the color layers, import the individual images into PhotoShop for that layer (example R!, R2, R3, and R4 for the red layer). Next, paste a copy of each of these images into the correct color channel image you have created leaving each as a distinct layer (in this example there would not be 5 layers). Next, for each layer, lower its opacity down to 60 or so and align the layer on top of the LUM base layer using the stars as references in the exact same way as you did before. Once all layers have been aligned correctly, simply delete the base LUM layer form the image and you will be left only the color channel image for that layer. Repeat this for each of the color channels and when done, you can then perform the other mosaic tasks on each layer. Once complete, simply flatten each image and use the resulting 4 images to compose your LRGB image as you normally would.

Conclusion

Hopefully this has given you a little insight and few tips and tricks to use in processing mosaic images with PhotoShop. Please feel free to contact me with any questions or corrections you may have to this process.

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