



NIGHT PHOTOGRAPHY WORKSHOP

PROGRAM GUIDE

The goal of this workshop is for you to leave with the knowledge and ability to shoot the stars on your own. I'll be guiding you through the basics of landscape-astrophotography all the way up to some advanced techniques.

We'll also touch on some basic astronomy information that will help you plan and capture images of the stars.

What we will learn:

- Camera settings for shooting the stars
- Focusing your camera in the dark
- Understanding the manual settings required to shoot at night
- How to find and shoot the Milky Way
- Creative Composition
- Light Painting
- Star Trails / Timelapse
- See how the moon impacts on our night photography
- Post Processing techniques

Basic equipment required:

- DSLR or Mirrorless camera with manual settings
- Wide angle lens
- A sturdy Tripod
- Spare batteries and memory cards
- External shutter release (Mainly for star trails, exposures longer than 30 sec)
- Torches
- Warm clothes
- Comfortable chair ... for star trail shooting

Other handy tools:

- Compass
- Stellarium ... App for IOS or Android (Free)
- Photo Pills for IOS & Android
- Starstax software for stacking startrails
- GPS ... (Very handy to find locations in the dark)
- Stacking Software: Sequator for PC, Starry Landscape Stacker for Mac

Basic requirements for Nightscape shooting:

1 A Dark Sky: The number one key element to capturing the night sky, Milky Way, or stars in general is having a dark sky, and I mean the darkest sky possible. Please note, if you can't see the Milky Way with the naked eye, it will be very hard to capture it any better on camera.

2 Moon Phase: The next equally important step is checking the moon phase. If there is a moon in the sky, the stars will never appear to shine as bright. The moon is much closer than any of the stars seen in the night sky, therefore it will wash them out, and in fact a long exposure at night with even a small moon can look like daylight. Shooting at New Moon ensures that the moon is not visible in the sky and that the Milky Way appears as bright as possible.

3 Sturdy Tripod: The third crucial item is a sturdy tripod, this is one of the steps that many people compromise and therefore sacrifice the quality of their night shots. By sturdy I don't mean heavy ... just solid. A good tripod head is just as important.

4 Manual Camera: The 4th and last necessary item is a camera with manual mode functionality that shoots in RAW format. This allows the user to have ultimate control both when capturing the stars and in the post processing. My preferred camera is the Nikon Z6, which handles the high ISO and noise induced from night sky shooting flawlessly. I shoot with and highly recommend the Nikon 20mm f1.8S and G series lenses for many of my star shots. Starting at f/1.8 this is a very sharp and fast lens. My other favourite lenses are the Nikon 14-24 f2.8 & Sigma 35mm f1.4

Lens & Camera Advice:

If you are looking to get into nightscape photography and are not sure what kind of camera or lens to select there are a few points to keep in mind. In my opinion a full frame camera with a 35mm sensor is the best way to capture the night sky.

When talking full frame sensors a few good ones come to mind. Regarding Canon the 5D Mark III or Mark 4 will work fine as well as the 6D and the new EOS-R mirrorless. With Nikon the D850, D810, D750 or the D600 series are all really good as well as the mirrorless Z6 & Z7. Sony have the excellent A7 series. A7iii, A7riii and A7r4 in particular.

Looking at cameras that don't have a full frame sensor (*These are called crop sensor cameras*) the Canon 7D, 700D/800D, 70D/80D/90D or the Nikon D5100 – D7500 will do the trick, but a full frame camera makes it easier to capture the Milky Way and all the stars simply because of its superior high iso & low light abilities.

The latest Fuji mirrorless cameras such as the XT-3 or similar are excellent for night photography. Micro 4/3rds cameras such as the Olympus EM-1 and Panasonic G9 are ok but you'll be pushing those smaller sensors to the limit.

Lenses:

Moving along to lenses there are a few major points that need to be touched on. Having a lens with an aperture of f/2.8 or faster, is pretty much absolutely necessary for capturing the Milky Way, for star trails it is not so much a necessity.

Recommended Lenses for Milky Way capture:

(FULL FRAME CAMERA)		(CROP SENSOR CAMERA)	
Canon	Nikon	Canon	Nikon
Canon 16-35 f2.8	Nikon 14-24 f2.8	Tokina 14-20 f2	Tokina 14-20 f2
Tamron 15-30 f2.8	Tamron 15-30 f2.8	Tokina 11-16 f2.8	Tokina 11-16 f2.8
Sigma 14mm f1.8	Sigma 14mm f1.8	Tokina 11-20 f2.8	Tokina 11-20 f2.8
Samyang 14mm f2.4	Nikon 20mm f1.8	Samyang 16mm f2	Samyang 16mm f2
Samyang 14mm f2.8	Sigma 20mm f1.4	Sigma 18-35 f1.8	Sigma 18-35 f1.8
Sigma 20mm f1.4	Samyang 14mm f2.4	Samyang 14mm f2.4	Samyang 14mm f2.4
Samyang 24mm f1.4	Samyang 14mm f2.8	Samyang 14mm f2.8	Samyang 14mm f2.8
Canon 24-70 f2.8	Samyang 24mm f1.4		
Tokina 16-28 f2.8	Nikon 24-70 f2.8		
Sigma 35mm f1.4	Tokina 16-28 f2.8		
Canon 50mm f1.8	Sigma 35mm f1.4		
Laowa 15mm f2	Nikon 50mm f1.8		
	Laowa 15mm f2		

Follow this link for a comprehensive lens guide for other camera brands:

<https://www.lonelyspeck.com/lonely-specks-ultimate-list-of-best-astrophotography-lenses/>

Basic camera settings for milky way shooting:

I would always shoot with manual settings.

IE: Manual Shutter speed, Manual Aperture, Manual ISO

Choose the widest suitable aperture available and the shutter speed which is most appropriate to the lens chosen. (See chart on following page)

The ISO setting is determined by the quality of the camera sensor and it's ability to handle noise at high ISO. As a rule of thumb most of my nightscape images are between 1600 and 6400 ISO. The newer full frame cameras will handle high ISO much better than older models or crop sensor cameras.

I also select a manual white balance setting of between 3450k – 5000k

It is possible to achieve great results with auto white balance, but like just about everything else with night photography, the camera is easily fooled into selecting the wrong setting. Also when shooting a sequence it makes sense to keep this set.

The other major issue facing the night shooter is focussing. Never, I repeat, never attempt to use auto focus at night. You will be forever frustrated if you do. We will spend a considerable amount of time discussing methods of focussing in the dark. Because the stars appear to move with the rotation of the earth we need to be aware of the maximum shutter speeds we can use with any given lens. If we exceed these exposure times we will see that the stars leave a trail rather than remain as sharp dots.

The table below introduces what is known as the 500 rule.

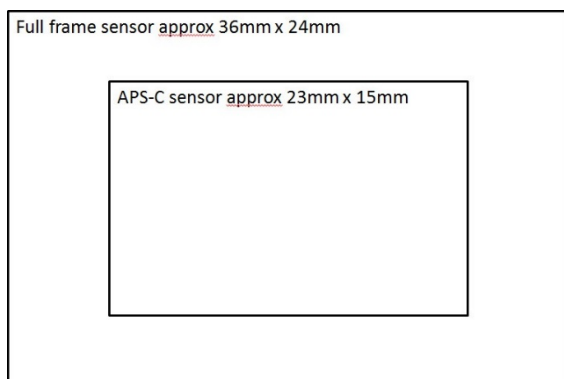
This is simply a calculation dividing the focal length of your lens into 500.

EG: $500 \div 14 = 36$ (Note: I would usually use the 400 or even 300 rule when shooting with high megapixel modern cameras to obtain sharp stars)

EXPOSURE IN SECONDS BEFORE STARS BEGIN TRAILING				
Focal Length	Full Frame Camera		Crop Sensor Camera	
	500 Rule - 300 Rule		500 Rule - 300 Rule	
10mm	n/a		31 sec	19 sec
14mm	36 sec	21 sec	22 sec	13 sec
16mm	31 sec	18 sec	20 sec	11 sec
20mm	25 sec	15 sec	16 sec	10 sec
24mm	21 sec	12 sec	13 sec	9 sec
28mm	18 sec	11 sec	11 sec	7 sec
35mm	14 sec	8 sec	10 sec	5 sec
50mm	10 sec	6 sec	6 sec	4 sec
70mm	7 sec	4 sec	4 sec	3 sec

If you are using a crop sensor camera you will have to divide the full frame result by a factor of 1.5 for Nikon and 1.6 for Canon cameras.

EG: $500 \div 14 = 36$ $36 \div 1.6 = 22$

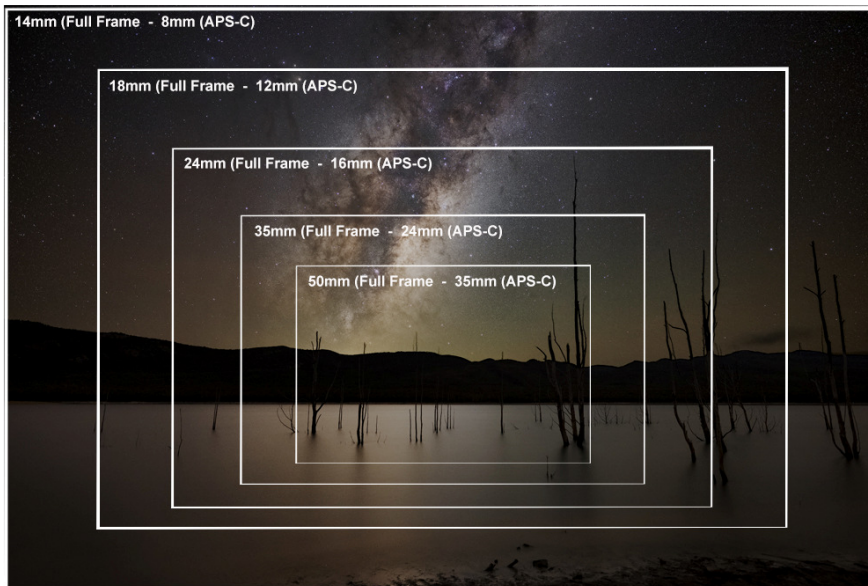


This diagram illustrates the difference in sensor size between a full frame camera and an APS-C crop sensor.

The full frame camera is able to operate much better at the higher iso's and low light shooting required for nightscape photography.

The image below illustrates why the crop sensor camera appears to have more "reach" that the full frame model.

In reality it's only showing the centre area that is covered by the full frame model. It's not actually magnifying the image any more, even though it gives that impression.



This diagram helps us see what effect the combination of sensor size and lens focal length has on a milky way landscape photo.

Focusing in the dark:

As mentioned earlier, when shooting at night it is very difficult to find accurate focus as the auto focus becomes unreliable. Generally we need to find infinity focus to shoot the milky way, however this is sometimes more difficult than it first seems.

Focus Methods to find infinity focus:

- Turn on live view and focus manually on a bright star or the moon by using zoom buttons on rear of camera. (This is not zooming the camera lens). When star becomes a sharp point it's in focus.
- Focus the camera on a distant mountain or landscape whilst it's still daylight and make sure the lens doesn't move before you shoot at night. This method does not work with Focus by Wire lenses. (Usually mirrorless lenses)
- Shine a light or torch on a fence post at an appropriate distance once it's dark outside (this distance varies depending on focal length of lens ... see Depth of Field Calculator later) and repeat steps explained previously using live view screen.

Focusing is probably one of the single most difficult things to do at night and it takes quite some time to master.

Generally speaking when taking landscape photos we want everything to be sharply in focus. The challenge is to balance the focus of foreground objects with the distant stars ... sound easy but it isn't.

This is where a Depth of Field Calculator comes in handy.

The following link is an example of a depth of field calculator. <http://www.dofmaster.com/dofjs.html>

Photopills is another great one: <https://www.photopills.com/calculators/dof-table>

When shooting with a wide angle lens it's easier to get everything in focus once you can find infinity. The more you zoom in, the harder it becomes.



An example of the rear screen in live view mode.

When you zoom in using the plus and minus buttons on the left, the red centre rectangle becomes larger helping you see the correct focus.

Be sure to adjust the camera to manual focus mode.



Many lenses have infinity markings on them but it is my experience that these are not accurate.

Out of all my lenses I have only one that when lined up perfectly at infinity it actually is infinity.

My advice is to always check the fine tuning of any lens.

How to find the Milky Way:

This is where the rubber hits the road. You've packed all your gear, you drive out into the dark sky to a country location, you look up and see no milky way.

Having a basic understanding of astronomy certainly helps us with nightscape photography but those of us who have no idea about astronomy need help.

Although there is usually some portion of the milky way visible all year round, we have to understand that the best images are those that focus on what is known as the Milky Way Core.

In both the Northern & Southern Hemispheres we find the core, which is the thickest and brightest part of the milky way in the constellations of Scorpio and Sagittarius.



The image above left was taken during February at 12.27 am facing south. The image on the right was also taken in February but at 4.25am facing south east.

You will notice that due to the earth's rotation the brighter and thicker part of the milky way which wasn't visible in the first image has risen above the horizon and is placed beautifully behind the tree. (*Southern Hemisphere images*)



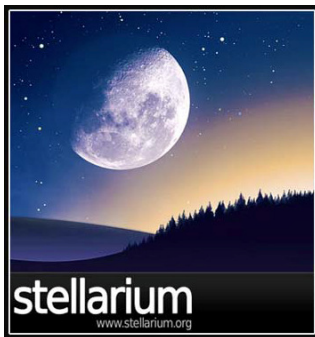
To put this into perspective the image to the left above was taken during July at about 11pm facing almost directly overhead, whereas the image above right was taken during September at about midnight facing south west.

The milky way is constantly on the move and unless we know where it will be when we go out to shoot at night we run the risk of being constantly disappointed.

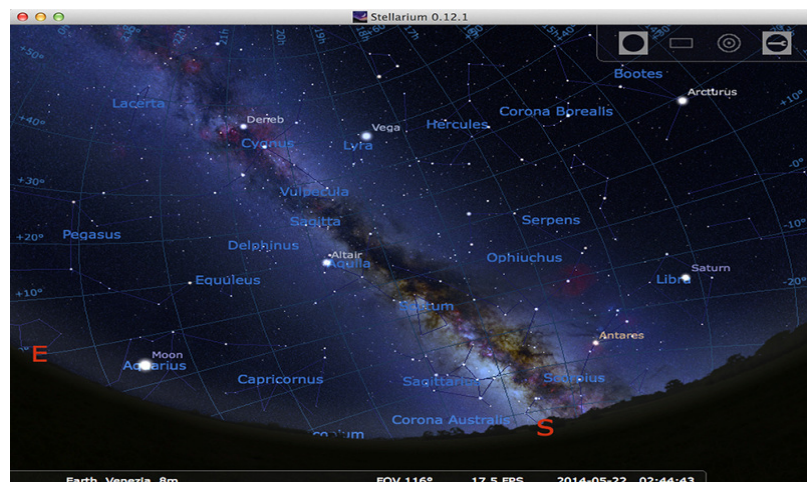
Added to this is the fact that the milky way core is not visible at all during November through January.

Thankfully there is an amazing piece of software to help us Stellarium.

Stellarium is great software available for desktop and mobiles and what it does is amazing. For any given day, month and year it will tell us where everything is located in the day or night sky. It gives moon phases and shows where planets are as well. It also shows altitude, elevation and compass direction to make planning where and when to shoot a breeze.



www.stellarium.org Also available from app stores, Apple and Android.



This is a screenshot of the Stellarium interface, and whilst it may appear a bit daunting at first, believe me it is a life saver once you get used to it.

Equipped with Stellarium and a good compass, it becomes simply a matter of deciding where to shoot.

Creative Composition:

Ok now we get to a challenging yet most rewarding aspect of nightscape photography.

A question I constantly have to ask myself. What makes a great image ...??

Is it the light, or perhaps the angle of view ... maybe it's the subject matter.... perhaps nailing the exposure settings.

All of those responses are certainly true and contribute to a great image, but there is one thing that must be present when attempting to get a great nightscape image.

The ability to see something in our mind before we actually see anything on the rear screen of our camera we need imagination, we need to learn to pre-visualize our work.

We've discussed many aspects already regarding the steps required to simply prepare ourselves to shoot at night, but all the technical ability in the world won't produce a master shot It takes just as much energy to think through the night photography process before we leave home as it does once we arrive on site to shoot.

In fact I'd say that there is considerably more time spent during daylight hours seeking shooting locations and researching where the milky way is likely to be after dark than anything else. That's why we need to develop our imagination, foster a keen sense of what the scene could look like without daylight, or perhaps how it might look when light painted.

Whichever way you look at it, photography is art. People who love photography are genuine artists. The problem is that because we have to cram our heads full of so much technical stuff the creative juices can run a little thin. When we go out to shoot what is going through our minds ...?? I can guarantee, especially with night photography that a large proportion of our thinking and preparation is going into the gear required to get the shot, making sure the batteries are charged and a thousand other details.

When we get to the point of preparing the gear in auto pilot mode and begin to imagine the type of shots we can get when we go out to shoot and give ourselves space to create, well that's when the brilliance happens.

So in summary, the process of shooting nightscape images goes something like this.

- Learn how to operate your camera efficiently in manual mode
- Practice focussing your lenses and study the results on your computer
- Study the techniques until they become second nature
- Get a basic understanding of astronomy
- Spend lots of time scouting locations in the daylight hours
- Let your imagination run wild and don't limit yourself

Composition in any form of photography is vital, and even more so when shooting the nightscape image.



I'd like to draw attention to an obvious but often overlooked aspect of nightscape shooting ... a lack of light. Now before you start laughing at me and ask what that has to do with creative composition, I want you to consider the two images above.

On the left we see a lovely shot of the milky way rising above a country landscape. It could be anywhere and it's not until we see the exact same shot above right but with the addition of a person (me) shining the light into the sky that we get an understanding of what the scene really looks like ... with the simple addition of light we are much more drawn into the image.

The sky is exactly the same but the detail in the foreground gives the image a sense of depth and perspective.



The above images show exactly the same thing. The left image exhibits a lovely silhouette and many times that can be quite stunning, but at other times the addition of detail in the foreground brings the image to life as represented in the image on the right above.

All of this brings us to ask the question: How do I add this lighting to my images ...?

Light Painting:

Ok, this is potentially a very complex subject but I will keep it to the basics for the moment. There are many ways to add light into a night landscape image including using hand held light sources such as torches or flashes, making use of ambient light such as street lighting, using moonlight to help light a foreground and also taking advantage of incidental light sources such as passing traffic.

I'd like us to focus on light painting with hand held sources, usually torches. Most of the nightscape images I take use this method in one way or another. As demonstrated above there are many times where adding a small amount of light brings a remarkable lift to our night images.



Both of the above images were lit using a basic led torch. Using a gentle painting motion being careful not to create “hot spots” in the image you can easily introduce beautiful texture, form and shape. By keeping the light low and off to an angle we create lovely shadows, especially on 3D objects such as cars and buildings.

Light painting requires a fair amount of practice to get right. Because we generally set very high ISO's on our cameras when shooting at night, it's really easy to overexpose our image by putting too much light into it.



You can see how this night photo of a canola crop quickly overexposes when light painted with a small hand held torch.

This is a 20 second exposure at a high ISO of 2500.

I had to wave my light over the crop for only a few seconds to correctly expose the scene.

So as you can see, light painting with a simple led light can introduce an enormous amount of creativity to our night images. Light painting is exactly that ... painting with light. Don't ever let anyone tell you that photography isn't art ...!!!



The image to the left shows some of the lighting devices I commonly use to light paint my photos.

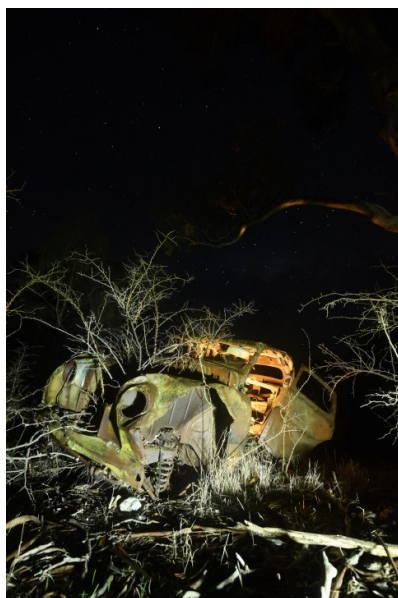
From left to right:

Z96 video light Dimmable
1000 lm LED torch zoomable
450 lm LED torch zoomable
300 lm LED torch zoomable

Because most LED lights are balanced to more of a blue colour I like to use coloured gels to add some yellow into the mix. Added to this I usually set my white balance in camera to somewhere between 3800k & 4500k. This has the effect of exposing a more to the blue end of the colour spectrum and my reason for doing this is because I like that colour balance. Not everyone will agree and that's quite ok.

During post processing of raw image files it's quite easy to adjust the white balance of the image to bring out the warmer yellow tones so it makes sense to give the light source a bit more yellow to start with.

Just to illustrate my point, check out the two images below. The left image is a standard led torch whilst the right image has a ½ cto filter (Colour Temp Orange). White balance on both is set to 3450k.

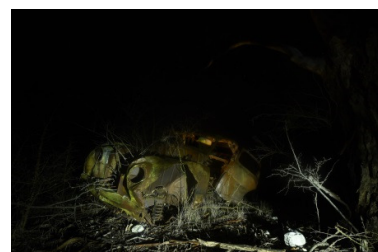


As we delve more into the creative side of taking pictures at night we quickly realize that there is no limit to the possibilities when it comes to lighting our shots.

There are times when we may want to blend multiple images to create for example a panorama or simulate a high dynamic range image (HDR). This involves using more than one shot to create a photograph. I have used as many as 16 images to create one single photograph a few times and whilst this in itself is a challenging scenario especially at night, the lighting of such an image becomes critical.



The above picture is a combination of 5 separate exposures. One for the milky way sky in the background, and four more using light painting techniques to creatively light the car and surrounds from different angles to best bring the image to life.



These 5 images are the raw shots blended to create the single image shown above.



One further complication with a blended image as per the one shown on the previous page is focus. The more you consider the image the more you realize that the distant milky way will obviously require infinity focus on the lens, whereas the old car in the foreground is only a matter of 2 or 3 metres away from the tripod mounted camera. This adds another element in the never ending obstacles placed before the creative photographer seeking to create a nightscape masterpiece.



Creative use of light painting as shown above will transform our nightscape images from ok to awe inspiring but as you can imagine this is no easy task. It takes lots of practice.

So in summary, here is my light painting guide:

- Make use of standard LED lighting devices
- Consider putting on gels to balance out the colour of LED's
- Practice using gentle sweeping strokes. Paint the light.
- Be careful not to overexpose the shot
- Never light your subjects from directly behind the camera
- Use angles to create shadow and texture
- Light from low down, especially over grass and shrubs
- Look for opportunities to make use of "backlighting" as per images above
- It is possible to light distant objects such as mountains with stronger lights

We started this section discussing creative composition and so I'd like to conclude by saying that all the rules designed for daylight photography remain at night.

Things such as the rule of thirds, creating leading lines, drawing attention to single objects etc are what make a great image ... always have and always will.

At night all of this becomes harder to achieve but much more satisfying when you do. As I keep saying, photography is an art form and the more we practice the better we become.

We have one more dynamic subject to consider in our night photography journey.

Star Trails:

We may well have left our best topic till near last. Star trails can be fairly ordinary or quite stunning. What makes the difference ..? Well, not surprisingly just about all of the things we have discussed previously apply to taking great star trail images.



The above image is a compilation of 10 x 3 minute exposures. 14mm lens at f3.5 with a relatively low ISO of 640. White balance was about 3800k

When I first started taking pictures of the night sky as a teenager, all that was realistically possible were star trails. Back then using film cameras you would leave the shutter open for hours and let the rotation of the earth give the effect of streaking or trailing the stars.

This is still possible with modern digital cameras but I find it much more effective to combine, or “stack” multiple shorter length images. It is quite simple to do this in software such as photoshop and there is a free piece of software called Starstax which is available for both windows and mac.

Check this link; <http://www.markus-enzweiler.de/StarStaX/StarStaX.html>

The first question many of you will be asking is how do I keep the shutter open for 3 minutes as most cameras have a maximum of 30 seconds as shutter speeds.

There are a number of methods but the best and easiest to use is an intervalometer.



This is an intervalometer. It enables the user to set any shutter speed by selecting the bulb mode on the camera.

As well as shutter speed it gives us the option to take any number of shots at any given shutter speed one after the other.

This is the same device used commonly to capture timelapse sequences.

It's a simple matter of setting the number of shots required, the shutter speed and the interval between each shot.

So as we discovered previously, once we set the device to operate the camera to capture the images the responsibility is on us to correctly focus and compose the shot.

All of the techniques such as light painting are used whilst capturing star trails. Sometimes the foreground can be lit and captured in the first 3 minute exposure and during the other remaining exposures you can go relax and have a cup of tea. As the majority of the shots are capturing the stars, there isn't really much that you can do except wait.



Old Truck Star Trails

10 x 3 minute exposures
at f2.8 ISO 800 (Stars)

Then blended with 3 more
exposures focussed on
the truck at f4
25 seconds ISO 800.

One of my favourite
images comes to life
simply because of the time
I spent lighting the truck
and grass in the
foreground.

I find that the best star trails are captured facing south in the Southern Hemisphere and north in the Northern Hemisphere as the stars rotate around that part of the sky. This gives us a full circle of motion which is somehow pleasing to the eye. It also means we can have shorter length shots and still see the motion quite clearly.

Star Trails in summary:

- As with all nightscape photography .. use a steady tripod
- Use an intervalometer to automate the capture of star trails
- Generally use wide angle lenses to capture more sky
- Use light painting to give the foreground some perspective
- Look for interesting subjects to compose in the foreground
- Relax and enjoy the view as the camera does it's stuff ...!!!!

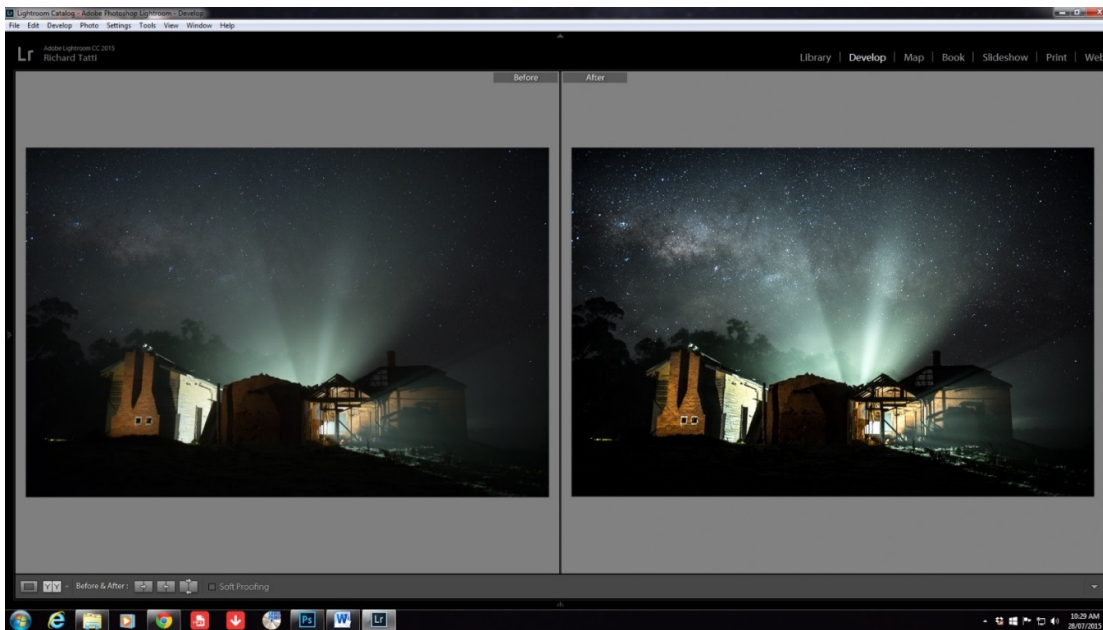
I haven't spoken a lot about post processing as I feel this requires more hands on discussion. Everybody has an opinion as to the amount of image manipulation required to obtain that perfect shot.

For what it's worth I do the vast majority of my nightscape photo editing in Adobe Lightroom with a lesser amount of complimentary work in Adobe Photoshop. I usually use this combination to process my star trails.

As stated you can use Starstax for star trails and a free windows program called Microsoft ICE for panoramas, although now that's an added feature in Lightroom Creative Cloud I tend to use that and Photoshop more.



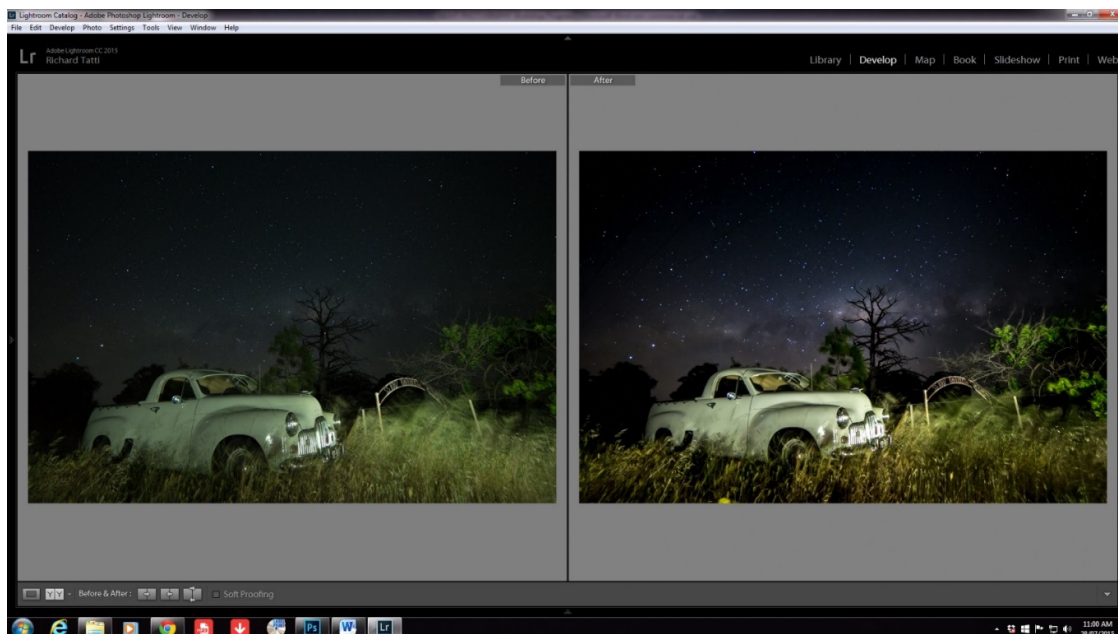
Here is a screenshot showing the Lightroom interface. You will notice the various adjustments made to the image on the RH side panel.



This is before and after of the same shot. You can clearly see how the simple adjustments made to the image reveal the detail, especially in the milky way. This proves that the detail is captured in camera, but especially in raw we need to tweak the settings to bring it out.

I did mention earlier that we should always capture our nightscape images in raw format. This becomes very apparent when we begin post processing as the raw image retains all the necessary information to make whatever adjustments we need to do possible. If we captured all our images in jpeg format we have already lost significant data which compromises our final results.

The images shown below of the old ute highlight the differences possible when delving into the raw data retained during capture in that format.



In the image below I'd like to draw our attention to the sliders on the RH side of the Lightroom panel. During long exposures at high ISO's you will notice quite a lot of digital noise is generated. This means we have to introduce a level of noise reduction. Lightroom noise reduction is pretty good at doing just that but be aware that there is always a trade off when getting rid of noise. A lot of noise is reduced but at the expense of the fainter stars as the software sees these as noisy spots.



One other aspect which relates more particularly to wide angle lenses is distortion. When shooting very wide you will often notice vertical lines lean into the middle of the shot. This is a normal characteristic of any wide angle lens but it can appear quite off putting at first

Lightroom deals with this very effectively in it's lens correction panel. There are numerous adjustments possible there but remember that whenever making adjustments to the lens correction you will often lose some 'real estate' on the final image. So be warned, if you are shooting a subject that will ultimately need a lot of lens correction to fix vertical straight lines, then don't go too close to the edges of the frame as these will inevitably be cropped out.

There are numerous instruction manuals and videos available for both Lightroom and Photoshop which address all of these techniques in greater detail than we can get into here. Take the time to study some of these as like everything else, practice makes perfect.

Panoramas:

Milky Way Panoramas are certainly possible with lots of wonderful software options. I often use Lightroom CC for this but Photoshop, PTgui, Microsoft ICE, Hugin, Autopano and others are really good options.



The above panorama image was created using 21 images. Three horizontal rows of 7 shots with about a 40 - 50 % overlap between the images.

The equipment I used for the above shot was Nikon D750 & Nikon 20mm f1.8 @ f2.8 aperture, 20 second shutter speed and iso2500 for each shot.

It's important to keep the camera level when shooting as this greatly affects the outcome. Some prefer to use a dedicated panorama tilt head for this type of shooting although I've never used one myself.

The shot below is only 3 images with the same camera/lens & settings as above.





Final thoughts:

I am of the opinion that photography is an art form and as such the final outcome of an image rests in the imagination of the photographer. I also believe that most people want to see a nightscape image the way that they imagine it should look.

When we first begin taking images of the stars at night we realise that the camera can see a whole lot more than we ever could. That, coupled with the power of post processing software which has the ability to enhance and bring out the colour and beauty of the night sky ... well the sky is literally the limit.

When we tap into the techniques discussed in this manual and begin to see what we can achieve I guarantee we will become much more accomplished photographers in every other aspect of the craft. Night photography is immeasurably more complex than its daylight cousin, yet they share the same chemistry, the same mystical romance that draws us more into the journey of making beautiful pictures.

And never forget to savour the moment whenever you experience the awe inspiring milky way on a dark moonless night. The night sky is art in itself, we as nightscape photographers are privileged to bear witness to it.

General information:

Equipment used to capture & process all the images used in this manual:

- Nikon D750, Nikon D610
- Nikon 14-24 f2.8, Nikon 20mm f1.8G, Sigma 35mm f1.4, Nikon 50mm f1.8, Samyang 14mm f2.8, Samyang 24mm f1.4
- Manfrotto tripod with pan/tilt head
- Inexpensive Intervalometer Ebay not brand name
- Simple LED lighting fixtures as shown
- LED Lenser P7.2 Torch
- Adobe Lightroom CC Classic
- Adobe Photoshop CC
- Starstax software
- Stellarium Software (Desktop & Mobile)
- Photo Pills available for IOS or Android
- Microsoft ICE for stitching panoramas
- GPS for finding locations in the dark
- Compass App on smartphone
- Depth of field calculator (Software & Mobile App)

Equipment I added more recently:

- Nikon Z6 Camera
- Nikon 20mm, 35mm, 50mm f1.8“S” for Z mount lenses
- Sirui W2204 Tripod Carbon Fibre
- Sequator software for stacking & noise reduction
- Syrp Genie Mini
- Edelkrone & other Timelapse motion slider equipment