INTRODUCTION

This is the second installment in a series of articles on night photography. The first installment, *Aim for the Stars*, covers techniques for capturing star points, whereas, this segment describes a digital approach to photographing star trails.

If you have not already read the first article, I encourage you to do so before proceeding, as the fundamentals of night photography will not be repeated here.

Simply stated, a star trail records the rotation of the earth as reflected by the shifting position of celestial bodies. When executed properly, star trails yield stunning photographs that can captivate the imagination of viewers. Armed with a few techniques and a bit of patience, you too can produce awe-inspiring star trails of your own.

IMAGE STACKING

To shoot a star trail, film photographers leave the shutter open for the duration. But this is rarely a viable approach for digital photographers. During very long exposures, film is susceptible to a phenomenon called reciprocity failure (causing color shifts), but digital photographers have to contend with an even worse problem: digital noise.

If you were to leave the shutter open on a digital camera for a few hours, the resulting image would likely be unusable, hopelessly ruined by countless white speckles in the shadows. While moderate digital noise can be successfully removed in software, eradicating excessive noise can cause irreparable damage to image quality.

Thus, the digital photographer must apply a different technique for capturing star trails: image stacking. The principle behind image stacking is simple: shoot a
succession of identical frames over a period of time, and merge the frames in post-processing.

Using a multiple frame technique, the photographer can control the exposure time to avoid excessive noise in the resulting image. So, image stacking enables the photographer to reduce noise by using a much shorter shutter speed.

You may wonder if there are big differences between star trails created using a single frame and a multiple frame technique. Well, there are none. I have seen photos of the same scene shot in film and digital, and the results look identical.

The rest of this article explains the process of capturing star trails using the stacked frames approach. Topics include when and where to shoot, setting up your camera, shooting the frame sequence, and post-processing with one of the free software options.

**WHEN TO SHOOT**

So, how long does it take to capture a star trail? It takes at least thirty minutes to see moderate star rotation, although a more complete star trail will need an hour or two. And, I’ve also seen stunning star trails spanning over many more hours.

For your first attempt though, you probably want to limit the duration to around thirty minutes. This will allow you to get familiar with the entire process and correct any mistakes without a big time sink. As you gain experience and confidence, you can experiment with longer star trails.

The phase of the moon may also influence the choice of duration. Although you can shoot star trails at any time of the month, moonlight will always reduce the visible volume of stars and weaken the intensity of the resulting trail. So when shooting under moonlight, you may want to increase duration in order to offset the reduction in intensity.

Whether you shoot on moonless nights or under a full moon is a matter of personal taste. I prefer to shoot star trails under a half moon, which corresponds to the first and fourth week of the moon cycle. Ambient light makes it easier to
include the surroundings, and the softer lines are less dizzying than the intense trails made on moonless nights.

What time of day is best for shooting star trails? I shoot all my star trails in the evening, although you can create equivalent images in the wee hours before dawn. But the challenges of composing and focusing in the dark makes dawn less practical, and only suitable for advanced night photographers.

You can start shooting a star trail sequence about forty-five minutes after sunset, which corresponds to the end of Civil Twilight. At that hour, the sky will still be blue, painting a pleasant backdrop for your star trail. But if you prefer to shoot in total darkness for a more intense look, you’ll need to wait until the end of Astronomical Twilight, which arrives a little more than two hours after sunset in New England.

WHERE TO AIM

The most dramatic star trails are usually those that form concentric circles above the main subject. While there are numerous examples of beautiful star trails of different types, most photographers seem to value concentric circles above all.

If you want a complete circle, then you need to aim your camera toward the North Star, or Polaris as it’s officially known. Since the earth’s axis points toward Polaris, the star appears fixed in the sky, serving as a perfect guidepost for your shot. Find Polaris, and position the star in the upper half of the frame to capture a concentric circle.

So then, how do you find Polaris? It’s not always the brightest star in the night sky, so it can be tricky to locate. In the absence of electronic gadgets, you’ll need to identify the Big Dipper and the Little Dipper, then trace your way over to the North Star. The Space Sciences page of the Office of Naval Research shows you how to do it.

Even better, if you own a smart phone, download one of the GPS-enabled apps to pinpoint the precise location of the North Star on your phone. There are several
good applications that can do the job. I currently use Star Chart on my iPhone but have also used Sky Map by Google on an Android phone with equivalent results.

If you point your camera anywhere but north, the resulting image will contain a partial circle, with all lines rotating in the same direction. On occasion, you may witness a befuddling phenomenon of nature, where the lines are seen to rotate in both directions. This can happen if your camera is pointing toward the Celestial Equator, which enables you to capture the rotation around both poles. If you manage to get one of these images, I recommend that you showcase it on your coffee table as a conversation piece.

**EXPOSURE TIME**

Unlike star points, shooting a star trail is not subject to the 600 rule (i.e. 600 divided by the focal length of your lens) for figuring exposure time. Here, you actually welcome motion in the stars rather than working hard to avoid it.

The most common shutter speed used for shooting star trails is **30 seconds**. Why? Because it represents the longest exposure supported by most DSLR cameras. Thus, it requires no special equipment and usually delivers very low noise. So, 30 seconds is the best shutter speed to use for your initial attempts.

But there is a slight disadvantage to the 30-second shutter speed: the number of frames. Capturing a one-hour star trail yields some 120 frames at 30 seconds each. And since at least one second must elapse between each frame, minuscule gaps are inserted in the star trail that may trouble the perfectionist.

As you gain experience, you may want to experiment with longer shutter speeds. But moving beyond the built-in camera limitation of 30 seconds requires a timer cable release, also known as an intervalometer.

What is an appropriate shutter speed to use? That depends on the camera. The majority of star trails are shot with shutter speeds in the range of **thirty seconds to four minutes** in duration. A four-minute shutter speed effectively reduces the number of frames by a factor of eight and lowers the frequency of tiny gaps in the trail.
But as is always the case with night photography, digital noise is the main culprit to watch when increasing shutter speed. The only way to know the upper limit is to test your camera on a dark night. Start at 30 seconds and ratchet the shutter speed in 30 second increments until you reach three or four minutes. Back at your computer, zoom in on the sky at 100%, and check for noise to determine the slowest shutter speed to use with your camera.

**SETTING UP YOUR CAMERA**

The gear required to capture star trails is identical to that needed for star points. The camera settings also share common elements, with a few notable differences.

- **Set image quality to RAW.** The added flexibility to apply post-processing adjustments to white balance and exposure is important in night photos.
- **Turn OFF mirror lock-up.** Mirror lock-up involves pressing the shutter release twice, not relevant with a release cable locked for continuous shooting.
- **Turn OFF long exposure noise reduction.** Long exposure noise reduction takes twice the elapsed time and would result in noticeable gaps in the star trail.
- **Open up the lens to its widest aperture.** This is usually f/2.8 or f/3.5. A wide aperture will take in maximum light under nighttime conditions.
- **Set the shutter speed to 30 seconds or higher.** Use 30 seconds for your initial trials, and increase toward the slowest shutter speed, if you own an intervalometer.
- **Set focus on true infinity.** Look for the little sideways 8 on your lens, and set the focus line in the middle of that symbol to ensure a sharp star trail.
- **Set ISO to 400 or lower.** ISO 400 should be adequate for moonless nights. On moonlit nights, lower the ISO speed as needed to avoid over-exposure.
INITIATING THE SEQUENCE

All tips contained under TAKING THE SHOT in the first article apply to shooting star trails. Be sure to arrive early to test the composition and focus before it gets too dark. And always install a fresh battery before starting the sequence.

Since your camera settings will remain fixed for the duration of the sequence, the early shots will be more brightly exposed than the rest. To get started, your main concern should be to make sure that the initial shots are properly exposed.

To verify readiness, apply all camera settings, take a test shot, and check the exposure on your histogram. The goal is to expose as far to the right of the histogram as possible without blowing out the highlights. If the highlights are over-exposed, then you will need to wait longer before initiating the sequence. Re-test every ten minutes or so, until you have obtained a proper exposure. Alternatively, lower your ISO setting to match the lighting.

In testing readiness, also be sure to check your focus by zooming the LCD on a star. Verify that the star resembles a sharp point in the sky, without any fuzziness.

For star trails, the workhorse that will do most of the work on your behalf is your cable release. There are three options for controlling the star trail sequence:

1. **Standard cable release.** A normal cable releases will work fine for star trails, but make sure that your cable includes a lock button. To use a release cable, you must first set the release mode on your camera to Continuous. This is a crucial setting -- without it, your camera will halt after the first shot. With the camera set to Continuous, press the cable release button to initiate the sequence, and carefully lock down the button for the duration. Use a watch to time the exposure, releasing the lock button to abort the sequence.

2. **Timer cable release.** If you own an intervalometer, you must set the shutter speed on BULB (effectively transferring exposure control to the cable release). You’ll also need to program the timer cable release to the desired exposure, number of shots, and intervals between shots. Enter an interval of one second more than the exposure time to allow time for saving
the image (31 seconds for 30-second exposures), while minimizing gaps in the star trail. Divide the target duration of the star trail by the exposure time to compute number of shots.

3. **Built-in interval timer.** Some cameras have built-in interval timers that allow you to program the camera for continuous shooting. The process is similar to using a timer cable release, except that the exposure is limited by the camera (usually 30 seconds). Like a timer release cable, you'll need to specify the number of shots and the intervals. Again, use an interval of one second over the camera exposure time to minimize gaps in the star trail.

Once you have a good first exposure, go ahead and initiate the sequence. After pressing the button, be sure to step away from your tripod until the sequence is finished. If you accidentally nudge your tripod in the middle of the star trail, you will alter the composition and likely ruin the sequence.

One more word of caution about timing. When humidity is high and the temperature drops, condensation can form on the front of your lens. While there is no foolproof way to completely avoid dew or condensation, mounting a lens hood may help.

You can't wipe down the lens once the sequence begins, so it's best to check weather and humidity before heading out on location. If the risk of condensation seems high, it may be best to defer the star trail attempt to a more promising day.

**ASSEMBLING THE STAR TRAIL**

Okay, so the star trail sequence finished successfully. What now? If your exposure time was set to 30 seconds (for example), then a one-hour star trail will leave you with some 120 separate photos of the same scene. The only difference between each frame should be the position of the celestial bodies.

There are three distinct steps involved in post-processing your star trail. With the right tools, you can zip through these steps in just a few minutes.
1. **Tweak the RAW files.** This is where you make adjustments to the individual files. For example, you may want to tweak white balance to restore a blue sky, adjust exposure, add contrast, and apply light noise reduction at this stage. Plane and satellite trails are a common annoyance in long exposures. This may be a good time to remove them from the original frames. Plane trails appear as a series of colored dots, whereas, satellites show up as straight white lines. If you use Lightroom, you can apply the fixes (except plane and satellite trails) to one frame and then *Synchronize* the changes across all photos.

2. **Create the star trail.** Once the individual files have been tweaked, it's time to assemble the actual star trail in software. There are several free applications you can use (see next section). Most third-party stacking applications accept JPG or TIFF files. Even if they accept RAW files, it's better to output TIFF files using a proven RAW processor of your choice, rather than relying on conversion by a third-party application. Note that it's possible to throw away frames at the beginning and end of the sequence without ruining the star trail. I occasionally remove leading frames if their presence throws off the overall exposure. But never remove frames from the middle of the sequence as it will cause visible gaps in the star trail. Put the converted TIFF files in a folder for easy access, then run the star trail application to merge the frames into a single image. In most cases, this simply involves opening the files in the application and initiating the merge. The stacking process can take several minutes, depending on the number of files. Once the merge is complete, save the resulting star trail as another TIFF file.

3. **Adjust the final image.** This is where you make last-minute adjustments to the star trail image, just as you would for any other photo. Here you may want to tweak color, saturation, and contrast. If you haven’t done so already, this is also the place to remove any remaining plane and satellite trails.

**STACKING SOFTWARE**
Before you can assemble your star trail, you’ll need to download and install one of the available stacking applications. All the applications I’ve used so far are free. The main job of these applications is to take the brightest pixels from each frame and assemble them into a new image.

There are many stacking and star trail applications. But I can recommend the following solutions because I have used them with good success.

**StarStaX**: This is currently my application of choice. It supports both Windows and Macintosh platforms. It is also free, reliable, and easy to use.

**Startrails**: This European application is great on Windows personal computers, but does not support Macintosh at this time. This software is probably the most popular.

**Photoshop Action**: Photoshop users can download a Photoshop *action* to assemble the star trail. I find this approach slower, but it has the advantage of working directly with RAW files.

**WHAT NEXT?**

As you gain experience and confidence with star trails, you will want to experiment with variations on these methods. You can try exposure times greater than 30 seconds, and ISO speeds other than the default ISO 400. You may also want to shoot star trails during the various phases of the moon.

Night photography is fertile ground for experimentation. So, feel free to add your own spin as a way of differentiating your star trails from the rest of the pack.

Stay tuned for the next installment in this series, *Foreground in the Night*. The article will feature ways to add foreground subjects to your night images.

Until next time, “Happy Trails to You.”

**Mike Blanchette**

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