Fornax Lightrack Mount

Exquisite Execution of an Elegantly-Minimalist Design

By Gary Parkerson

To my eyes, the Fornax Lightrack II represents exquisite execution of an elegantly-minimalist design. Although I'm firmly of the function-over-form school of astro tech, such perfection of fit and finish is always a plus, and the Lightrack II is Swiss-watch-like gorgeous in that regard.

But we invest in tracking mounts for functional accuracy, not beauty. Fortunately, the Lightrack II is as exquisite in function as it is in form, owing much of its accuracy to an innovation that is, to my knowledge, unique to ultra-portable camera tracking mounts.

Some Context

Although alt-azimuth mounts can be used for astrophotography when equipped with a field de-rotator between the telescope and camera, equatorial mounts – specifically German equatorial mounts, or GEMs – are far more popular among astrophotographers, because field de-rotation is inherent to the design. It's not surprising then that most portable camera tracking mounts also use a simplified equatorial design, meaning they have a main (RA) axis that is aligned to polar north or south and driven at "clock" speed to counter Earth's rotation and thus element star trailing in long-exposure images. Most portable camera tracking mounts use one of two drive types – a worm gear or a leadscrew – both of which involve screw threads.

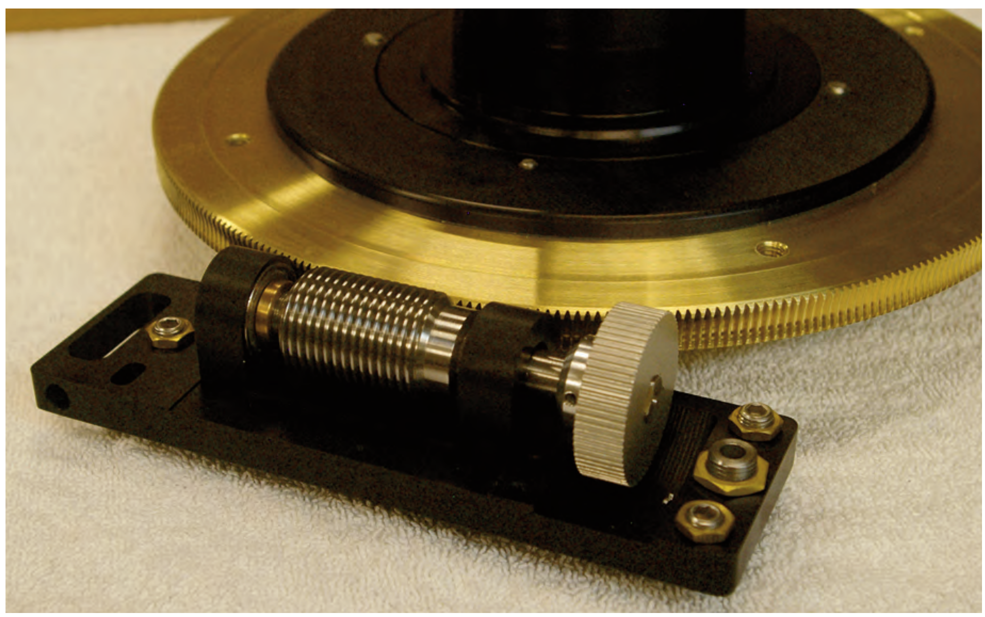

Image 1 - A high-precision stainless-steel worm screw (foreground) and bronze worm wheel (background) by Mathis Instruments machined to an accuracy of ±0.0001 inches in residual run-out and thread lead error for native tracking accuracy of ~5.0-arc seconds peak-to-peak error.

Worm Drives

Worm drives (**Image 1**) consist of two parts: a "worm screw," a cylinder with screw threads formed around and along its outer circumference, and a "worm wheel," a disc with gear teeth, similar to those of a spur gear, cut into its rim. The screw threads of the worm screw mesh with the teeth of the worm wheel. When the worm screw is rotated about its axis, its threads force the teeth

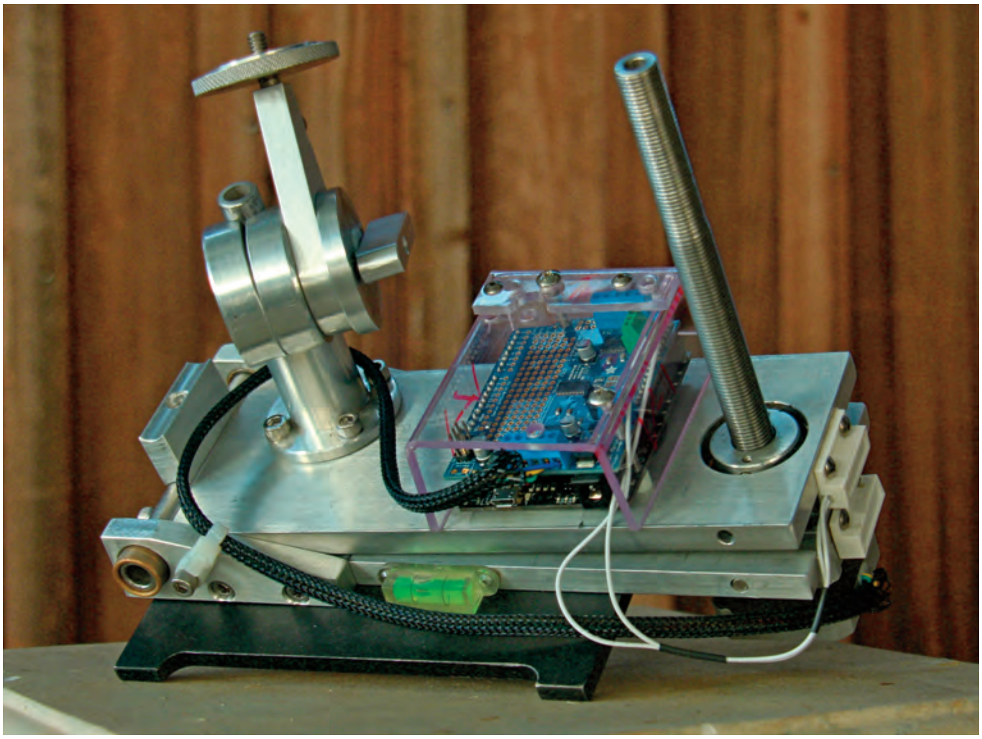

Image 2 - The StarSync camera tracker uses a leadscrew drive system as is typical of barn door-style trackers. The leadscrew is driven by a stepper motor. As it rotates, it moves a drive nut along its length. The drive nut in turn moves the upper plate, and the camera mounted on it, in the desired arc.

of the worm wheel to move the space of a single tooth for each rotation of the worm screw. The number of teeth of the wheel thus determines how many revolutions of the worm are required to rotate the wheel a full 360 degrees. For example, if the wheel has 360 teeth, then 360 rotations of the worm are required to produce a full revolution of the wheel, regardless of the diameters of the worm or the wheel, which makes things delightfully simple for designers of telescope mounts.

The advantages of worm drives also include inherent reduction in rotational speed of the wheel versus input speed of the worm, which is great for tracking mounts for which, by definition, the RA axis must turn very slowly – just one complete revolution per day.

Another advantage is that, when the worm screw is stationary, the worm wheel is effectively locked, holding your telescope firmly in position, unless a clutch assembly is incorporated into the

Image 3 - The drive-disc bearing surface of the Lightrack II's virtual disc section is actually the inner surface of the slot formed along the outer (bottom) edge, which position serves to protect the critical drive-bearing surface. The drive roller is positioned inside of the black motor housing.

Image 4 - The package tested was Fornax's full-set option, including the Lightrack II mount, a polar scope and its FMW-200 wedge.

worm drive to allow controlled rotation independent of the worm screw.

The disadvantages of worm drives include that the screw threads and gear teeth must be formed very precisely to produce the ultra-smooth tracking required of long-exposure astrophotography. It is relatively difficult to cut and polish spur-gear teeth such that every tooth perfectly matches the profile of every other tooth, just as it is difficult to form precisely-consistent screw threads. As with other aspects of astro tech, increments in worm-drive precision are often accompanied with disproportional increases in cost.

Worm drives are also susceptible to a phenomena called "backlash," caused by space between the screw threads and gear teeth, often purposely designed into the system to accommodate lubrication. Backlash is managed with preloading the gear mesh.

Vixen's Polarie Star Tracker and iOptron's SkyTracker camera tracking mounts are popular solutions that use worm drives, just as do the larger Ger-

Image 5 - The FMW-200 wedge is accurate and easy to use. Fit and finish are top-notch, complimenting the jewel-like mount perfectly.

Image 6 - The Lightrack II's control interface is simple and intuitive.

man-equatorial telescope mounts produced by both companies.

Leadscrew Drives

Leadscrews are used to translate rotational motion of a screw to linear motion of a nut. Like worm screws, leadscrews feature external threads formed around and along their lengths. Instead of worm wheels, leadscrews turn inside of a nut that has internal threads, such that one revolution of the screw moves the nut linearly a distance equal to the space between the spiral threads, also know as the thread pitch.

As with a worm drives, leadscrew drives offer the advantage of inherent reduction in speed, as well as that of locking the driven nut form further linear movement when the screw is not rotating. The disadvantages of the leadscrew are also similar to those of worm drives in that producing precise threads is difficult, thus exceptional accuracy is relatively expensive.

Unlike worm-drive mounts which, due to their full-circle worm wheels, can run continuously beyond a full day, subject to other mount design limitations such as meridian flip, the tracking period of a leadscrew drive is limited by the length of the leadscrew.

The StarSync tracker (**Image 2**) on which I reported in this magazine's first issue of 2016, is a barn door-style tracker that uses a leadscrew-drive system. Because the angle of the screw changes with respect to the RA axis as the nut advances along its length, the StarSync stepper-motor control compensates for that change by adjusting the speed of revolution of the screw rotation to maintain consistent tracking throughout the entire tracking period – the length of the leadscrew.

The AstroTrac camera tracker, to which the Lightrack is often mistakenly compared, also uses a leadscrew drive in a configuration know as a tangent-arm drive, so named because the leadscrew describes a tangent line or plane.

Friction Drive

The Fornax Lightrack uses neither a worm nor leadscrew drive, but opts instead for a friction drive, also called a roller drive. Its only functional similarity to the AstroTrac is that its tracking period is limited by the sectional arc of its virtual drive wheel, just as the AstroTrac's tracking period is limited by the length of its leadscrew, resulting in a similar overall profile.

The Lightrack friction drive consists of a smooth motor driven roller that is pressed against the smooth outer edge of a much larger drive disc, which virtual disc is represented by the Lightrack's arc section (**Image 3**).

The main advantage of a friction-drive system is that it's much easier – thus, much less expensive – to machine a smooth edge into a near-perfect disc than to cut near-perfect teeth along the edge of a disc of similar diameter. The other advantage is that, because mating is between smooth surfaces rather than discrete threads and teeth, friction drives are inherently free of backlash.

Disadvantages include that, because these smooth surfaces must be pressed quite firmly together lest they slip causing loss of camera position and, worse, marring of the mating surfaces, relative hardness of the surfaces must be carefully engineered, or the softer bearing surface may deform.

Given the advantages versus disadvantages, though, I'm surprised more mount manufacturers don't deploy friction drives, but there is a lot of inertia in tradition, and tradition weighs heavily in favor of worm drives. The only other coverage of a friction-drive mount I recall in *ATT* was Oliver Penrice's report on the Mesu Mount 200 in Volume 6, Issue 3 (2012), Issue 3, despite that *ATT* has covered a lot of mounts over the years.

Claimed Periodic Error

The effective diameter of the Lightrack's virtual drive disc is approximately 436 mm (17.17 inches) by my rough measurement, but because the actual contact section is just 1/12 of a full disc, yielding 2.0 hours of tracking versus continuous tracking, the mount is far more compact, measuring roughly 275-mm long by 135-mm wide by my tape, 280 by 140 by 80 mm by Fornax's. I can't confirm the diameter of its roller, because I resisted, despite temptation, disassembling the mount to make that measurement, but I estimate its diameter at 4.5 mm.

Fornax claims that its factory-calibrated friction-drive system, including motor and motor controller, combines for a peak-to-peak unguided periodic error of approximately 2.0 arc seconds throughout the roller's 8.0-minute period, which I took on first impression to be a very bold claim. To put it into perspective, that's less than half of what is claimed for the industry-leading Astro-Physics' Mach1GTO, the Mathis Instruments MI-500 and the Software Bisque Paramount MYT, and as impressed as I was with the design and execution of the Lightrack II, I was skeptical that any mount as light and portable could approach that degree of tracking accuracy.

Lightrack II Full Set

The package we tested was Fornax's full-set option, including the Lightrack II mount, a polar scope and its FMW-200 wedge (**Image 4**). The only things left for the user of this package to supply are a tripod with a standard 3/8-16 mount post, a camera ball head and, of course, a camera and lens.

Image 7 - The mount's on/off button, 12-volt DC power port and custom autoguider port are located within easy reach on its underside.

The Lightrack II accepts polar scopes made for the Sky-Watcher EQ5, as well as for Celestron's CG5, Advanced GT and Advanced VX mounts. The full-set package included the Celestron option with reticle engraved with the familiar star patterns of the Big Dipper, Cassiopeia and Octans. Judging from our results, the polar scope registered accurately in the provided adapter. The polar scope mounts into an integrated arm that swings into whatever position is most comfortable for

Image 8 - A single 5.0-minute exposure of the Orion-Horsehead region cropped for the center of the frame. It was captured with a Canon 6D through a 135-mm lens, both supported by the Lightrack II.

eye-to-lens access. Very nice!

The FMW-200 wedge (**Image 5**) is as accurate and easy to use as any such equatorial wedge I've had the pleasure of testing. Fit and finish are top-notch, complimenting the jewel-like mount perfectly. Its twin altitude knobs provide precision adjustment and hold the desired setting once there. Nevertheless, each is accompanied by a locking knob that absolutely secures altitude against accidental rotation of the altitude knobs. Azimuth is adjusted via opposing thumbscrews that push against the head of a stainless-steel cap-screw. As with altitude adjustment, azimuth adjustment is precise and sure.

The Lightrack mount features simple controls. On its outer face (**Image 6**), the left-most control button cycles between sidereal, solar, lunar and half-sidereal tracking modes, the center button switches drive direction between northern and southern hemispheres, and the two right-hand buttons allow resetting the drive quadrant. The mount's on/off button is located on its inner face (**Image 7**), as is its 12-volt DC power port, as well as another port that supports the standard ST-4 auto-guiding protocol via an included custom lead. We did not test the mount's autoguide function.

Fornax's specifications list the mount

Image 9 - M42 imaged as a stack of ten 3.0-minute images captured with a Canon 60Da fitted with a Canon 18- to 300-mm kit zoom lens set to its long end, 300-mm (ISO 800).

as weighing 1.3 kilograms (2.86 pounds), and although I had nothing on hand to confirm that claim, that felt about right, which is to say, the mount is remarkably lightweight. Fornax also claims the mount is rated for a maximum payload of 6 kilograms (13.2 pounds), and although we never loaded it to near that capacity, I'm satisfied that is well within its capability.

Fornax recommends a maximum focal length of 300 mm, which matched the longest camera lens we had on hand, as well as a maximum exposure duration of 6.0 minutes, and for reasons you'll soon read, I now judge both specifications conservative.

Performance

During tracking, the mount is essentially silent to my ears when standing next to it. My hearing is such that I had to put my "good" ear firmly against the mount body to hear anything at all, at which point I was treated to a rhythmic trill reminiscent of a musician working softly up and down the scales of a xylophone – so pleasant, I regretted not being able to hear it at a normal distance. Bottom line: Whether by plan or happy accident, the Lightrack II sounded just as high-tech as it looks.

As for imaging with the mount, all

Image 10 - Ultra-wide field of the Constellation Orion region, also captured using the Canon 60Da and the kit lens, this time at its extreme 18-mm short end. It too is a stack of ten 3.0-minute images (ISO 800).

Image 11 - TA single 3.5-minute exposure at 300-mm, cropped to show detail, captured with the Lightrack II purposely misaligned by 60 degrees to show tracking error. Resolution of the imaging system was 2.95 arc seconds per pixel, so the images demonstrate absolutely minimal error.

Image 12 - Another single 3.5-minute exposure at 300-mm captured with the mount purposely misaligned by 60 degrees. The straight, true star trails offer proof of exceptional tracking accuracy.

astrophotos that accompany this article were captured by *ATT* Associate Editor Austin Grant. Although I tested the mount independently of Austin, my eyesight and dexterity are now too poor to achieve results of which he is capable and certainly too poor to verify the extreme accuracy claimed for the Lightrack II.

That said, I'm pleased to report that my results confirmed Austin's and that Austin's results confirmed Fornax's claims. The Lightrack II is easy to align, and when properly aligned, tracks with major-league accuracy.

Image 8 is a single 5.0-minute exposure of the Orion-Horsehead region cropped for the center of the frame. It was captured with a Canon 6D through a 135-mm lens, both supported by the Lightrack II. **Image 9** of M42 is a stack of ten 3.0-minute images captured with a Canon 60Da fitted and a Canon 18- to 300-mm zoom lens set to its long end, 300-mm. **Image 10** was also captured using the Canon 60Da and the zoom lens, this time at its extreme 18-mm short end. It too is a stack of ten 3.0-minute images.

Images 11 and 12 were executed solely for the purpose of testing the periodic error of the mount. Both are single 3.5-minute exposures at 300-mm, cropped to show detail, captured with the mount purposely misaligned by 60 degrees to show tracking error. Resolution of the imaging system was 2.95 arc seconds per pixel, so the images demonstrate absolutely-minimal error. It would appear that Fornax's claims for the Lightrack II are not overly bold, even at 300-mm focal length. Of course, Austin could have extended both exposures to 6.0 minutes, or beyond, but 3.5 minutes represented a sufficient portion of the roller's period that any inherent periodic error should have been revealed.

Conclusion

I wish to thank Csaba Bereczki of BCS Astro (bcsastro.com), Fornax's North American distributor, for the extended loan of the Lightrack II tested for this report.

It's not the most compact tracking mount available, nor is it the most affordable, but it is, on the whole, as competent and as easy to use as any camera tracking mount we've tested and is far more accurate than typical. If there is a downside, it's simply that premium accuracy comes at a premium price – the Lightrack II full-set package is priced at $930US, $1250CAD and 859 Euro (including VAT).

Is it worth it? As always, that depends. If most nights find you imaging at sub-f/4 and 50 mm, or less, you're likely to find it overkill, but if pushing the limits of ultra-portable wide-field astrophotography is among your nightly goals, the Lightrack II gets you there at a price well justified by the results. Oh, and it doesn't hurt that it's Swiss-watch sexy, to boot!