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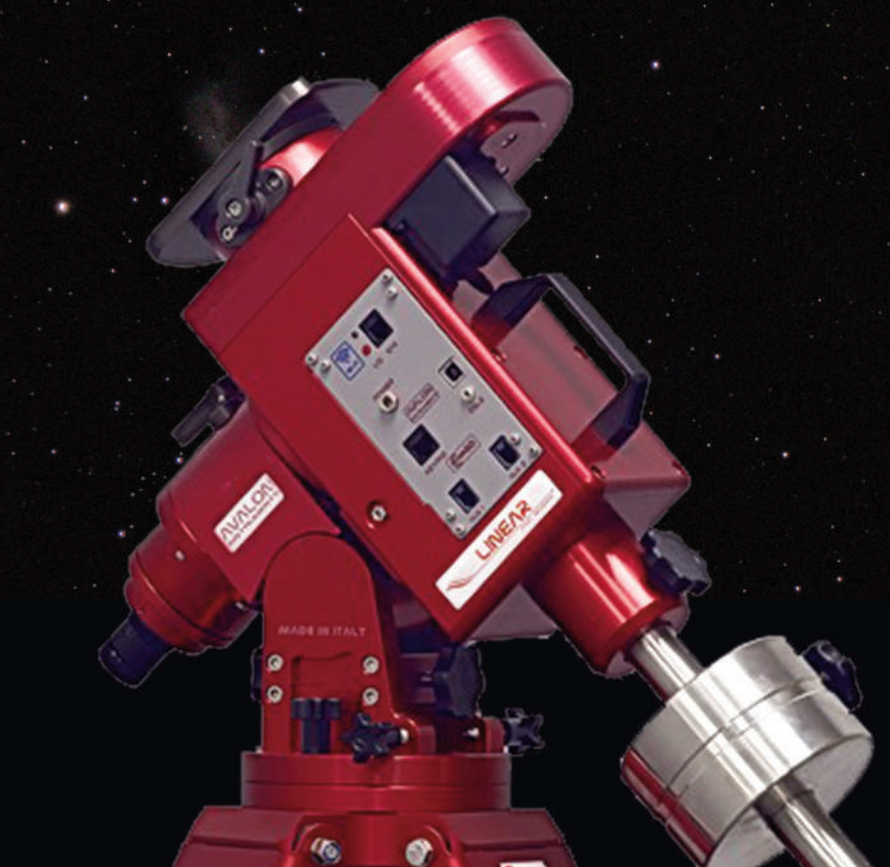
AVALON LINEAR TELESCOPE MOUNT



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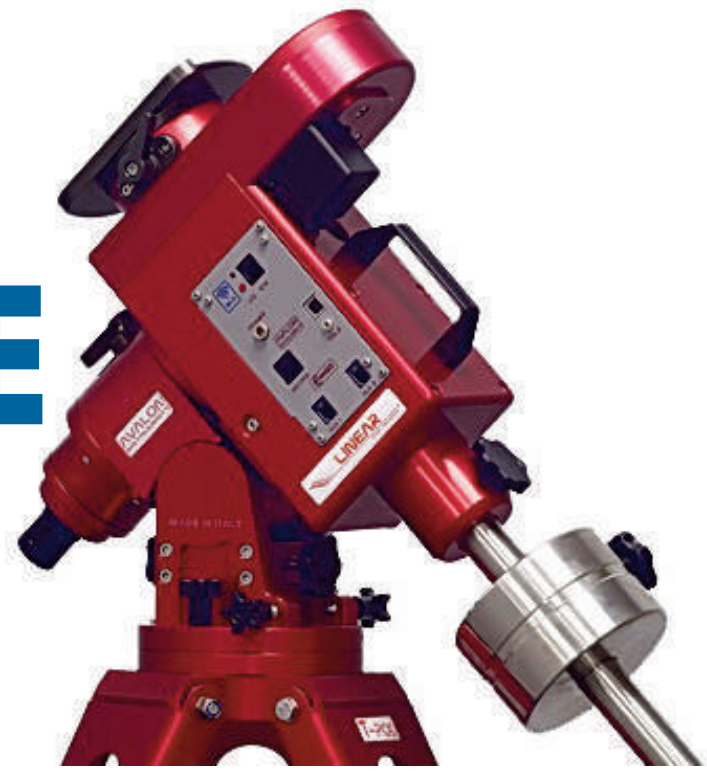

By Thomas Fowler

Avalon Instruments (www.avalon-instruments.com) is an Italian manufacturer of higher-end telescope mounts. They have many innovative designs, and in this review I will discuss their "Linear" or German Equatorial Mount.

First, though, let me correct a common misconception about Italian products, namely that Italy is a low-tech country better known for its art and architecture. Art and great architecture are indeed there in abundance, but in fact, Italy has a large high-technology industrial base that makes and exports products worldwide. Car manufacturers such as Ferrari and Maserati are well-known, and the 10 Micron line of telescopes mounts is familiar to the astronomy community. They also make many high-tech military items through companies such as Finmeccanica.

The Avalon Instruments company, based in Aprilia (near Rome), has rethought the design of telescope mounts, and has introduced several important innovations, including designs that eliminate meridian flip. In this review, I will discuss their version of the more conventional GEM. This mount is intended primarily for astrophotography, including EAA, but of course works extremely well for visual astronomy.

It has two important innovations that also appear in Avalon's other mounts. They are (1) use of pulleys and toothed belts instead of gears to move the mount, eliminating backlash; and (2) replacement of the usual "smart" hand controller in favor of wireless control by tablets or cell phones. I will cover these in detail later. First, however, an overview of the mount.

Mount and Tripod Overview

As befits a product from a country known for beauty, the mount and the tripod both look like works of art. Deep red color together with aluminum and stainless steel make a striking combination (**see Figure 1**). Physically, the mount uses solid 35 mm axis shafts, and has bearings so smooth that when your scope is attached and balanced, if the clutches are released you can literally move the scope by blowing on it - something that I've never experienced before with other mounts.

All parts are beautifully machined, so the mount performs as well as it looks. It includes a Skywatcher or Losmandy-style polar finder, and a 75mm (3") Losmandy-style dovetail plate. Counterweights attach to a quick-release 30mm stainless steel shaft. The Skywatcher polar finder has a reticle with a clock face around which Polaris revolves. If you rotate that reticle so that the 12 o'clock mark is at the top, you can use any of the polar scope apps for your phone that will show you the position of Polaris at that moment, to facilitate polar alignment.

There are no setting circles, but as discussed later, the position of the mount at any time (RA/Dec) is visible on your computer screen. The mount has the usual four

Figure 1. Avalon Linear GEM Mount

Figure 2. StarGo hand controller

speeds: Slew, Move, Center, and Guide. The regular slewing speed is about the same as most other mounts; but there is a high-speed slew available when the mount is powered by a higher-voltage (15 v) power supply.

The mount package includes an A/C power supply that can be switched to 15 v. However, I use the mount in the field and power it with a portable 12v supply, which works well and the slewing speed is adequate. There is a simple lightweight hand controller with physical buttons that plugs into the mount and that can be used to move the mount and adjust the speeds (**see Figure 2**).

The mount comes in either a WiFi or Bluetooth version for connection to wireless devices. It sports a handle attached to facilitate carrying and fixing it to a pier or tripod. The mount weighs 26 lb (12 kg) without counterweights and counterweight bar. It does not come apart into RA and Dec components. Avalon sells a nice heavy canvas bag for transporting the mount. (The mount and tripod are also available in black, but who would want that color after seeing the red version?)

The Linear is rated at payload of 44 lb (20 kg) visual, and 33-40 lb (15/18 kg) photographic. These would be maximum values; based on my experience, I would recommend no higher than 35 lb visual and 33 lb photographic as better suited to this mount. The configuration that I use for astrophotography is about 31 lb (see **Figure 3**, which also shows the MGEN-3 autoguider), consisting of a 140mm CFF APO refractor, Orion 60mm guidescope, APM finder, Canon camera and the counterweights.

The clutches on this mount do not grip as tightly as on other mounts (such as my Losmandy G11), so it is important to avoid large imbalances on the axes. This can present challenges so major configuration changes are often best down with the mount in the usual parked or counterweight down (CWD) position.

The tripod, called a "TPOD", is available separately from the equatorial head, and can be used with mounts from other manufacturers (Avalon sells adapters for this purpose). It is fairly lightweight (about 18 lb), but remarkably sturdy, and comes with a nice carrying case.

I purchased the 130 model, which has a height range of 39-51" (85-130 cm), depending on leg extension. It is rated at a capacity of 100 kg (220 lb). A useful accessory (essential for long OTA scopes) is the Linear Extender, which can be seen in Figure 3). It extends the height for the mount attachment, thus raising the mount and reducing the chance for the bottom end of the scope to collide with a tripod leg. As a convenience, I fabricated a circular aluminum tray that sits on the tripod braces when it is opened, to hold eyepieces and other gear; but of course, the mount does not require this (**see Figure 4**). Feel free to email me for more information on how to make this plate (my email is available at the end of the article).

Mount performance

In terms of tracking performance, as reported by my MGEN-3 autoguider, I routinely get 0.3-0.4 arcsec per axis, significantly better than what I get with my Losmandy G-11, which usually gives values about double (0.6-0.8 arcsec per axis). **Figure 5** shows Leo Triplet, the result of stacking 6 360s images at ISO 800, taken with my CFF 140mm f/7.5 APO and a modified Canon T7 camera.

Belt Drive System

The Avalon mounts all use a belt drive system with pulleys and toothed belts. The belts are made of a special material with steel strands, so they are expected to have a very long life. There are four stages of reduction from the motor.

When I ordered my mount, I asked if I should also order a spare set of belts, but Avalon recommended against that, saying that they were not needed (a set costs about $100). Since there are no gears, there is no need for lubrication of any internal parts, so there is essentially no maintenance.

My experience is that this system delivers on its promise of no backlash and

Figure 3. Linear Mount and Telescope configured for astrophotography

Figure 4. Circular plate (fabricated by owner) for eyepieces and other gear

quick reverse. It is also very smooth and quiet. All the pulleys and the main RA and Dec axes rotate on roller bearings, with 13 each for the RA and Dec axes, which does indeed (as Avalon claims) reduce total friction to near zero.

The belt system does, however, have a slight "springiness" to it, which can result in increased damping time, especially for long, heavy OTAs such as refractors (my OTA is about 36" or 95 cm without dew shield extension. With dew shield extended, and focuser racked out with camera or diagonal/eyepiece attached, overall length is closer to 48").

This has not proved to be a major problem, but I did devise a simple system to reduce the effect of my finger on the fine focus control knob. With shorter instruments, such as SCTs, this is likely to be less of a problem. Avalon rates the Periodic Error (PE) at +7 arcsec per 2 minutes, very smooth, easily handled by modern autoguiders.

Telescope Control System

The control system for the mount, called "StarGo", is probably the most unusual aspect of the mount, and I want to discuss it in some detail, since it may affect your decision about the mount.

The basic motivation for this system is to take advantage of the capabilities of modern cell phones and tablets, with their enormous storage capacity for astronomical data bases and ability to display planetarium images on the device that you hold in your hand, as well as the capabilities of modern PCs, especially laptops, commonly used for astrophotography and EAA. Full use of the StarGo system requires both a laptop and a wireless device such as a tablet (or a separate planetarium program such as Cartes du Ciel (CdC)).

As I noted earlier, the assumption is that the mount will be used primarily for astrophotography and EAA applications. I have found that the small additional complexity associated with this method is easily worth the effort, as I can see at a glance the position of the mount and other important information, as well as location in the sky to which the mount is pointing on a tablet or smartphone (**see Figures 6 and 7**).

It is also fun to watch the mount pointing position indicator move across the sky on a planetarium program when you perform a slew or a go-to operation! However, for those who prefer maximum simplicity in telescope operation, and for whom the capabilities of smart hand controllers are sufficient, the need for a PC with the StarGo may be a showstopper.

That said, it is possible to use the mount without a PC and just a tablet or smartphone once certain initial settings have been made; I discuss this later. However, it is not possible, with just a tablet or smartphone, to store or recall an alignment. (I should add that with most modern mounts, such as those by Celestron and Losmandy, it is possible to use external interface equipment to allow use of tablets and smartphones running SkySafari.)

As I mentioned, the StarGo system is designed with astrophotography in mind, and with astrophotography, use of both a laptop and a handheld device at the same time is common, regardless of type of mount. The StarGo system works for visual astronomy as well, though the overall complexity is more than visual astronomy requires. For use with the StarGo, I strongly recommend a good tablet and a program such as Sky Safari. I use a Samsung Galaxy Tab S7+, a very nice device with a beautiful 12" high-resolution screen that renders SkySafari extremely well (see Figure 7).

This does transform the user experience, since you can see on the tablet screen the position of your scope in the sky, you can call up for observation practically anything that has a catalog designation, and you can create observing lists and direct the mount to go to each item with just a tap. The common smart hand controllers by Celestron, Losmandy, and others are limited in the data that they contain. For ex-

Figure 5. Leo Triplet imaged using Avalon Linear Mount and MGEN-3 Autoguider

Figure 6. StarGo program (right side, red background), X-Solver program (left). StarGo screen shows current mount position (RA, Dec), current slewing speed selected, current tracking speed, and observatory location. X-Solver graph shows position of currently in use alignment stars.

ample, with the Losmandy controller, I've plugged in SAO numbers for some well-known stars like Bellatrix, and they were not found.

Of course, you can also move the Linear mount manually with Sky Safari and select slewing speed. You can also do alignments with SkySafari on your phone or tablet. The only downside of such programs is that there is no tactile feedback for manual scope movement. For moving or centering the scope while viewing through an eyepiece, you can just use the supplied hand controller shown in Figure 2, whose buttons have a very tactile feel. The hand controller is also designed to handle a Baader Steel Drive focus system, though Avalon has told me that they no longer support that interface (I have not tested this feature). The StarGo system has many other capabilities, including polar alignment using its associated plate solving program, the X-Solver, described in the StarGo manual.

Some of the important features of the program, however, are not well-documented, so I'm covering a few of them here. For example, the manual indicates that you should use a plate solving routine for alignment, their "X-Solver" program, which is certainly good if you are doing long exposure astrophotography. But it is possible to do the usual alignment routine as well, where you tell the mount to go to an object, center the object, and then tap or press the "Align" icon, and repeat for as many alignment stars and objects as desired. Note that if you save your alignment, only the star positions will be saved.

There are two ways to use the StarGo system.

Method 1

In the first method, which I recommend, you connect your laptop to the mount with a USB connection. This allows full control over all mount parameters, including location, time/date, allows you to park and unpark the mount, and call up previous sky alignment mappings. You will get a display on your laptop that shows current RA and Dec, tracking speed, slewing/movement speed, observatory location, and some other information, as shown in Figure 6. Then you connect your phone or tablet with the wireless link (WiFi or Bluetooth, depending on which option you ordered with the mount), and use that to operate the mount and perform alignments.

I use Bluetooth and it works well. Sky Safari knows the position of the mount as soon as it connects. You can also use Cartes du Ceil (CdC) to operate the mount from your laptop for the same purpose, though I've found this to be less convenient than using Sky Safari. After doing an alignment, you can save the alignment information using the X-Solver routine. You can also display an image that shows the position of your alignment stars, as shown in Figure 5.

In my case, I just connect the mount and the imaging camera that I'm using to a hub, and run one USB cable from the hub

Figure 7. Sky Safari 7 Pro display connected to StarGo through Bluetooth. Note sky position of mount shown at left below Celestial Equator, near Rigel. Slew rate is shown in the purple boxes near bottom.

to my laptop (often inside my house). You could also connect your autoguide camera to the hub if you are using PhD for guiding. (I use an MGEN-3 for autoguiding so I don't need to connect it to the hub). I recommend this method as it is easy to set up and gives you maximum control over the mount.

Method 2

In the second method, assuming that you have already set location and other parameters at least once with the first method, you connect your phone or tablet and skip the direct connect to a laptop. This does work, though at present it requires a simple step to sync Sky Safari with the mount position, because Sky Safari does not have a separate interface for the StarGo system. You then use Sky Safari to control the mount, add alignment stars, etc. This would be handy for cases where you need to do a quick setup, or just plan to use the mount for visual observations. However, with this method you cannot park or unpark the mount, call up previous sky alignments, etc.

User Support

Avalon maintains a user support web page with much useful information, and a User Forum where users can ask questions and get answers from other users and from Avalon tech people.

Cost and Position

The Avalon mounts are not the highest cost or the highest performance. They should be considered "Upper Middle Class", just below the highest class that includes 10 Micron and Astrophysics. This is true both with respect to price and performance. The cost of a mount and tripod, with extender, will be on the order of $6,000 including shipping. This is about 50% higher than a Losmandy G11, but less than half of a 10 Micron or Astrophysics mount. As will almost all products, cost increases exponentially for a linear increase in quality. It is difficult to compare performance of mounts because there are many variables involved. My research, admittedly imprecise because of the dearth of information, suggests the following graph of mount price vs expected total tracking error (**see Figure 8**):

The dotted red line curve fit has proven to be fairly accurate. It is about right for the

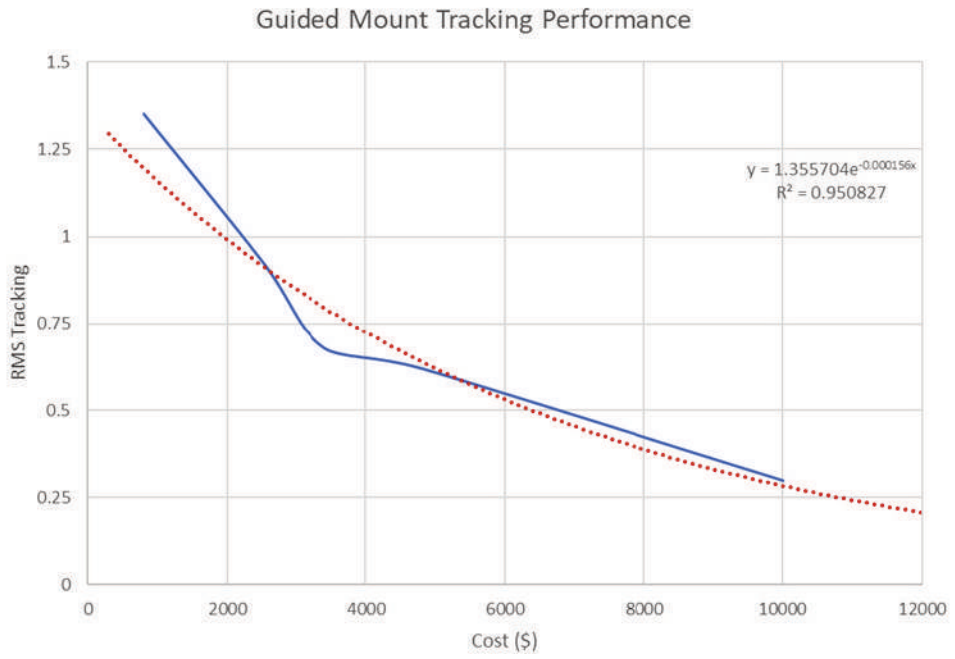

Figure 8. Performance of Mounts as gauged by RMS tracking error and cost

Avalon - around arcsec RMS. You could spend 2-3x as much to get the RMS tracking error down to 0.25, but it probably isn't worth it unless you need heavier payload capability, because your tracking error will be swamped by atmospheric disturbances ("seeing"). The more expensive mounts would be useful for such payloads, though their weight is significantly higher.

If portability is important to you, you must decide how much weight you wish to lift and assemble on site. In effect, you have to decide if you want astronomy to be a good hobby or avocation, or a body-building exercise! If you are fortunate enough to have a large scope, and a permanent observing location, Avalon has recently introduced an observatory-class mount, the EVO-quattro, with a 250 kg capability, somewhat expensive at about $22,000, and definitely not a portable mount, but suitable for that 12" refractor in your garage.

Issues

There were two quality control issues with my mount when I received it. First, there was an assembly error on the mounting plate, which is held in place by four screws. The plate was installed 90o out of alignment, so that the clutch lever was at the back rather than on the side, making it very difficult to use. I just removed the four screws, rotated the plate, and reinstalled the four screws. Second, there was a slight misalignment of the mounting holes on the extender, so I had to slightly enlarge one of the holes to allow the extender to be secured to the tripod. But it was easily done with my portable drill.

Conclusions and Recommendations

The Avalon Linear is an excellent mount and a real pleasure to use. It is nice to use a mount where backlash isn't a problem, and which operates as smoothly as the Linear. Tracking is quite good, so long exposure imaging is easy to conduct. The belt drive system definitely delivers on its promises, and the StarGo control system, though not to everyone's taste, works quite well once you get used to it. Plus the beauty of the mount is sure to impress other astronomers and friends at star parties!

If you have a mid-weight scope (4-6" refractor, 6-10" reflector or SCT), this is certainly a good choice for your mount. Contact me - tbfowler@caa.columbia.edu - for further information about the mount, and copies of my "cheat sheets" for mount connection.