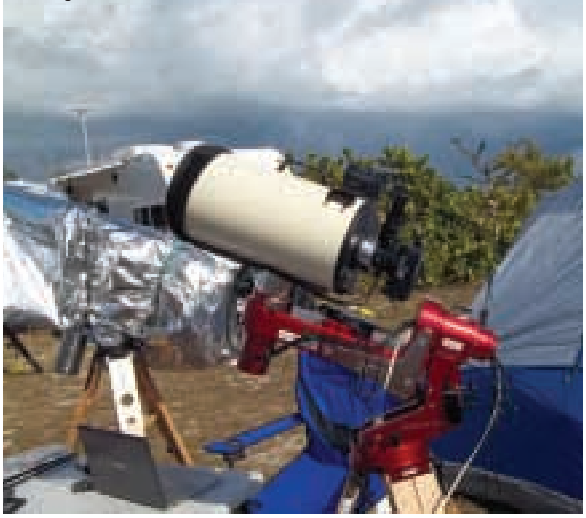
M-Uno: A Pier-less Mount

Image 1 - The M-Uno at WSP 2013.



Armed and Amazing

By Theodore Saker

A solid mount is as essential for astrophotography as fine optics and a capable camera. There's no getting around it. The most meticulously made optics and the best camera will not produce good images if placed on a mount that cannot track a target object accurately. Choosing the right mount for astrophotography can be a major technical and budgetary challenge.

Avalon Instrument's M-Uno is a radical, if not revolutionary, advancement in design and construction of the modern equatorial mount within the reach of serious astrophotographers. The M-Uno is a compact, portable mount designed to enable high-quality astronomical imaging without many of the drawbacks of other mount designs. I was fortunate enough to attend the 2013 Winter Star Party, and being given the opportunity to examine and use the M-Uno at that event was an exceptional bonus.

To grasp the extent of Avalon's accomplishment, a description of the current state of the art is helpful to show just how distinct the M-Uno is when compared to similar mounts in its class. Every mount design, like optics, represents a compromise of one kind or another. The ultimate goal is for the image to contain round stars, an indication of good tracking and of a mount that performs to the best of its design and construction standards. Astro-imagers have long relied upon equatorial mounts as mainstays for imaging. Equatorial mounts track an object with only one rotational axis, thereby greatly enhancing tracking accuracy.

Serious astro-imagers rely on the German Equatorial Mount (GEM). The German Equatorial design dates to the early 19th Century and is credited to Joseph Fraunhoefer, the Bavarian who discovered absorption lines in sunlight and cast the first true optical glass. It is a classic design whose chief advantage is its ability to track objects using one rotational axis and with the weight of the mount and payload perpendicular to the ground.

Although serious astroimagers rely chiefly on the GEM, it has a number of significant drawbacks. The first is known as the "meridian-" or "pier-flip." When the telescope is pointing east, the telescope is on the west side of the mount. As the object ascends towards the meridian, the telescope and payload get closer and closer to the GEM's body. When the object reaches the meridian, the telescope must be "flipped" to the other (east) side of the mount in order to track the object west of the meridian. After the pier flip, the user has to reacquire the object on the camera chip's field of view. It may be difficult or impossible to find a suitably-bright guide star. The user loses the opportunity to image objects when they are located in a prime place in the sky.

Another disadvantage with the GEM is the necessity of placing counterweights of similar weight opposite the payload. The counterweights may require adjustment to improve the mount's tracking ability after a pier flip.

Most astro-imagers shrug their shoulders and deal with the GEM's drawbacks, concluding that its advantages outweigh the disadvantages. When compared to other prevalent designs, the GEM holds the advantage.

Some astro-imagers use fork mounts to avoid the pier-flip problem. In order to use one rotational motor, the fork mount usually is placed on an equatorial wedge to align the right-ascension (RA) axis with the Earth's axis and utilize only one motor to track objects. The chief problem with a fork-mounted telescope is its inherent instability. When placed on a wedge, the weight of the mount and payload is unevenly distributed on the tripod. To combat this problem, a fork mount requires a heavy base and beefier fork arms to support

Image 2 - Luciano Dal Sasso of Avalon Instruments and the M-Uno.

Image 3 - The M-Uno in its parked position.

the payload, which severely reduces portability and exacerbates the weight distribution issue.

Portable fork mounts are frequently used with short-tube instruments, like Schmidt-Cassegrains, and are generally unsuited for long-tube instruments, like refractors and Newtonian reflectors. Fork mounts have issues with pointing towards the celestial poles when the telescope carries an imaging train of any length. Counterweights placed at or near the objective may also be necessary to balance the weight of the imaging train on the declination axis. Finally, fork mounts are known to suffer from the "tuning fork" effect, where the vibration from the motors is transmitted through the fork arms to the payload. The result is misshapen stars — the tell-tale sign of bad guiding.

When I was asked to meet with Luciano Dal Sasso of Avalon Instruments and Giovanni Quarra Sacco of Unitronitalia at the 2013 Winter Star Party, I had no idea what to expect. That was a good thing since I brought no preconceptions to the project. When I first saw the M-Uno and learned I would be using it, I was dumbfounded. It was unlike anything I had ever seen before. The M-Uno's red anodized finish, and stainless-steel fittings and accessories, gives it style like an Armani suit. It's built to retain its appearance over the life of the mount. But my first thought was, "How does it move?" I couldn't wait to find out.

Before I got to see the M-Uno in operation, Luciano and Giovanni spoke with me at great length about the philosophy underlying M-Uno's design and manufacture. Luciano has been an amateur astronomer for over 15 years. He explained that he has owned at least a half-dozen mounts over the years, and the M-Uno's design incorporates a large number of features he wanted to see in a portable equatorial mount that he found lacking in the mounts he had previously owned. Luciano guided himself by the basic principle, "Keep it simple." It's apparent that Luciano succeeded. He based the design with simplicity and portability in mind.

Unless one lives in the land of 300 clear nights per year, frequent travel to dark-sky sites and star parties is routine. The M-Uno is light enough to be carried by one person using the handle kit, yet robust enough to support significant loads. An astro-imaging mount would normally be a highly complex device, requiring hours of painstaking practice to master, since astro-imaging places high demands on the mount. Achieving sub-arc second tracking performance raises the technical level well above that of an observing mount. As any astro-imager knows, the more complex a system is, the more likely something will go wrong. That does not appear to be the case with the M-Uno.

Luciano described the M-Uno as a "single-arm fork equatorial," but having only one tine means that it is not a fork in the conventional sense. A typical fork mount has two tines that attach to the optical tube on either side. In contrast, the M-Uno supports the tube from below like a GEM. I believe that it's more accurately described as a "single-arm equatorial."

At WSP, the M-Uno was equipped with a V-plate saddle, which can be replaced quickly with a D-plate "drop-in" saddle. The M-Uno's features don't stop there. It is constructed from a single block of aluminum using five-axis CNC and CAD-CAM machines and anodized red. Stainless-steel fastenings and accessories not only accentuate the appearance, they retain their durability for years to come.

In keeping with the theme of simplicity, the hand controller's four direction buttons control movement, and four smaller buttons adjust motor speeds and operate a Baader *Steeltrack* focuser. What really makes the M-Uno perform is Avalon's *StarGo*, the proprietary software that runs the mount through the USB interface. ASCOM-compliant programs, such as *The Sky X* and *T-Point*, can also interface with the mount using the LX-200 communication protocol. In addition to the USB hardwire connection, the M-Uno can be controlled wirelessly through the built-in Bluetooth connection using a similarly equipped laptop, or even an iPhone or Android equipped with *Sky Safari*. Luciano also advised me that a Linux version of the control software is in development that will run on *Ubuntu 12.04 LTS*. Being a Linux guy, I couldn't help but be impressed. How many mount manufacturers are writing control software for Linux? None that I know of.

The control panel has three auxiliary ports to control external devices. For autoguiding, the control panel has an RJ-11 port for a standard ST-4 interface that accepts commands from the guiding camera without an intervening optocoupler. In addition, the control panel has dedicated ports to enable remote operation of a DSLR and the Baader *Steeltrack* focuser (using the hand paddle). The mount's firmware is updatable over the Internet. The M-Uno runs on 12-volt DC from the supplied AC adapter or from a 12-volt battery in the field where AC power is not available.

The most obvious difference between the M-Uno's design and that of GEM and fork mounts is what it looks like in the parked position. When parked, the arm lays at an angle equal to the mount's latitude location, with the polar finder scope mounted in the shoulder and pointing up through the wrist at the celestial pole. It reminded me of an arm-wrestling contestant getting ready for a match. The M-Uno also has an optional external polar finder scope that attaches to a dovetail milled into the side of the arm with a removable stainless-steel holder. The standard polar finder scope is the Vixen design, but an optional adapter for the Losmandy-style polar finder scope is available.

I think the first of the M-Uno's radical functions is that polar alignment is done first before placing the instrument on the saddle when using the internal polar finder scope. Once the payload is attached, the stainless-steel clutch levers may be carefully released to check the instrument's balance.

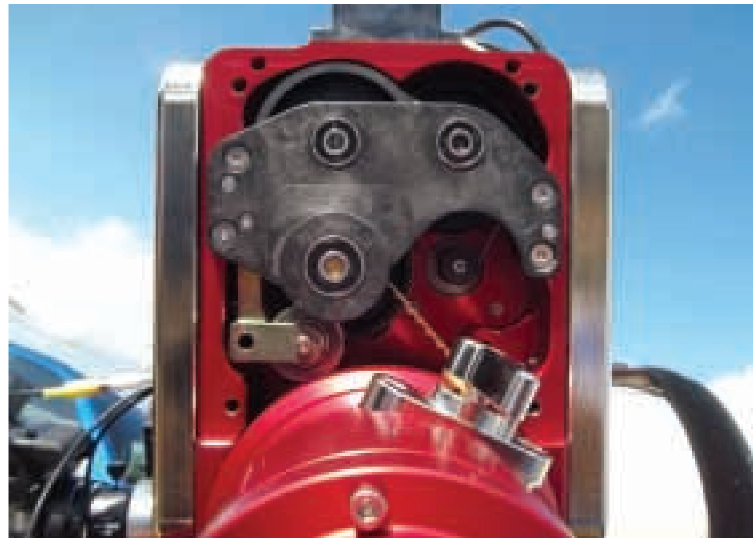


Image 4 - The M-Uno's "Fast Reverse" drive: a tooth belt-pulley system.

The M-Uno has a listed capacity of 25 kilograms (55 pounds), although for imaging, 20 kilograms (44 pounds) is recommended. For heavier payloads, counterweights are required to balance the load in RA, but due to the single-arm design, they can be much smaller and lighter than those required by a GEM. Avalon offers stainless-steel counterweights of up to 30 kilograms (66 pounds) total.

The arm's position relative to the shoulder can be adjusted in order to alter the center of gravity of a heavier payload and make balancing the load easier. The M-Uno can support lighter payloads without using any counterweights. None were needed for the payload Luciano brought to WSP. The user can balance the payload on the declination axis in the same manner as a GEM by sliding the payload back and forth on the saddle. Despite its robust ca-

Image 5 - The Horsehead Nebula in Orion. 3 x 20 minute integrations (L only).

pacity, the M-Uno can be carried by one person using the supplied handle that attaches to a dovetail milled into the top of the shoulder.

Instead of routing the camera and other control cables internally though the mount, the M-Uno's simple and elegant design helps eliminate cable binding issues that can totally mess up an image or impede slewing to the target object. If polar aligning using the internal polar finder scope, the user removes it and feeds cables though the shoulder bore. If using the external finder scope, the user can polar align with the payload in position without disturbing the balance.

All of the cosmetic features would just be good marketing if the M-Uno couldn't back up its snazzy appearance with performance. The M-Uno has a ground-breaking drive system Avalon calls "Fast Reverse." Most mounts utilize a worm-and-wheel gear system where a cylindrical worm gear drives a wheel-shaped gear. The gaps between teeth on the worm and wheel gears produce an effect known as backlash — the time it takes the motor to overcome the play created by the gaps when reversing direction. Backlash complicates guiding when the mount needs to react quickly to commands from the camera. Although software can help compensate for backlash, the settings may cause the mount to overreact or under react, leading to guiding errors.

The M-Uno employs a unique belt-drive system. Luciano explained that the M-Uno is built with a four-stage transmission system utilizing a 700:1 gear reduction ratio to drive both RA and DEC axes. When Luciano first described it, I thought that the system could not live up to its billing. I was certain that over time with frequent use, the performance would decline with stretched belts or deformed pulleys, and I asked Luciano about that. He answered that the pulleys and belts are the same kinds used in high-precision machine tools. The pulleys are made of a polymer resin combined with glass fiber that resists deformation from thermal expansion and contraction, and erosion of the teeth.

Likewise, the four drive belts are made from similar materials which resist deformation, thermal expansion, and tooth degradation. The company's literature identifies the belt material as *Puliuretan*, a technopolymer, with steel reinforcements. Avalon manufactures the pulleys itself. Micro-stepper motors drive the pulleys and both axes ride on needle bearings.

The M-Uno comes equipped with absolute encoders so that it does not lose track of its position if moved manually by hand or with the hand controller. On top of all that, the drive is maintenance free. No grease is applied to any of the drive elements and they remain free of contaminants that lubricants attract. No adjustment is necessary or recommended. When the mount moves, the soft sound is almost musical and the motion is extremely smooth. With the four belts grabbing half the circumferences of the corresponding four pulleys, there is no backlash at all. The M-Uno responded immediately and smoothly to auto-guiding commands without the hesitation common in worm-and-wheel drives.

Another problem with worm-and-wheel drives is periodic error, a predictable drift of a mount from the intended target position. It is a product of the manufacture of the worm gear. Most mounts correct pe-

Image 6 - NGC 2903 in Leo. Full frame, 30 minutes. (L only). Boxed area cropped and enlarged 400 percent and shown in Image 7.

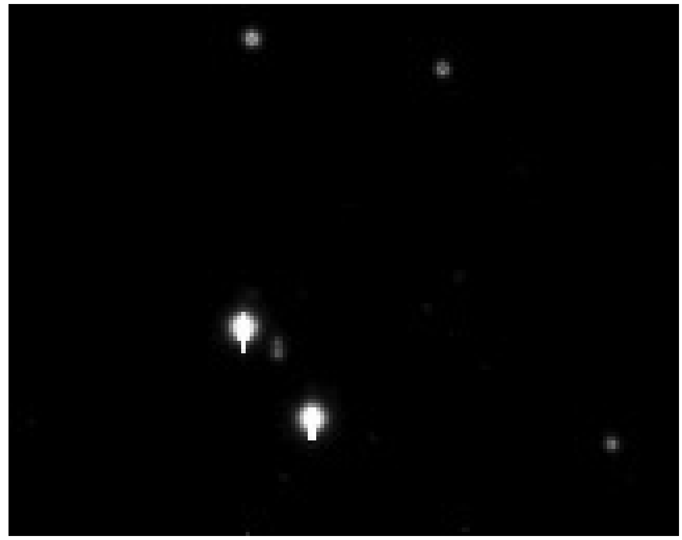


Image 7 - NGC 2903 in Leo. Image 6 cropped and enlarged to 400 percent over original.

riodic error by recording the drift and compensating for it with the mount's electronics. Autoguiding programs can also compensate for periodic error.

Virtually everyone wants to know what the M-Uno's periodic error is. That question does not really apply to this mount since the M-Uno does not use worm gears and the multiple belts and pulleys do not generate that anomaly as commonly perceived and understood. Each of the four pulleys, by themselves, would generate a periodic error. However, all four pulleys combined average out the periodic error of each one. If plotted on a graph, the curve spreads out over a far longer time span than that of a standard worm-and-wheel gear. It is more descriptive to compare the M-Uno's tracking error rate to that of other worm-and-wheel driven mounts.

The M-Uno I evaluated rides atop the Avalon Hercules tripod. Constructed of beautifully varnished hardwood, the tripod has an anodized aluminum base and a brass pier for adjusting the M-Uno's azimuth setting during polar alignment. An accessory tray provides stability for the legs. Each leg has a reversible, adjustable red anodized aluminum foot. One end is for use on grass and the other end has a rubber foot for use on hard surfaces.

Luciano brought with him to WSP an imaging f/6 Intes 110 Mak-Cass, a Canon 1000 DSLR and a Lodestar guiding camera on an Orion off-axis guider. Having no experience with DSLR cameras, I was anxious to use my SBIG ST-8XME camera and CFW10 filter wheel to see how well the mount performed. On a clear night at WSP 2013, Luciano afforded me the opportunity to run the M-Uno using his Intes OTA and my camera and filter wheel. The astronomical images included in this article were taken with this configuration. I controlled my camera from my laptop running *MaximDL*, and ran the mount from Luciano's laptop using the *StarGo* control soft-

Image 8 - Arp 244 in Corvus (L only).

ware and *Cartes du Ciel* for object selection and go-to operation.

Right from the start, I was greatly impressed with the smoothness of the mount's motions and its nimble responses to commands. It handled like a Lamborghini. The go-to functioned perfectly, placing the objects right where I wanted them. Adjusting the object's position in order to locate a suitable guide star was precise and effortless. Luciano explained that the auto-guiding settings should be set at 0.05 to 0.02 seconds (a low setting in my experience) in order to avoid overcorrection and oscillation.

I began the imaging run shortly after 8 p.m., after the end of astronomical twilight. The first target was the Horsehead Nebula in Orion, an object I had not imaged before. Orion was already nearing the meridian, but that was no problem for the M-Uno. I took a 60-second image, a 5-minute, and three 20-minute images. During that run, the object transited the meridian without any need to adjust the mount or the guiding settings. The tracking was optically flawless. Using *Maxim's* error graph log recorder, over a ten minute period (the program inexplicably quit recording error correction after ten minutes), the largest correction was 0.46 pixels, and that happened only once. Typical corrections were in the hundredths and low tenths of pixels in average seeing (for WSP). Not having to interrupt the imaging run to perform a meridian flip was worth the price of admission.

Next, Luciano suggested I slew the mount to NGC 2903, a beautiful spiral galaxy in Leo. Once again, the go-to was spot-on, and the hunt for a guide star was as smooth as could be. Starting at shortly before 11 p.m. local time, I proceeded to take one image each of 10-, 15-, 20- and 30-minute durations as the object approached the meridian.

The 30-minute integration included here shows the lower left portion of the frame enlarged to 400 percent to demonstrate the M-Uno's tracking accuracy. Blooms from my NABG camera aside, the stars are round and tight. The mount carried the imaging train across the meridian without a pier flip and without any discernable impact on tracking. (I think the longest integration I took with my own mount was 10 minutes.) The M-Uno produced round stars after thirty minutes integration. To me, that's phenomenal.

Luciano wanted to capture an image of Arp 244 in Corvus, the Antennae Galaxies. I have imaged this object before, but with only mediocre results. Off we went, with the M-Uno slewing smoothly and quietly, and placing the object right on target. Even though it's tough to capture much detail with a 7-inch telescope, a 10-minute integration captured the object's faint filaments. The go-to was, once again, spot on, and M-Uno's precise tracking produced nice round stars.

The coup de grce was the next object, the Leo Triplet (M65, M66 and NGC 3628). I took a break to allow the objects to get close to the meridian so that I could see how well the M-Uno tracked across it. Imagine that — delaying the imaging run to let the objects cross the meridian. That would be almost unheard of with a GEM.

The Intes scope has a wide enough field of view that I was able to position all three objects on my camera's chip, acquire an adequate guide star, and track across the meridian without interruption. I began a LRGB imaging run at 12:55 a.m. local

Image 8 - The Leo Triplet (LRGB).

time. As the objects crossed the meridian, I continued the imaging run without disturbing the OTA. In processing the image, I was very impressed with the amount of detail in the galaxies that the M-Uno enabled the 7-inch scope to obtain. In addition, the M-Uno's accurate tracking produced round stars in every sub-frame. There were no wasted frames due to faulty tracking, in contrast to the other imaging runs I did with my own GEM.

Luciano and Givoanni generously loaned the M-Uno to me for additional evaluation. The mount and tripod pack into two durable soft cases for easy transportation. I decided to test M-Uno's upper payload limits by putting my f/10 C-11 and camera on it. I was very excited to see if the M-Uno would perform as well with a heavy payload as it did with the smaller telescope, and at a higher latitude.

Prior to leaving WSP, Luciano installed the latest version of *StarGo* on my laptop. Configuring the program to communicate with the M-Uno through the USB interface was quick and intuitive. Installation of the driver is necessary to interface with the mount using a planetarium program and/or *POTH*.

In order to explore the M-Uno's Bluetooth interface, I was forced to violate my open-source software rule. I purchased *Sky Safari Plus* for my Android smartphone to run the M-Uno via Bluetooth. *Sky Safari* is an impressive program, but that's another story. I selected the LX200 Classic interface and, violà, the phone and the mount were talking to each other.

Even though the skies were obstructed by clouds, I decided to play around. I guestimated Sirius' location, slewed the mount to that point, synced it, and picked objects seemingly at random to "find." The M-Uno responded precisely to each command. It would be entirely possible to control the M-Uno solely from the smartphone, but some star parties restrict the use of wireless devices. Configuring the laptop to run the M-Uno si necessary if attending such an event. I also discovered that the DEC motor setting needed to be reversed in order for the mount to slew correctly to the chosen Object.

Unfortunately, Ohio's winter-wonderland weather prevented futher meaningful analysis of the M-Uno's capability by the time this article went to press. Perhaps *ATT* will permit me to update these observations in a subsequent issue.

Looking back on my time till now with the M-Uno, it's really difficult to find any problems with it, but if pressed, I would have to point to two items, neither of which reflects poorly on the mount's design or manufacture. The M-Uno's carrying capacity limits it to smaller-aperture scopes. That would be the result of achieving the goal of portability. I have found that my C-11 represents the upper limit of portability and, coincidentally, that happens to be the largest and heaviest telescope that the M-Uno is rated to carry according to Luciano. If portability is a priority, the mobile astrophotographer would likely avoid larger OTAs anyway. Therefore, the M-Uno's payload capacity would not really be a problem.

The other issue is the length of the OTA and imaging train the M-Uno can accommodate. The mount's shoulder blocks longer payloads from reaching areas close to the polar regions when using the standard saddle. Avalon has a solution for that problem: An optional extension plate raises the payload higher from the arm, but doing that would require placing counterweights on the underside of the arm to balance against the leverage of the higher weight differential.

It is readily apparent that a lot of careful thought has gone into the M-Uno's design and construction. It represents an enormous advancement in portable mounts for astrophotography. The Fast Reverse drive system provides responsive, accurate tracking motion. The single-arm design provides a stable platform that enables the imaging payload to track objects from horizon to horizon without striking the mount's body, pier or tripod. Its stylish appearance is made to last.

Also, it's not just for pretty pictures. Luciano explained that in photometry, a pier flip results in data being taken through a different area of the filters. The data is then averaged to account for possible differences in the areas of the filters used to collect the data. With the M-Uno, photometric readings can be taken uninterrupted through the same area of the filter, making data averaging unnecessary. Likewise, when taking LRGB images, not having to perform a meridian flip makes registration of all constituent frames and sub-frames a snap.

This was apparent when I processed color frames of NGC 891 and M76 taken at WSP with luminance frames of these objects I had taken at the Black Forest Star Party five months before. Had I been able to image across the meridian, I would have been able to obtain all LRGB frames at that event. As it turned out, the color frames I obtained at WSP required additional processing time, an effort that M-Uno enabled me to avoid when I processed the Leo Triplet image.

Luciano told me that one of his buyers, a retired amateur with lots of time to use the mount, brought it in for a check just for the heck of it. Luciano advised that after two years of frequent use, the M-Uno tracked exactly as well as it did when it left his factory.

The M-Uno is an amazing product that promises to relieve many of the complications involved in astro-imaging. From its ease of transportation and set-up, its choice of wired or wireless control, its capability of imaging across the meridian without a pier flip, zero backlash and precise tracking of its Fast Reverse drive system, and its maintenance-free construction, the M-Uno's many innovative features promise to make the mobile astro-imager more productive and to produce better images. I was very favorably impressed with the results it produced. The M-Uno deserves close attention when choosing an imaging mount or upgrading a current rig.

Unitronitalia, Avalon's primary distributor, has been marketing the M-Uno in Europe for the past two years. They are ready to bring it to America. Check it out at NEAF. ATT