The Future of the Dobsonian

A personal view by Keith Venables FRAS

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Introduction

When John Dobson invented his telescope design, it was low cost, easy to make and transportable, yet stable. This was back in the 1960's. Ever since then amateur builders and commercial manufacturers have been finding ways to modify it.

Many examples built now still stick to his original design very closely. Often the only change is the use of more modern materials to help make the scope lighter and more durable.

At the other extreme, we may have any combination of fast optics, ultra-compact rocker and mirror box design (UC), digital encoders and motor drives. These telescopes are often referred to as the 'premium dobs' and are certainly expensive. The degree to which the 'extras' are useful will be discussed later! All variants from basic to the sophisticated can have excellent optics but sourcing a really good mirror set is often the biggest hurdle and a major expense.

This article will attempt to explore where next with the Dobsonian design. I admit to being an 'early adopter' of new technology and I am excited by what is possible, even if it doesn't get into mainstream usage.

Mechanics

There are I believe 3 basic Dobsonian mount designs - Pivot, Classic & Ultra-compact or 'UC'. Pivots are most commonly used on the smaller commercial telescopes where the balance point is high up on the OTA. They may have some benefits but these for me are over-shadowed by the difficulty in getting a smooth altitude action and achieving balance. Not surprisingly this type of mount is rarely seen in larger or more expensive telescopes.

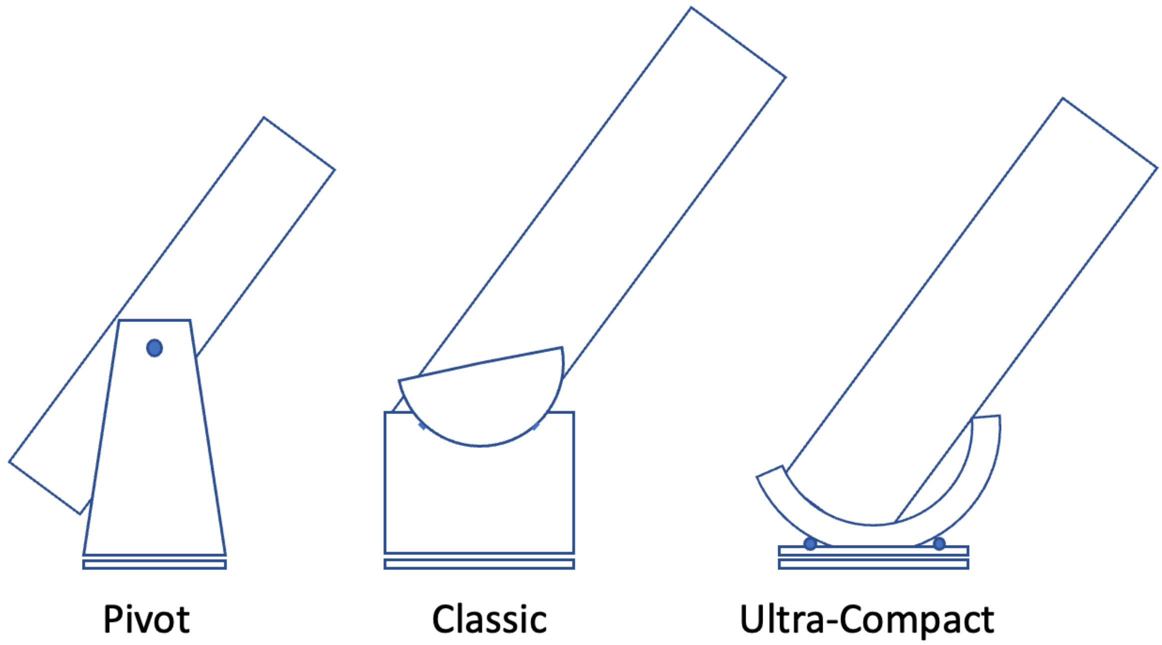

Figure 1 - The three basic types of Dobsonian mount

Interestingly the pivot approach could allow new motor types to be used, such as strain wave drives. These drives are emerging from many suppliers in an EQ format, and rather expensive at the present time, but their use on a Dobsonian style mount could be interesting. A key advantage would be their ability to hold a position against significant out of balance forces.

The Classic is still a favourite amongst the ATM community. Most people with some carpentry skills can produce a sturdy mount even if the finish isn't cosmetically perfect. The mirror is well protected and there is plenty of space for drives and accessories. Usually any Dobsonian above 24" is still made to the classic design, whether they are commercial or ATM produced. At these sizes, the weight of the mirror really tends to negate the advantages of a UC design. The Classic mechanical design continues to be refined in small ways, most often in the use of alternative bearing materials or even ball race bearings.

The UC design has become very popular in recent years. So much so that Obsession has now stopped making the classic in favour of their UC line. It can certainly produce a much more compact telescope, my own 18" UC fitting comfortably in the boot of my Mustang. It also has the popular advantage of helping to reduce the eyepiece height.

Figure 2 - The author's 18" homemade UC

In principle, the UC can produce a more stable and accurate mount with less material in the rocker box to distort and bigger altitude trunnions. However so many times the UC has been compromised by weight and size reductions in other parts of the telescope. Reducing the number of truss poles, and in particular slimming down the upper tube assembly (UTA) can seriously compromise a Dobsonian's overall performance especially when used with large and heavy coma correctors and wide field of view eyepieces.

The UC will doubtless become the most popular design in the future and we can hope to see improvements in stability. Achieving this isn't difficult but requires care and as we approach a second generation of UC designs it should be the primary performance feature - commercial manufacturers please take note!

Encoders and Drives

Usually considered an 'add-on', the subject of encoders and drives on a Dobsonian is complex and interesting. There has clearly been a progression from basic push-to with a finder, to adding encoders, to adding drives. But many observers still prefer the simplicity of no encoders and especially no drives. A good question is whether if the drives were cheaper, easier to use and more reliable, would they become much more popular. I think so.

For me, tracking is an essential feature. Having acquired the right field it helps find difficult targets, and makes changing eyepieces and filters easier. I can also comfortably increase magnification to the limit of my scope and seeing and not have to continually hand track the target. I like to go after challenging targets that might need 10 minutes with a high magnification before I barely glimpse them. I really couldn’t imagine being able to do this without tracking.

The trouble is, adding tracking drives to a Dobsonian isn’t simple. They are altazimuth mounts and so require encoders and computers. No simple equatorial RA clock drive on a Dobsonian! The exception is the EQ platform solution, which can work well but each is limited to a specific latitude, is big and heavy and often introduces instability. They have never proved popular for these reasons.

Adding encoders and driving a Dobsonian in azimuth can be relatively simple. Apart from with pivot designs, doing the same in altitude can be much more difficult. When done, the result is quite a lot of extra hardware that is a potential for problems in the field. It is this that puts many users off from adding these features.

There aren’t a large number of suppliers of encoder systems and drives either. With StellarCat withdrawing from the market, the choice of add-on drives is currently very limited.

Once tracking capability has been added to a Dobsonian, with the exception of EQ platforms, GoTo functionality is usually supplied as a 'free' extra. It is however my experience that the bigger the Dobsonian, the lesser that GoTo is used. My own scope has slip clutches and I almost invariably push the scope to the next target, perhaps using GoTo to refine the pointing once I am close if I haven’t been able to 'eyeball' the target straight away. This is part down to speed as I'm often avoiding clouds, or a visitor asks to see something specific and its so much easier to just swing over to the target. It also saves battery power. Plus you get to learn the sky.

Some commercial small Dobsonians use only motor encoders to keep track of where the scope is pointing, this means that GoTo always has to be used. Others have added 'dual encoders' so that this limitation is removed.

There is an alternative to telescope encoders, something which astrophotographers have known for a while, and Celestron are now offering with their Starsense system. Add a small finderscope, camera and computer and you can know exactly where your telescope is pointing by plate-solving images. Readers may remember in one of my previous articles that I was experimenting with this, and it has transformed the way I use my own Dobsonian and has attracted a lot of interest.

To achieve good accuracy typical axis encoders require the mount axes to be orthogonal, travel to be regular and a good initial two or three star alignment done. Pointing models can help refine accuracy and overcome some mount errors, but they take time to populate and need repeating if the scope is re-positioned.

Adding a digital finder to a Dobsonian almost completely removes the need for accuracy in the mount, although of course stability is still key. A digital finder can determine the Dobsonian's RA & Dec as accurately as the alignment between the finder and the main telescope. Typically, an arc minute. The disadvantage is that the scope needs to be stationary during the exposure (about a second) and the plate-solve can take another 1 or 2 seconds. This disadvantage needs to be balanced against the advantages of mount simplicity and no reliance on an initial two-star alignment. Losing power for instance, doesn't require going back to do an initial alignment.

Figure 3 - The author's 'eFinder'
The adjustable mount isn't now required

From the RA & Dec, Az & Alt can be easily derived (given scope location and time) and also the required tracking rates in Az & Alt. A very simple motor control box can then drive the motors at these speeds. The RA & Dec can be fed to a phone, tablet or pc to display scope position in a planetarium app. If wanted, the plate-solved image could be displayed, complete with eyepiece field of view circles and stars and deep sky objects labelled.

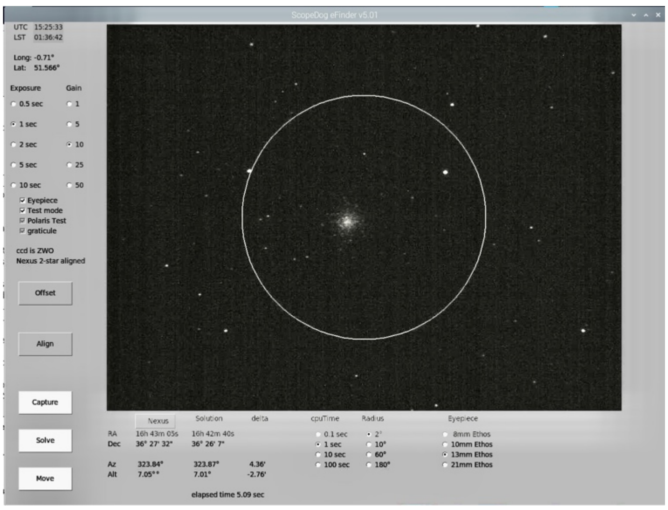

Figure 4 - screen shot of the author's eFinder GUI display on a tablet. A 1 second exposure of M13.

Could this represent the basic tracking Dobsonian of the future? The observer pushes the scope to the target, the digital finder takes a couple of seconds to determine position and then the scope starts tracking. Scope position is displayed either on the finder or an attached tablet.

Such a system knows where it is and how to track, and the next step in functionality would be to add the ability to position the scope to a target, typically from a catalogue. Given that the digital finder knows where it is pointing now, it is easy to calculate the delta in Az & Alt to a given target (ie a GoTo target from a planetarium App). It isn't practical to push the scope to the target due to the lack of real-time reading of position. One would have to push, wait for a position capture, push again, etc. Not good! However, the Az & Alt motors could be driven to move the delta based on calculation. If the delta is say less than 5 degrees then the target can be acquired in one step. A large delta could mean the scope was driven to the theoretical target position, a plate-solve done and the delta finally closed out.

With my own prototype, I now push the scope to near the target, find and select the target in SkySafari by which time the plate-solve has been done, and I hit GoTo. By the time I get back to the telescope the target is centred in the eyepiece to within a couple of arcminutes and is tracking.

The delay while the digital finder produces a 'fix' could be seen as a deal breaker by some. But in practice as observers are we waiting at the eyepiece instantly wanting to see the target, or are we standing by the telescope thinking about which eyepiece to use, etc. With current systems we might take a look through the eyepiece, but we don't know if we are on target. Usually we have to look at the field and make an adjustment. What if when we first look (2-3 seconds later), it is exactly spot on?! Its a slightly different way of observing. Astrophotographers have switched, should visual observers try it too? I am sure a dedicated fast lens and processor could reduce the total 'fix' time to less than a second.

The table attempts to summarise the relative pros and cons between an encoder and digital finder based solution.

	Encoders	**Digital Finder**
Pros	Almost instantaneous readout. Very familiar technology.	High precision throughout observing session without need to re-align or sync, even if powered off. Technology proven by the astrophotography community. Option to display annotated field image.
Cons	Mount geometry needs to be very accurate. Initial alignment must be good. Often needs periodic local aligns or syncs. A power loss means back to a re-start.	Time to get a fix. Susceptible to dew, but easily manageable.

There are two further potential improvements in mounts that should be considered. One is the incorporation of slip clutches in both axes. The freedom this gives to an observing session has to be experienced to be truly appreciated. I can walk up to my own scope which might be tracking a target, simply push it in Az & Alt to a new target and when I let go the scope resumes tracking immediately. Visitors are usually surprised by the simplicity with which I can change targets (especially if they have requested 'a look' at something particular) and for me it bridges the gap between today's sophisticated Dobsonian and John Dobson's original intent for his 'sidewalk telescope'.

The other is the approach taken with the altitude drive if fitted. The problem arises from the motor drive only being on one side, combined with the clearance/friction/stiction in the trunnion bearing pads and lateral guides. Too much friction or stiction and when the altitude drive motor tries to move the scope, the opposite trunnion sticks or drags, causing unwanted rotation in azimuth. Too much clearance in the lateral guides and a similar effect occurs. Large Obsession UC with a folding trunnion had ptfe bearing strips that covered the whole length of the trunnion support, this was to overcome the 'bump' that might occur as the hinge passed over the more typical small ptfe pad. However, this reduced the pressure per unit area on the ptfe bearings to a very small level, which gave problems with balance on non-driven versions, and on both driven and non-driven scopes there is a tendency to rotate significantly in azimuth on these full length ptfe strips. Obsession has now addressed this issue.

My own scope runs on ball race bearings instead of ptfe pads. This makes for extremely smooth movement but does require judicious use of a damping pad on the motor driven side of the altitude trunnion. Because the pad is on the driven side, it doesn't suffer from the problems described above.

Another approach is to drive the altitude trunnions on both sides. Some UC designs achieve this by having a single driven shaft that reaches both trunnions. The SpicaEyes Dobsonian is a good example, but this simple approach is only possible with UC designs. With a Classic design the body of the scope passes between the altitude bearings and precludes a simple single shaft. However, a single shaft could still be used with perhaps twin belt drives up to the trunnions, or by having motors on both sides.

An integrated approach

Some commercial telescope manufacturers are able to take an integrated approach to the mount/encoder/drive solution. But only if they have the breadth of design capabilities and enough knowledge of the user's needs. We can all tell when a system has been designed by an observer, or the marketing department! Some companies have excellent capabilities in perhaps optics but have to outsource other aspects of the system.

Sometimes this outsourcing can have further problems. ServoCat and ArgoNavis have always been close cousins, being developed hand in hand. They work brilliantly together. But they were designed so interrelated that each lost some flexibility. Now that ServoCat is being retired, the makers of ArgoNavis have no option but to pick up the gauntlet and produce a replacement.

For the Dobsonian builder, the ability to put together a system from different components can be a blessing or a nuisance. Generally they all work together (astrophotographers look upon this with envy!), but it means that a total system is more complicated and expensive than it needs to be.

A full drive system today will include a pair of high-resolution encoders, a DSC, motors, a servo control box and a tablet running a planetarium app or observing planning app. Then there is the less obvious cost of making an accurate mount. Even assuming the tablet hasn't been bought for just this purpose, the drive system could cost a couple of thousand dollars at least.

Initially a change to a digital finder instead of encoders will not cost less, possibly more. But a modern single processor is more than capable of handling the plate-solve and tracking rate computations. Sophisticated stepper motor controllers are now single chips costing a few dollars. Excluding the finder scope and camera, the parts cost of my prototype controller was around $100. Two geared motors are another $100. My finderscope and camera cost about $200 and so an overall system total of around $400. A manufacturer should be able to source these at a much lower cost and hence sell a complete digital finder and tracking system for around a $1000.

Recently I came across a 50mm f1.8 cctv lens. Available at less than $50 it mates perfectly with my ASI120MM-S ccd and produces a 4 degree field of view. A 1 second exposure is sufficient for a successful plate-solve. With this field of view I no longer need the mechanical adjustable bracket to align with the main telescope. I point the main scope accurately to Polaris, and then the eFinder plate-solves an image to determine the offset between eFinder and main telescope. This offset is stored and applied for the rest of the session. An example of an integrated approach significantly reducing the complexity and cost of the system.

Figure 5 - Latest eFinder lens and camera

Figure 6 - New eFinder remote hand box

My 'final' improvement has been to combine the digital finder processing functions into the main ScopeDog control box. The plate-solving work is only undertaken relatively infrequently and I have found the Raspberry Pi quite capable of looking after this and the tracking computations. The original eFinder display and controls have been reworked into a remote hand-box connected via a USB lead. I used a Pico microcontroller ($5) and 1.3" OLED display ($8).

Summary

Almost 60 years on, John Dobson's 'Sidewalk telescope" is still enabling amateurs to buy or build large aperture, relatively affordable telescopes. The addition of encoders and drives has been very popular with many. The adoption of these enhancements probably being tempered by high costs, complications and often poor outcomes. A new approach using slip clutches and plate-solving technology could bring back the benefits of simple construction and easy use that John Dobson gave us, while retaining tracking and delivering very accurate pointing.

Astrophotographers need reasonably long focal length finder/guide scopes to achieve their required accuracy. For visual observers (not just with Dobsonians) a simple 50mm focal length lens at f/1.2 coupled with a basic mono guide camera will I believe be more than sufficient. In my own prototype the drive control box has more than enough power and spare time to undertake the plate-solves.

The time is also ripe for manufacturers to integrate the components into a more affordable package. This has been done for some smaller commercial Dobsonian telescopes, but we need something suitable for larger Dobsonians.

This principle extends to dew control. Very few telescopes 'as delivered' include active dew control, and for many it is very difficult to add. When done it is often less than effective and certainly not efficient. They should at least be designed for, if not with. This applies equally to finders, secondary mirrors and especially to refractors. Well done to Celestron for making a start, (rant over!).

Recently the new UC designs have gained popularity, but nearly all examples have suffered from stability weaknesses, caused perhaps by an overzealous search for size and weight reduction.