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A Digital Setting Circles Primer...

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In the battle between goto and non-goto many folks forget that there's a third option – Digital Setting Circles.

Digital Setting Circles (DSCs) have been around for a long time. In the late '80's Celestron was one of the first companies to commercially market a unit – the Advanced Astromaster. DSCs were in effect, a logical extension of the analog setting circles found on the axis of any german equatorial mount. Quite simply, the modern DSC was a small computer that allowed you to know where your scope was pointing, and assist you in pointing it towards a different set of coordinates. Today's DSCs often do a bit more, and

usually contain an internal database of objects which allow you to point your scope to thousands of targets.



The DiscMount shows its encoders...

A basic DSC setup consists of a small handheld computer connected to encoders which are attached to the axis of the mount. DSC's don't drive the scope like a goto system would, but they do tell you where it's pointing, how far and in what direction you need to move the scope (via directional arrows, and numbers that count down which are displayed on the DSC screen) to acquire a target out of the computers database. Think of DSC's as "push-to" instead of "goto" technology. The user supplies the muscle power.

Most who are aware of DSCs tend to think of them as a tool for dob owners, and while you rarely see a large dob without one, many DSCs also work quite well on other mounts: german equatorial, alt/az and fork – driven or not. In fact, Scott Losmandy offers a rebadged version of the Sky Commander for use on his legendary mounts. If you are creative (and even if you aren't) you can mount DSCs on just about any setup in use today.

While there have been dozens of different DSCs on the market; TeleVue, Discovery, Lumicon Sky Vector, Orion Sky Wizard, JMI Max series, Meade Magellen, Sky Commander, Orion Intelliscope and most recently – Argo Navis, there really are only a few companies that actually manufacture the units. Tangent Instruments is the major manufacturer, making $\frac{3}{4}$ (or more) of the units on the market, leaving Sky Commander, Meade, Orion's Intelliscope and Argo Navis (also the JMI Super-Max) as the competition. The Tangent units typically come in 2-3 different models and are differentiated by the size of the database (the more expensive the unit the more entries), the computer's physical size and its features. Typically the more expensive units can be hooked up to a computer and offer search and identification functions. Additionally, different manufacturers may spec out different databases for their units. The JMI NGC Max (a top level box made by Tangent for JM), includes 12,046 objects including the complete NGC, IC and Messier catalogs. It's a good match for a large scope owner who wants to go deep. Now compare this with the TeleVue Sky Tour: Another top level box made by



Sky Engineering's Sky Commander

Tangent, only this time for TeleVue. The Sky Tour uses the Tom Lorenzin 2000+ database which includes selected objects (NGC/IC, doubles and triple stars, dark nebulae, galaxies, star clusters, and colored stars) for small scope owners and is a much nicer match than the JMI unit for a small refractor.

I've owned and installed five or six different DSC systems (on too many scopes to count), and these devices haven't fundamentally changed over the years. My first unit was one of the very first Celestron Advanced Astromasters (circa 1988), and my latest is the Argo Navis. While the Argo certainly offers more features than the old AAM I owned, both guide you to targets equally well.

Basically there are three parts to any DSC system, and with the exception of the Orion Intelliscope (and possibly the Meade units) all systems work fairly well with one another.

Encoders



4000 tic encoder

The encoders (shown at left) sit on the mechanical axis of your telescope and report to the DSC computer how far it has rotated. Most encoders are optical, and interchangeable throughout nearly all systems. The Orion Intelliscope is an exception and uses magnetic encoders. The resolution of the encoders refers to how many increments (also called steps or ticks) the encoder moves through when it turns one revolution (360 degrees). Common values include: 2160, 4000, and 8192. Increasing the resolution of the encoders does not necessarily increase pointing accuracy – there are many other factors to consider. Perhaps the most important consideration in pointing accuracy is the orthogonality of the mount. That is: the motions of the axis need to be as perpendicular to one another as can be. Encoders

typically cost somewhere between \$50 and \$100 per encoder, depending on the resolution. Two are needed – one for each axis.

Mounting hardware

Once you have your encoders, you need to find a way to mount them to your setup. There are a number of solutions available for nearly any mount – check with your manufacturer or favorite e-group for recommendations. Most kits are easily installed by the end user, but on occasion (particularly if you are having a dob built) you



ALT encoder installation on 15" Truss



AZ encoder installation on 15" truss

will need to check with the manufacturer. Additionally, I've generally (but not always) found it preferable to have the manufacturer install and test the units – especially if you aren't "handy". If it's an older scope or a used item – you may want to give JMI a call. Most dob owners need look no further than Sky Engineering. Their dob mount kit is extremely inexpensive and works quite well. I've either installed it myself or had it installed on several of my dobs. For dob owners, basically you need a AZ pivot

pin that is pre-drilled to accept encoders, and a set of mounting brackets for the ALT and AZ encoders. While it's not hard to cobble something together, there are those of us who prefer to purchase pre-cobbled kits. <g> In the pictures accompanying this section, you can see both the altitude and azimuth encoder setups for a 15" truss. Also note the Teflon pad on the side of the rocker box in the picture above– one is located on each side and restricts the telescope from shifting side to side while it's being moved. This helps to further improve accuracy. The mount kit can cost anywhere from \$40 to \$250+.



WildCard Innovations':
Argo Navis

Digital Setting Circle Computer

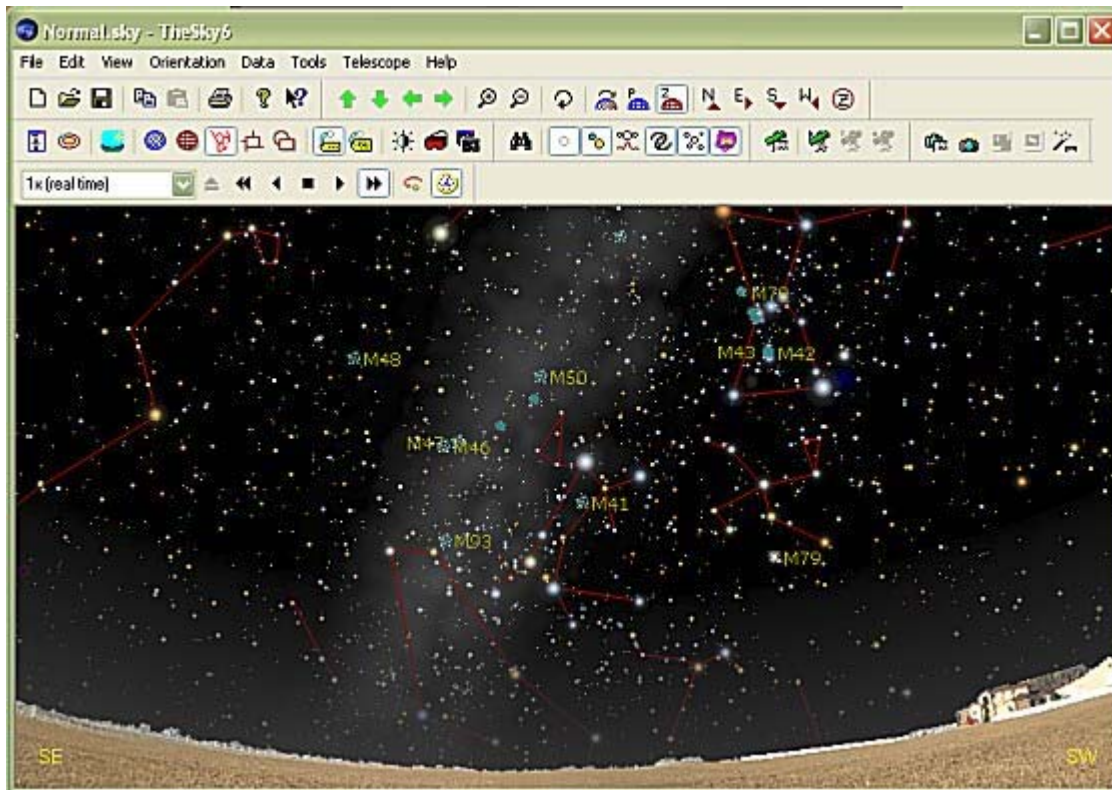
Finally we come to what most folks consider to be the DSC itself. The computer is generally a small box that contains a database, and has hookups for the encoders and perhaps a PC. Generally (but not always) the more expensive boxes offer more features and larger databases. A low level unit might offer RA and DEC readout, and have very very few database entries (220 or less). A high level unit will usually offer compatibility with equatorial tracking platforms (for dobs), an extremely large number built in catalogs (the current king – Argo Navis - offers over 29000 individual targets in its on-board databases), the ability to connect the DSC to a computer or PDA and interface with a piece of software like The Sky. Choosing a good DSC computer is especially important if you want to minimize the amount of equipment you take into the field, but if you are using the telescope in an observatory it may not be as significant – especially if you have a computer sitting nearby to interface with the telescope.

Are some DSC computers more “accurate” than others? Well, that’s not quite as easy a question to answer as you might think. Keep in mind that every DSC (in theory) should read the same set of numbers from the encoders, and in theory, give identical pointing results. However, at least one of the more expensive units on the market (Argo Navis) has support for atmospheric refraction, mount error correction, and more. In use does this make a huge difference? I’ll address that more completely in my upcoming comparative review of the Argo Navis and the Sky Commander, but in the meantime, I’ll say you should be able to get good results with nearly any of the units on the market. A DSC can be obtained for anywhere from \$100 (used) to

A DSC setup (encoders, mounting hardware and computer) will run from \$250 to \$800 or more.

Some setups provide even more functionality. Starmaster interfaces the sky commander with a track and goto system, while various companies offer a drive and goto system based on the ArgoNavis and sold by StellarCat.

SGT – another option



The Sky 6 (along with countless other programs) is capable of interfacing with encoders given the right equipment – *image used with permission...*

As I hinted above, although most folks tend to use DSCs self contained (read utilizing their own computer and database) it is possible to rely on a computer – PC or Mac - for the database and positional readouts.

If you are interested in simply hooking your PC (or PDA) up to your computer and letting a program like The Sky (or Pocket Sky for Pocket PC) show you where you are pointing, you can opt for a simple interface that allows you to hook your PC or PDA directly up to the encoders and use it as the DSC computer. This option is called SGT – Software Guided Telescope. SGT interface boxes are typically less expensive than DSC computers because they don't require onboard memory, catalogs or a great deal of processing power. All of this is supplied by the nearby computer.

Accuracy – I still havent found what I'm looking for...

You might assume that once you have DSC's installed on your scope, you will be able to easily center objects and no target will ever escape. Unfortunately, this is probably not going to be the case. Often you will find your accuracy will initially start off excellent and then degrade over the course of an evening. Or it will be acceptable in one area of the sky, but completely out of whack on the other. There are four main factors that effect accuracy on DSCs.

- Orthogonality of the mount
- Accuracy of encoder and DSC installation
- Encoder Resolution
- Initial Alignment

Orthogonality of the Mount

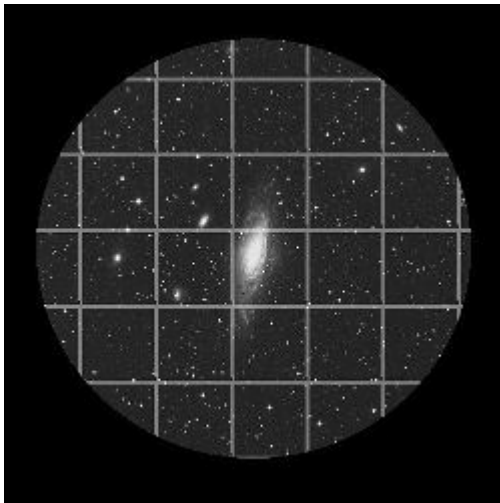
Simply put, this means that the mount axis are at right angles to one another. The DSC works on a simple (comparatively speaking) mathematical algorithm to compute the positions of items in the sky based on two or three reference points – usually an initial reference point (typically either with the scope in a level or vertical position – the exception to this is the Sky Commander which skips this step) followed by either a one or two star alignment so the scope can get an idea of where, exactly, it's currently pointing. This formula is based upon the assumption that the scope can only move at right angles, and can lead to problems. For example if the axes are actually at 88 degrees relative to each other instead of 90, this will induce an error that becomes progressively worse as you move further from the initial alignment points. There are ways to compensate for a non-orthogonal mount (T-Point from Software Bisque is one), but usually they require use of a computer and an SGT setup.

Accuracy of the Encoder installation and DSC setup

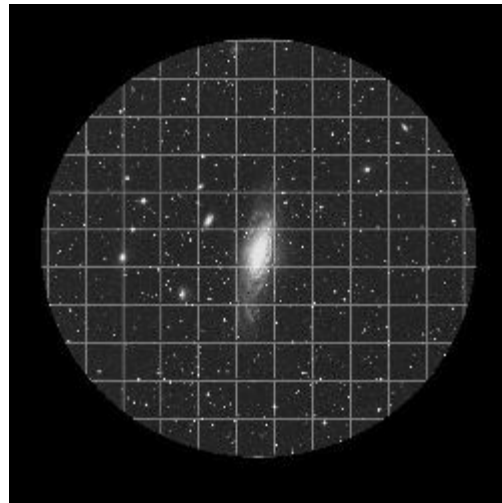
Didn't I just say that the positional calculations are all made on the assumption that the axes are orthogonal? Welllll... actually, that's not **quite** true. In reality, the positional calculations are made on the assumption that the encoders are placed orthogonal to one another. Since the encoders are generally placed on the axes, it often amounts to the same thing. However, if the encoders are not exactly centered on their respective axes you will again get cumulative positional errors creeping in. Additionally, if your DSC computer is not set up properly – say for example the direction of your encoders is reversed, or you have the wrong resolution programmed in – once again, you will get pointing errors.

Encoder Resolution

As I stated above, the resolution of an encoder measures how far it has turned about its axis. A 2160 step (or tic) encoder has 2160 discrete steps for one revolution. A 4000 step encoder has 4000 discrete steps and so on. The higher the number the higher your potential pointing accuracy. Doubling the encoder resolution on both axes results in quadrupling the overall pointing accuracy. How does this work? Take a look at the two eyepiece images of NGC7331. I've overlaid sample encoder grids on a simulated field of view. On the left, you see the grid created by my sample low resolution encoders, on the right a grid created by higher resolution encoders (2x higher than the low resolution).



Low resolution encoders



High resolution encoders

As you might guess, errors pop up when an alignment item does not fall exactly on a particular grid. However – don't assume by this that you can't get good pointing accuracy with lower resolution encoders. In part, this will depend on how large your true field of view is. If you have a smaller scope that generally gives wider a TFOV, low resolution encoders should work quite well – for visual use. Tele Vue's Sky Tour

encoders employs fairly low resolution 2160 tic encoders; however the TV102 still yields a TFOV of three degrees at low power, and this scope provides the narrowest field of views of any TV scope. From experience, I can say the 2160 tic encoders place items in that field of view quite well. You really need high resolution encoders when you are using equipment that yields narrow fields of view.

Initial Alignment



The Gibraltar has a pre-marked notch to help the user determine the initial position – note encoder housing on side

When you first turn the DSC computer on at the beginning of an observing session, you have to go through two or three steps to initially align. This is so the computer obtains its reference points and can determine where it's pointing. For many computers, the first step is an initial reference point that depends on the mount itself. As mentioned above, usually this involves placing the scope in either a vertical or horizontal position. Second, you have to align the telescope on the night sky – if you are using an alt/az mount (like a dob) you will need to pick two reference stars from a list and center them. Failure anywhere along this chain can be detrimental to your pointing accuracy. First, make sure

that your initial reference point is indeed a point that you can return to **exactly** every time. An error by so much as $\frac{1}{2}$ a degree can seriously affect your pointing accuracy with certain computers. Secondly, some stars work better than others for initial alignments. Typically, you want to choose stars that are at least 50-60 degrees (or more) apart but are on the same half of the sky. You should experiment to find different stars that work well for your site during various times of the year.

Finally, one mistake often made is to center initial alignment stars in a low power eyepiece. Since the eye can have problems determining concentricity of objects, you should center them in a high power, narrow apparent field of view eyepiece or by using an eyepiece with a cross hair or target reticle. It's extremely important to accurately center the alignment object: recall the "grids" above – you want to make sure the object you are centering is actually in the grid you are telling the computer it is. Personally, when I'm concerned about pointing accuracy, I like to use a 7 or 9mm ortho for that initial alignment.

When pointing errors persist

When you've aligned as well as you possibly can, and you've determined that your DSC is indeed setup properly, you may find that you still have pointing errors – probably due to the lack of orthogonality in the mount or because of inaccurate encoder installation. But – you can still use your DSCs to find objects, never fear! In fact, a good portion of the scopes/mounts I've seen, used and owned have had some orthogonal issues, but I still usually manage to find everything I look for. Here are a few tips:

Drop to your lowest power eyepiece.

- In accordance with Lord Murphy's Dictates, the object will often be *just* outside the field of view of the eyepiece you are using. If you use your lowest power, you maximize the chances of the object landing in the FOV.

Do some digging

- If the object isn't in the FOV of your lowest powered eyepiece, try taking a look through your optical finder. If you can't spot it either place, then slowly spiral out from the initial position until you come across it.

Plan ahead.

- If a mount/setup has orthogonality issues, you will often find that it will be dead on accurate in the area around its initialization stars, but the further you move across the sky the worse the pointing accuracy becomes. Plan your excursions so that you stay in the same area of the sky. If you do move to another area, familiarize yourself with the re-align function. This will allow you to re-align the computer on the item currently in the FOV and boost future accuracy in that area.

Be patient

- Don't get frustrated if you can't pull up an object. Occasionally (although it's getting to be rarer) there are errors in the database and the computer will tell you that you are centered on a particular target, but it's nowhere to be found. Try moving on to the next target on your list. If you continue to experience problems, try re-aligning. You can also check to make sure that your encoders aren't slipping, and that your batteries are good. Old batteries have often been the source of my pointing headaches. Finally, you can try turning your DSCs off and starting again.

DSCs are an excellent tool for the visual observer – especially one who seeks out faint fuzzies at the limits of their scope, regardless if it's under heavy light pollution or pristine mag 7 skies.

In my next article, I'll be reviewing two of the hottest units on the market today: the Argo Navis and the Sky Commander, so stay tuned!

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