Considering Video Astronomy?

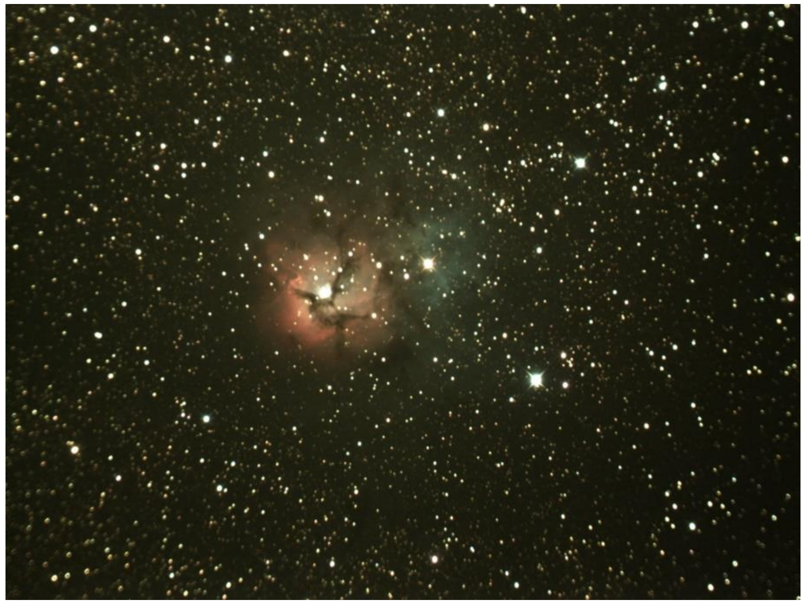
My hope with this article is to help other beginners make fewer mistakes than I have made. In doing so, I hope to reduce the expense and frustrations that is inherent with such a technical and rapidly advancing hobby. I will focus on some of the basics that I have learned about Video Astronomy.

In my previous Video Astronomy Basics article, I defined Video Astronomy and some of its benefits and negatives as well as how it differs from imaging or astrophotography. Briefly, Video Astronomy is near real time viewing (less than 1 minute exposures) and no or very little post processing of the image. Imaging, on the other hand, typically utilizes much longer exposure times as well as extensive post processing of the acquired images. There are various degrees of overlap between Video Astronomy and imaging which is beyond the intended scope of this basic article.

Determining your initial hobby interest, identifying budget constraints, and how you are going to use your equipment should be your entry points into exploring and purchasing Video Astronomy equipment. Be sure to join the Raleigh Astronomy Club and take advantage of all the club benefits. The club has a wealth of knowledgeable members. Be sure to check out the equipment loaner program and visit the clubs dark sky observing site. Most of all, ask questions! These are all very valuable resources. Keep in mind that purchasing Video Astronomy equipment is a very personal choice and that you will encounter a wide range of opinions. Stay objective, do your homework, and try out various loaner equipment before purchasing.

Determine Primary Interest

The very first thing one should do before selecting any Video Astronomy equipment is to determine what you want to observe (planets, solar, or deep space objects such as galaxies, nebula, and star clusters). There are differences in equipment choice depending on this primary decision. It is important to keep in mind that no single Video Astronomy setup selection can do everything. Equipment choices will be a series of compromises that most closely fit your hobby interests.



Identify Budget Constraints

You do need to set a budgetary range that you feel comfortable spending on equipment. This will require some soul searching and discipline. Astronomy is an expensive hobby and the combination of your expanding interests and chasing technology developments will be alluring. My advice is to start small and build your equipment base as you advance along your learning and interest curve. Your interests are most probably going to change with time so purchasing flexible equipment will be important in keeping your initial costs down.

Equipment Usage

You need to determine how you will be using your astronomy equipment. Will you be traveling, **Astrotreking**, to dark sky sites and Star Parties? If so, you might want to consider more mobile equipment that is less bulky, lighter in weight, and easy to setup. Maybe you are lucky enough to live in a dark sky area and want to setup a permanent setup or observatory. If this is the case, you will probably want to consider larger less portable equipment. This will go a long way toward determining equipment selection and costs.

The key to Video Astronomy is to capture as much light as economically feasible. The decisions among telescope type, aperture, Focal Ratio, mount characteristics, camera sensor size and sensitivity, camera sensor resolution and class rating all interplay with one another with respect to light gathering ability and your viewing preferences. I will attempt to describe these interactions as I understand them and how they impact the selection of Video Astronomy equipment.

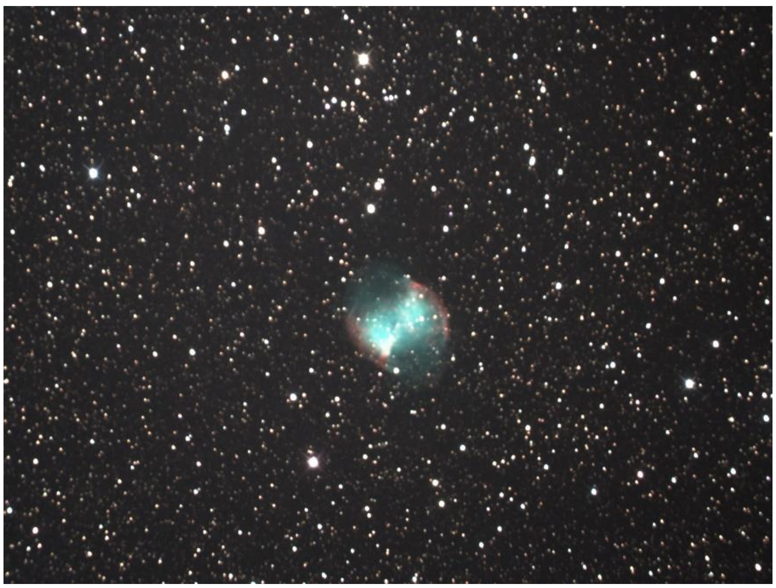
Telescope Characteristics

For the purposes of this basic article, there are two general types of optical telescopes, Refractors and Reflectors. Refractors use a series of lenses to gather and focus light on a Camera Sensor.

Reflectors use mirrors to gather and focus light. Each general type of telescope, in turn, has a number of sub-types or variations available. In general, I have seen both general telescope types effectively used for Video Astronomy depending on what is being observed.

Both Refractors and Reflectors come in a broad range of aperture diameters and focal lengths. The relationship of aperture diameter and focal length determines a telescopes focal ratio (FR=FL/aperture diameter). Focal Ratio is a measure of the light gathering capacity of a telescope. For example, a telescope with a focal ratio of f/5 will show an image of four times the brightness as a telescope with a focal ratio of F10 all other things being equal.

The light gathering ability of a telescope is very important to Video Astronomy. Logically, the larger the diameter of the telescope, the more light it can gather and therefore resolve smaller and dimmer objects. However, the larger the diameter of the scope, the heavier and the more expensive it is. Economics and weight, therefore, dictate size to a certain extent. As is in almost all of astronomy, compromises typically need to be made. The most common aperture sizes that I have seen used for Video Astronomy ranges from 3 inches to 12 inches. The smaller aperture scopes are typically travel scopes while the larger aperture scopes are typically used in less mobile applications.



Telescope field of view is also an important variable for Video Astronomy. This gets back to your original decision as to what type of object you have chosen to view. In general, the smaller the F ratio, the broader field of view and the more light captured. The larger the F ratio, the smaller the field of view and a decrease in captured light. This has significant impact on Video Astronomy and the sensitivity requirements of any particular camera and sensor choice. Broad fields of view give landscape type images and is good for viewing either very large objects and/or to get a better perspective of smaller objects and how they are located one to the other. Narrower field of views allow smaller objects to fill more of the field of view.

My choice of telescopes for viewing star clusters, galaxies, and nebula was a Mallincam Ritchey Chretien (RC) 6 inch aperture (native F9) and an 8 inch (native F8) RC scope. These scopes have the same basic optical design as the Hubble Space Telescope and are classified as a compound Reflector. I chose these scopes primarily because of the flat field of view produced with minimal optical distortion. I use a Mallincam focal reducer which takes my 8 inch RC scope from a native

F8 to about F4. I have found focal ratios of around F4 to work very well for Video Astronomy and viewing my objects of interest.

Mount Characteristics

There are two general types of mounts, Alt-Azimuth and equatorial. An Alt-Azimuth mount is a simple two-axis mount for supporting and rotating a telescope about two perpendicular axes, one vertical and the other horizontal. Rotation about the vertical axis varies the azimuth (compass bearing). Rotation about the horizontal axis varies the altitude (angle of elevation).

An equatorial mount compensates for Earth's rotation by having one rotational axis parallel to the Earth's axis of rotation. The advantage of an equatorial mount lies in its ability to allow the telescope to stay fixed on a celestial object with diurnal motion by driving one axis at a constant speed. Such an arrangement is called sidereal or clock drive.

Although I have seen Alt-Azimuth mounts used in Video Astronomy with varying degrees of success, field rotation can be an issue. This limitation of the Alt-Azimuth type of mount requires short image exposure times and thus a very sensitive video cameras in order to not see field rotation in the captured image.

For Video Astronomy, I chose the equatorial mount despite its requirement to be accurately aligned (polar alignment) with the earth's rotational axis. The equatorial mount was the single piece of astronomical equipment that provided me with the most problems as a beginner. There are a variety of telescope accessory equipment which can help provide quick and accurate equatorial mount polar alignment. However, this discussion is beyond the scope of this basic article. I chose the Celestron StarSense Auto-alignment accessory for obtaining accurate polar and star alignment.

I chose the Celestron Equatorial advanced AVX mount. It is an entry level mount costing approximately $900. This has served me well for 7 plus years as my mount for Video Astronomy. It can, if accurately polar aligned and maintained, track objects for up to 60 seconds. Keep in mind that for the purposes of this basic article that Video Astronomy is defined as near real time viewing with less than 60 second exposure to capture an image. So by definition this falls within the mounts tracking capabilities.

Video Camera Selection

This, in my opinion, is the hardest decision that must be made but can be made less so by clearly identifying your viewing interests well before selecting a camera. There are cameras that are best suited to planetary and solar observations. Others are better suited for deep space objects.

Within reason, I think that one should purchase the highest quality and most sensitive Video Camera that one's budget can afford. Highly sensitive amateur video astronomy cameras are

unfortunately expensive, roughly ranging in cost between $700 and $2,000. However, this investment allows the use of less expensive mounts, both Alt-Azimuth and Equatorial. It also allows one to use smaller aperture less expensive telescopes. Spending your money on the best most sensitive camera will also allow one to expand interests and crossover, within the limits of your mount's tracking ability, into various areas of imaging (astrophotography).

Sensitivity of a Video Camera is a function of the sensor type, sensor and pixel size, sensor noise, resolution, and sensor quality, as well as the quality of design and subtending electronic components of the camera. These should be key to your selection of a Video Camera.

Camera Sensor Type

Sensor types for both Video Astronomy and Imaging have made very rapid advancements recently. When I started Video Astronomy about 8 years ago, the CCD type of sensor was the more common sensor of choice for Video Astronomy. However, the sensor manufacturing industry seems to have shifted toward CMOS type sensors apparently because of reduced manufacturing costs. Some CCD type sensors are beginning to go out of production. CMOS sensors are now available in a large variety of sizes and resolutions. In depth discussions of CMOS versus CCD sensor technology is beyond the scope of this basic article. The majority of my comments about sensors will be about Video Cameras with CMOS type of sensors.

Camera Sensor Size and Sensitivity

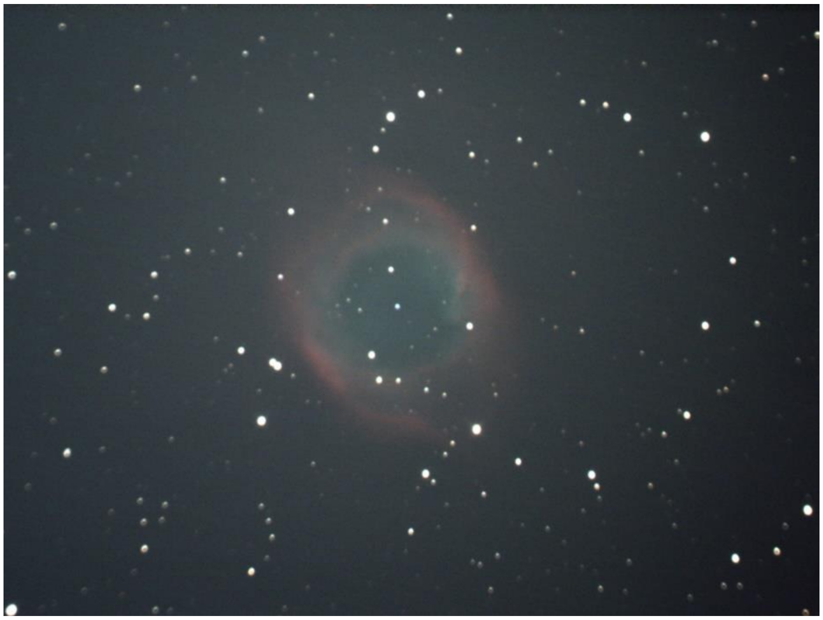
Camera Sensor Sensitivity is, in my opinion, the most important feature of a Video Camera setup. Sensitivity drives other equipment selection such as the type of telescope and mount characteristics. A highly sensitive Video Camera allows one to purchase a less expensive mount because exposure times are by definition less than a minute. Some Video Camera Sensors allow 15 seconds or less exposure to capture some deep space objects.

A highly sensitive video camera reduces the need for larger aperture telescopes which also reduces cost and travel weight. The lower the telescope Focal ratio and the more sensitive the camera, further reduces the necessary scope aperture which in turn lowers telescope size and cost.

With a given telescope, the larger the Video Camera Sensor the larger the field of view. This has both positive and negative results. The larger field of view also reduces the ability to observe and resolve details of smaller objects. Larger field of views do, however, allow one to see larger night sky objects and provides a better perspective of where these objects are located to one another. Again, this is a series of compromises depending on your viewing and target preferences.

Sensor Resolution

Camera sensor resolution is another important area to consider for Video Astronomy. Higher resolutions logically produces higher quality images with more detail. However, high resolution sensors typically have small sensor pixel sizes which in turn limits the quantity of light that impact individual pixels per unit time. This translates to lower sensor sensitivities and thus longer exposures to capture images. There is, therefore, a compromise between resolution and sensitivity. Remember, I have defined Video Astronomy as utilizing less than 60 second exposures because I do not want to over tax my inexpensive mount tracking capabilities. In fact, I much prefer sub 20 second exposures. The compromise, therefore, is a sensor with less resolution and larger pixel size and as high a sensitivity as possible. Keep in mind this is Video Astronomy and not maging where the rules are somewhat different.



Sensor Noise

Care should be taken to select a Video Camera with the highest quality sensors and subtending components. Inexpensive video cameras use low end commercial grade sensors. Low end cameras typically have hot pixels, unacceptable electronic noise, and many times objectionable amp glow. Make sure the camera sensor is industrial and/or scientific grade sensors…not commercial grade sensors. The best grade/class of sensor is Class 0 and/or Class 1. This adds to cost but well worth it.

Subtending electronics should be Grade 1 with tight scientific grade tolerances and should contain sufficient internal memory to insure the smooth flow of data to the computer. These are often overlooked when selecting a video camera.

In order to further reduce sensor noise, higher end video cameras often use a cooling system to cool down the sensor. Some manufacturers use a cold finger in direct contact with the sensor to cool it down with or without a sealed sensor chamber. Dew formation on the sensor or sensor optical window as a result of these lower temperatures has been a problem with this approach often requiring desiccants, sealed sensor chambers, and heating strips to attempt a dew free sensor environment.

I personally like Mallincam's approach. They have developed a cooling chamber which they call refrigeration cooling which subjects the CMOS sensor to cooling inside a triple sealed vacuumed sensor chamber controlled with a heating element mounted around the internal optical window. The chamber is cooled not by direct contact with the CMOS sensor. This eliminates the need for desiccants. Since there is no direct contact of the cooling system with the CMOS sensor, thermal shock is minimized. This is a recent feature developed by Mallincam.

Video Camera Manufacturer

My video camera purchasing decisions were made with the following considerations. First, I wanted to deal with a manufacturer that has a proven track record over the years for service and support and is a leader and innovator in Video Camera design. Outstanding build quality and serviceability were important. I was looking for a manufacturer that offered a broad range of cameras both in range of cost but also flexibility of usage. Extremely important to me was finding a manufacturer that also provided a broad range of accessories that have been designed, tested, and proven to be compatible with the complete line

of camera types offered. Being essentially lazy and a firm believer in the KISS principle (**K**eep **I**t **S**imple **S**tupid!), I was looking pretty much for a one stop shop (telescope, camera, camera control software, focal reducers, barlows, etc) thus eliminating many of the costly trial and error decisions for mixing and matching equipment across manufacturers to find something that works for my application. It was important to me that there was an active and helpful user's group to help me thru my learning curve. I chose Mallincam with facilities located in Canada because it offered everything I was looking for and everything worked pretty much right out of the box. This was the single best decision that I made getting into the hobby of Video Astronomy. Check out www.mallincam.com to see their line of astronomy equipment, video cameras, and optical accessories. Notice that there are cameras that are best suited to planetary and solar while others are best suited for deep space objects. Also, notice that the field of views and sensitivities vary dramatically based on sensor size and type.

My Video Camera Selections

After purchasing 3 different Mallincam Video Cameras over the last 8 years I finally have a feel for the camera specifications needed for viewing my preferred deep sky objects.

My first Video Camera was a Mallincam Xtreme with an ICX428 EXview HAD series Ceramic Class 0 CCD 8 mm diagonal sensor with 8.4 x 9.8 um pixel size. At the time it was one of the most sensitive video cameras available. As technology developed I had this camera upgraded to an Xterminator using the Sony ICX828 chip which had improved sensitivity allowing less than 2 second integrations along with reduced amp glow. Although ultra-sensitive, this camera and its improved modifications had two irritating problems. First, there was an objectionable amp glow that was difficult to impossible to get rid of especially at higher gains and longer exposure times. The second problem was that with such a small sensor size, the field of view was so narrow that it was difficult to land the object of interest on the sensor after a mount slew. It took lots of practice and very accurate mount calibration to find objects. It could be done but required practice and patience.

My second camera was the Mallincam DS16c Video Camera with a 22 mm diagonal Panasonic Class 1 CMOS chip with a pixel size of 3.8 x 3.8 um. I was attracted to the 16 megapixel resolution and reduced amp glow. I had not yet fully appreciated the compromises that must be made between camera resolution, pixel size, and sensitivity. This is a fine camera that provided really great high resolution images with good color. However, I found it to be better suited to imaging because of it vastly reduced sensitivity compared to the Xterminator. Integration times, sometimes well in excess of 60 seconds were required for my targets of interest plus additional stacking to reduce image noise. Remember, I have defined Video Astronomy as near real time viewing with integration times of less than 60 seconds and no post processing. These longer integration times were hard for my AVX mount to accurately track. I plan to use this camera if and when I venture into imaging/astrophotography.

My third and most recent camera is a Mallincam DS10ctech Video Camera with Sony IMX294CJK 21.63 mm (Type 4/3) color Class 1 CMOS image Sensor. It has 10.71 effective megapixels with pixel size of 4.63 x 4.63 um. It has no amp glow and relatively low noise levels when using the tech cooling. The pixel size is on the smallish side but by using digital binning 2, it is almost as sensitive as the Xtreme/Xterminator. So, I have compromised a little sensitivity in order to gain some image resolution yet still have less than 5 second integrations for many of my favorite deep space objects. With the larger chip I get a wider field of view which also makes it much easier to land an object within my field of view after a mount slew. Considering the compromises, I am very happy with this camera for Video Astronomy.

Video Astronomy Camera Control Software

Ideally, one needs to use software designed to take full advantage of all the features of the particular Video Camera you have eventually chosen. Unfortunately, very few Video Camera manufacturers offer software specifically designed for their cameras. One usually has to resort to generalized third party software that may or may not take full advantage of all of the camera capabilities and may or may not be completely compatible. I eliminated this variable by purchasing a camera from a manufacturer that offers camera control software designed and tested specifically to take full advantage of all of their camera features. I am specifically referring to the MallincamSky software designed specifically for the SkyRaider series of Mallincam Video Astronomy Cameras. I have found the software to be extremely robust with features that even allow one to start exploring imaging type of features such as live real time stacking of images, real time star registration and field correction, real time dark field corrections, histogram functions, etc. I especially enjoy the digital binning features of the software which greatly enhances camera sensitivity. I have yet to explore all of the software features giving me plenty of room to grow and learn. It is professional grade software and best of all it is **free**!

Conclusions

Hopefully, my discussion of some of the important considerations in Video Astronomy has helped focus in on one's hobby objectives and an appreciation for some of the key variables that need to be considered before purchasing Video Astronomy equipment. Telescope and mount type as well as Video Camera selection are extremely important decisions. For Video Astronomy the light gathering capability of the telescope and video camera sensitivity are of paramount importance. Finally, the quality and grade of components used to manufacture a Video Camera cannot be stressed enough. In order to achieve maximum flexibility and longevity, one needs to also consider the compatibility of focal reducers and Barlows for your setup of choice to extend a setup's capabilities allowing expanded hobby interests.

After many expensive forays into video astronomy equipment over the last 8 years I feel like I have finally settled on a setup that does everything that satisfies my astronomical interests for the foreseeable future. My interests have focused on deep sky objects (nebula, galaxies, star clusters) as seen above.

With these factors considered, here is my current Video Astronomy setup equipment list along with approximate cost.

Telescope:	Mallincam Ritchey Chretien (RC), 8 inch, native F8	$1,100
Finder Scope:	Telrad Finder Scope	40
Mount:	Celestron Advanced AVX German Equatorial mount	900
Mount Accessory:	Celestron Star Sense Autoalign Accessory	390
Mount Accessory:	Celestron Skysync GPS Unit	150
Video Camera:	Mallincam DS10cTech	1,400
Focal Reducer:	Mallincam MFR 10, 2" Large Format Focal Reducer	330
Barlow:	Mallincam 2.5X Barlow	150
Filters:	None	0
Camera Software:	Mallincam SkyRaider Series Mallincamsky Software	FREE

With this setup, I am able to achieve polar and star alignment and begin observing in 15 to 20 minutes regardless of location and regardless if Polaris is visible. Integration times for most night skies objects at F4 typically takes 5 seconds or less. I usually stack 10 to 50, 5 second exposures, using camera control software in real time, to eliminate electronic noise. Otherwise, no post processing and no filters. Please see image examples scattered throughout this article. In a typical evening of viewing I can enjoy several dozen deep sky objects in stunning detail and color. Also, because I have chosen a high end Video Camera and accessories, I can begin, if so inclined, to explore entry level imaging (Astrophotography). I would, however, have to invest in a higher end equatorial mount, guide camera, filters and post processing software to seriously pursue imaging.

I wish those of you who are just beginning to get into this hobby that they have the exceptional opportunities, learning experiences, and pleasure that I have enjoyed over the last 8 years using Video Astronomy. Enjoy and **keep looking up**!

Michael Carnes
Amateur Astronomer