

ICX825 Based Astro-Video Camera Comparison

by Jim Thompson, P.Eng

Test Report – Oct. 7th, 2016

Objectives:

The choices of camera available for use in video astronomy has grown rapidly over the past couple of years. This is great news for those of us who enjoy Electronically Assisted Astronomy (EAA). It does however also mean that choosing what camera to buy is more difficult than ever. Take for example just the cameras that are available that use the Sony ICX825 sensor:

- Atik Infinity;
- StarlightXpress Ultrastar; and
- MallinCam StarVision.

All three camera manufacturers boast large fields of view due to the 2/3" sensor, high sensitivity, low noise and easy to use fully integrated software. User testimonials for each camera are generally favorable, but given in isolation from each other; ie. few if any users have presented their experience with two of the three cameras let alone all three. Thus the objective of this test was to acquire a sample of each of these three cameras, and systematically test them in such a way as to allow them to be directly compared to each other.

Methodology:

The methodology of this test was simple: look at the same thing in the same way with all three cameras and compare the view. I was fortunate to be able to borrow an Atik Infinity C from a friend and the MC StarVision C from another friend, and the Ultrastar C I acquired towards the end of my testing. A picture of the three cameras I used for my testing can be found in Figure 1, with a close-up image of each camera's business end provided in Figure 2. All three cameras were the one-shot colour versions.

Image data was collected both indoors and out. The indoors data was gathered using a small aperture refractor (Mighty-Mouse 50mm) aimed at a laptop positioned across a darkened room. An image of the MM50 can be found in Figure 3 (far left side). A ND3.0 filter was used in order to make exposure times more representative of what would be encountered outside at night. A UV/IR cut filter (CM500S) was also used for the duration of the indoors testing. The images observed in this manner included high resolution versions of: a test pattern I custom designed, a uniform field of stars, M42 and M31.

Outdoors data was gathered on my backyard pier mounted Atlas mount with Williams Optics FLT98 and ZS66 refractors (see Figure 3). I made a point of trying each camera on each scope, and used the same focal reducer and filter on each camera. In almost all cases I used the long half of the MC MFR5 focal reducer (also called MFR8) for a reduction factor of around 0.67x. For most of the testing I used a Meade O-III filter to deal with the light pollution in my area. For

the final test performed observing M31 there was no filter used. A close-up image of each camera mounted on one of the test telescopes is shown in Figure 4.



Figure 1 Picture of the Three Cameras Tested: (clockwise from upper-right) Infinity, Ultrastar & StarVision

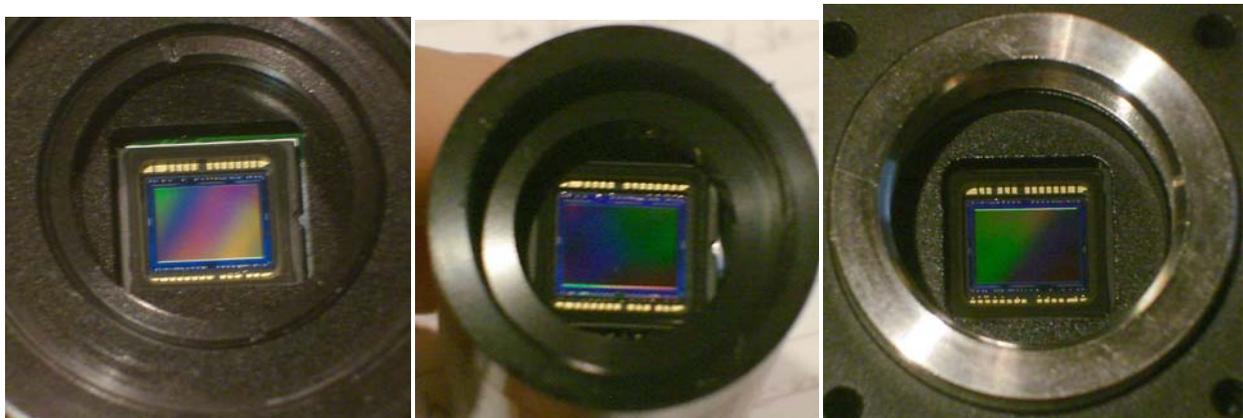


Figure 2 The Three Cameras' Sensors: (left-to-right) Infinity, Ultrastar & StarVision

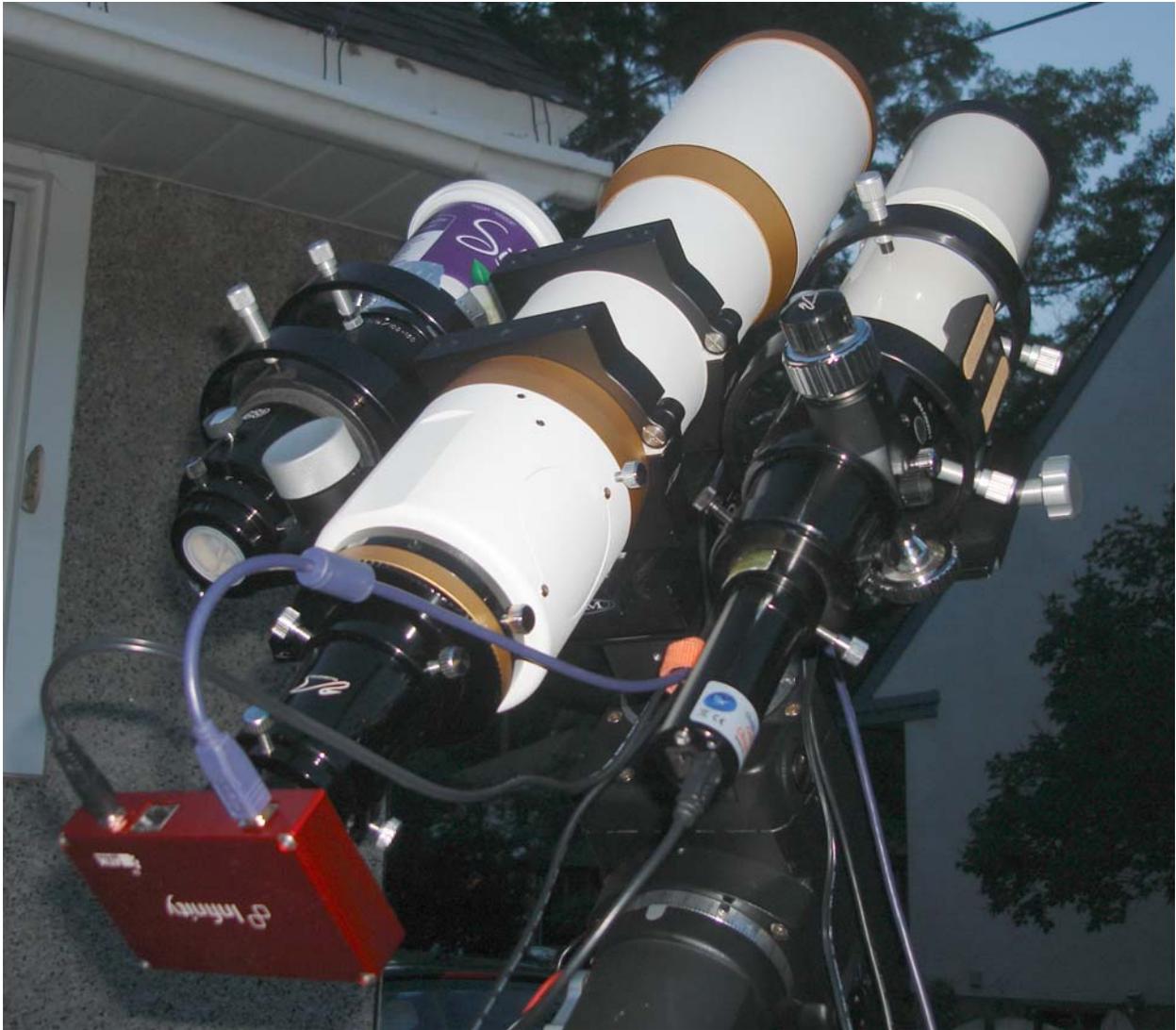


Figure 3 *View of Test Cameras on Telescopes During Testing: (left-to-right) MM50, FLT98 & ZS66*

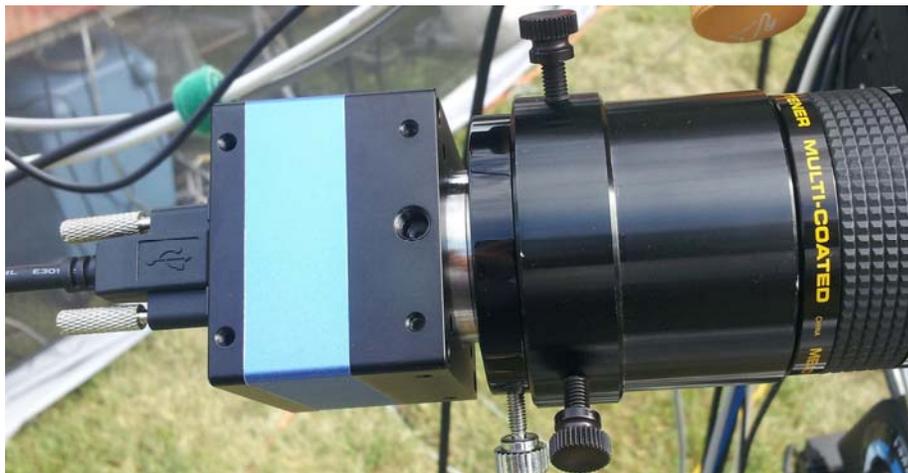
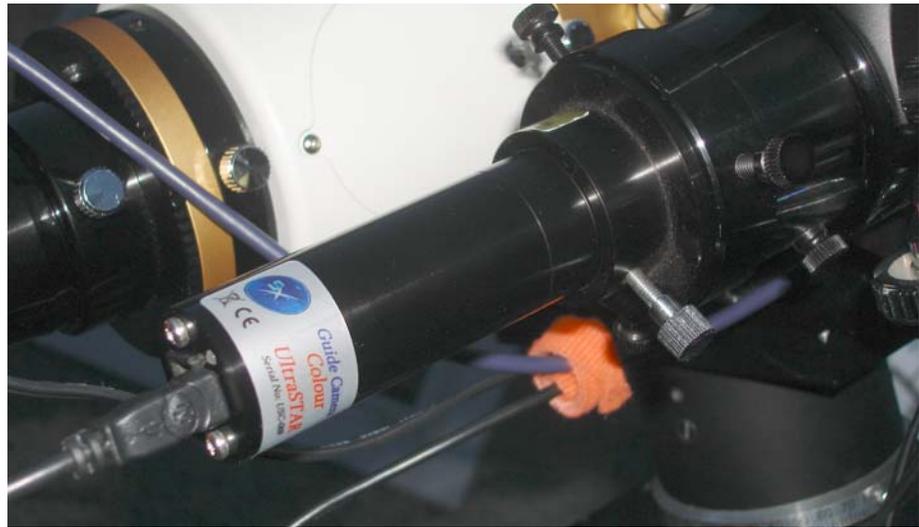
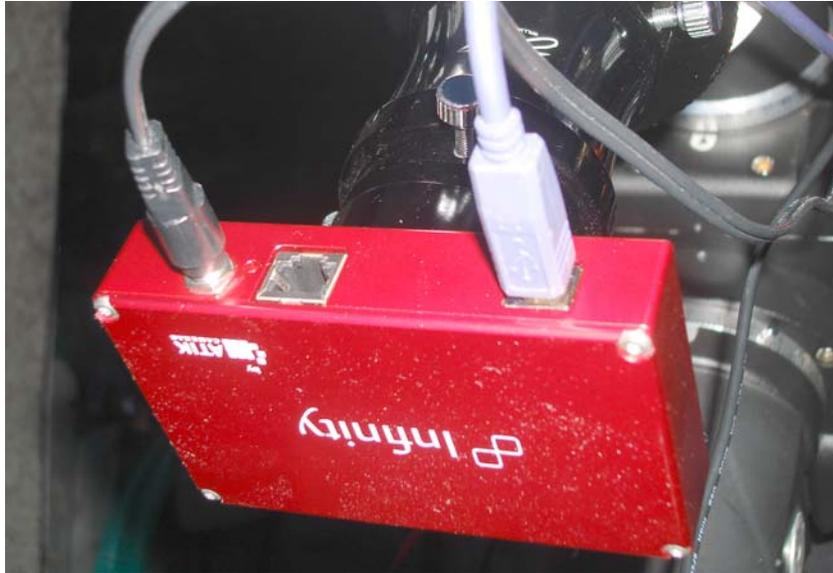


Figure 4 *View of Each Camera On A Telescope During Testing: (top-to-bottom) Infinity, Ultrastar & StarVision*

Results:

My results are in the form of image captures saved throughout the course of the testing. Crops from each series of images are shown in the body of this report, with the original images uploaded to my Flickr account in case anybody wants to see the complete images at full resolution:

<https://www.flickr.com/photos/abbeyroadobservatory/albums/72157673227072061>

Indoor Tests (Sep. 18th):

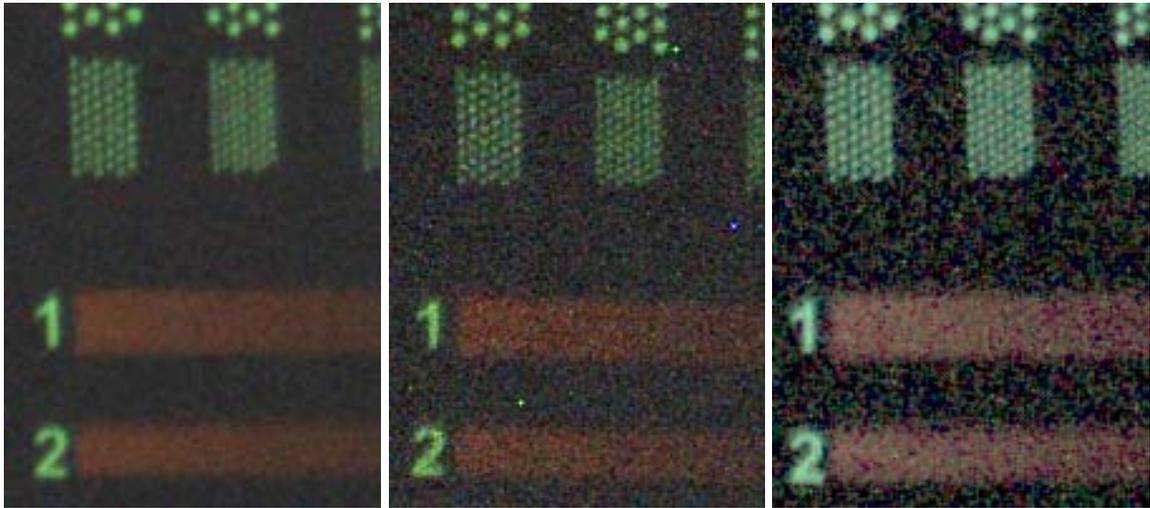
Figures 5 through 8 present a cropped section from each of the test patterns that were observed during the indoor testing. Each figure shows the single frame captures first, followed by the 10 frame live stack version of the same scene. For all the indoor testing a per frame exposure time of 5sec was used. Histograms were adjusted to give roughly the same overall scene brightness. On the Ultrastar and StarVision cameras the built-in dark frame tool was not used (the Infinity software has no such tool). On the StarVision camera GAIN was set to 50x (half way) and GAMMA was set to 0.40. The auto white balance setting was used for all three cameras.

I was surprised at how obvious the differences were between cameras. The Infinity camera was pretty consistent in its ability to present a smooth noise free image. It did however still have a number of very prominent hot pixels. It also did not provide the best white balance of the three cameras, being tinged slightly greenish. I found the stacked image also to be somewhat soft, ie. not sharp edges around details.

The Ultrastar camera was considerably noisier than the Infinity, and presented a much larger number of warm and hot pixels. Stacking did greatly reduce the noise, however more frames stacked would be required to match the same level of smoothness that the Infinity produced. Since the target was not moving during the test (no alignment of frames required), I found that the stacking revealed a fixed pattern of faint vertical streaks in the noise. I found the Ultrastar's white balance to be similar to the Infinity, if not slightly more yellowish. The stacked image from the Ultrastar did appear to be noticeably sharper and more contrasty than the Infinity.

The StarVision was even noisier than the Ultrastar, although it presented about the same number of hot and warm pixels. I chose not to use the noise reduction tools available in the software because my objective was to compare raw frames from each camera. The "Noise Reduction" tool applies a Gaussian type blur that can be useful to reduce the appearance of noise at the cost of sharpness. The "3D Noise Reduction" tool is essentially a frame stacking feature that I found works extremely well with short exposure times, but less so with longer exposures because there is no frame alignment. The "Stacking" tool was also effective at reducing noise, however like with the Ultrastar more frames would need to be stacked to get the same smoothness of image as the Infinity. I did also see a couple thin vertical line fixed patterns in the stacked image. I found the image from the StarVision to be a lot more contrasty than the other two cameras. The StarVision also presented the best white balance of the three cameras tested, although the saturation of the colour green in my test pattern #1 was lower than for the other two cameras.

Single Frame

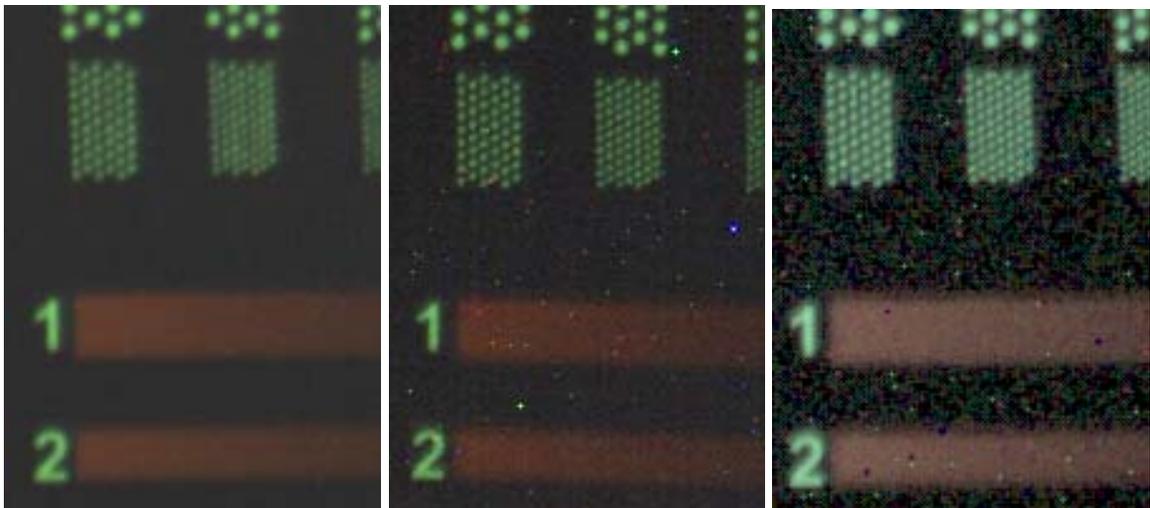


Infinity

Ultrastar

StarVision

Live Stack 10 Frames



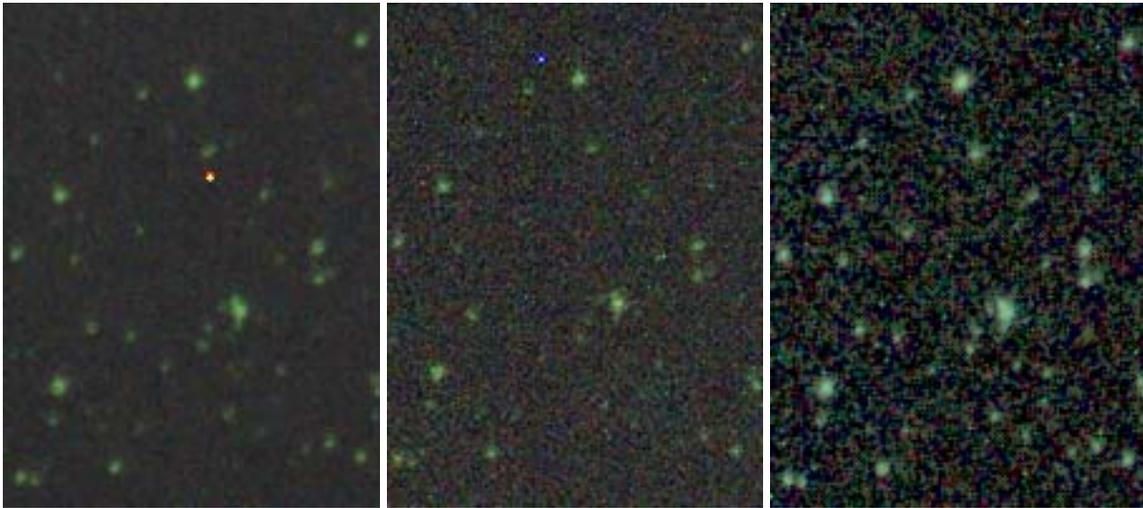
Infinity

Ultrastar

StarVision

Figure 5 *Crop View of Indoor Test Pattern #1*

Single Frame

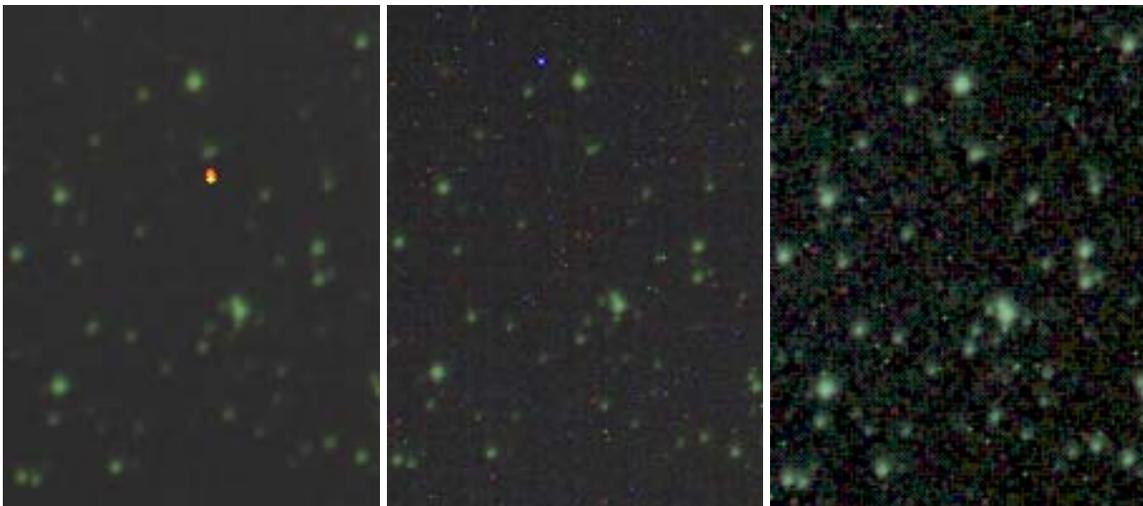


Infinity

Ultrastar

StarVision

Live Stack 10 Frames



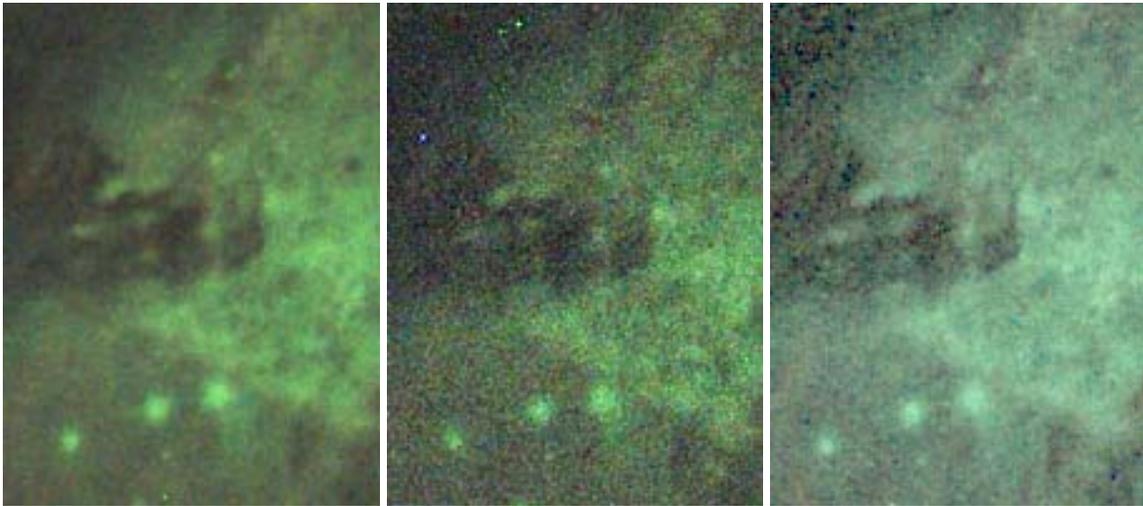
Infinity

Ultrastar

StarVision

Figure 6 ***Crop View of Indoor Test Pattern #2***

Single Frame

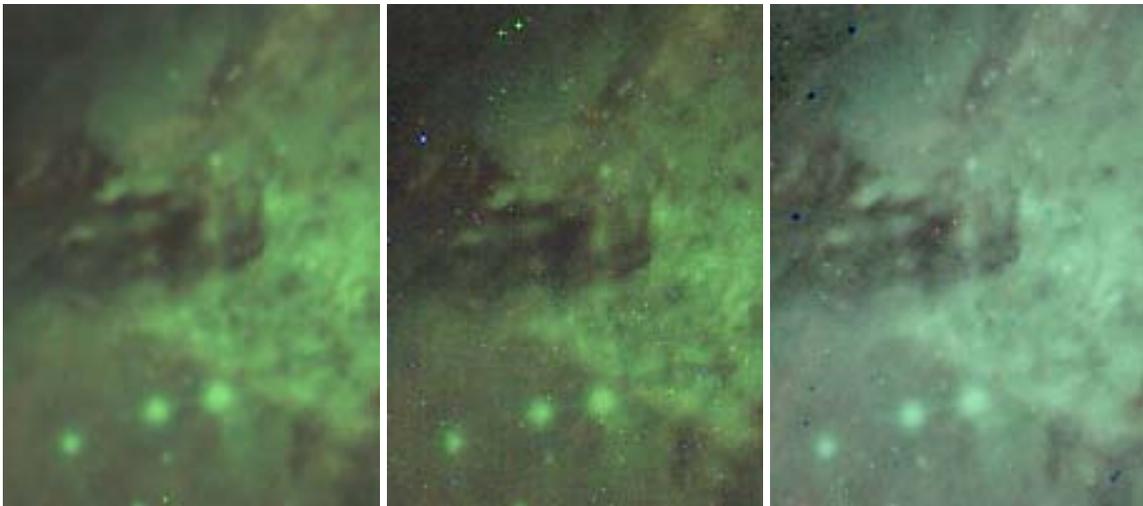


Infinity

Ultrastar

StarVision

Live Stack 10 Frames



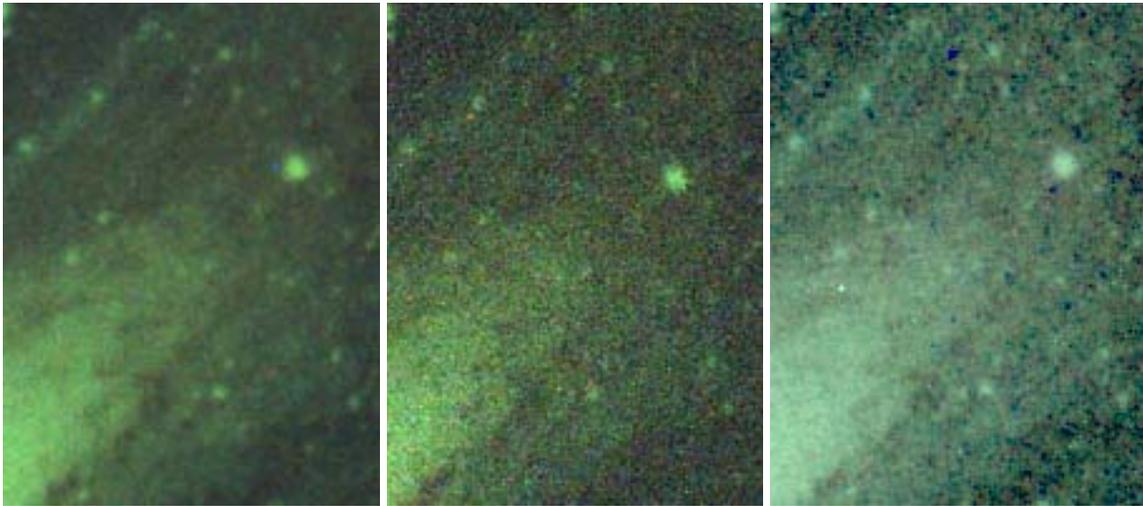
Infinity

Ultrastar

StarVision

Figure 7 Crop View of Indoor Test Pattern #3

Single Frame

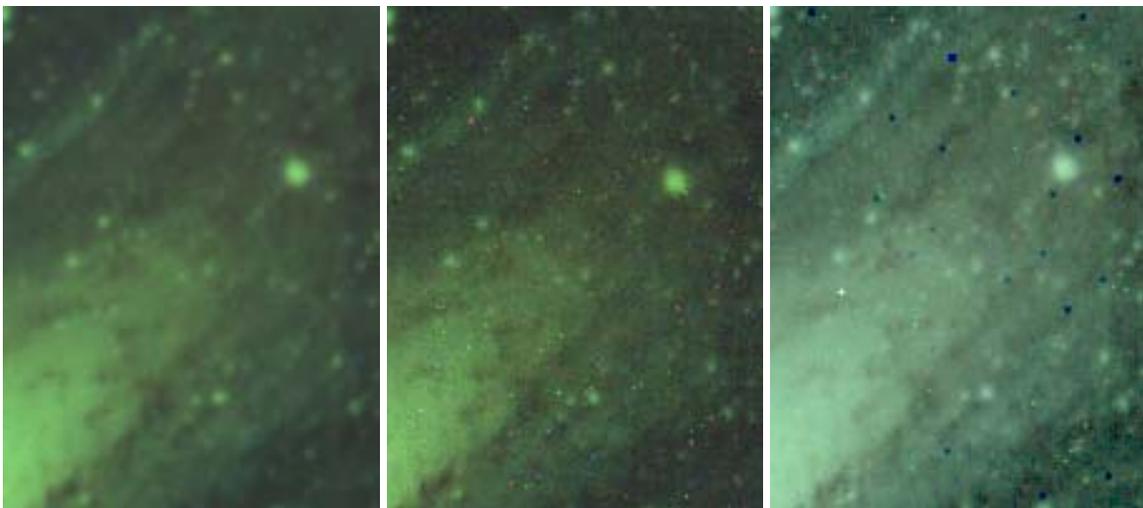


Infinity

Ultrastar

StarVision

Live Stack 10 Frames



Infinity

Ultrastar

StarVision

Figure 8 Crop View of Indoor Test Pattern #4

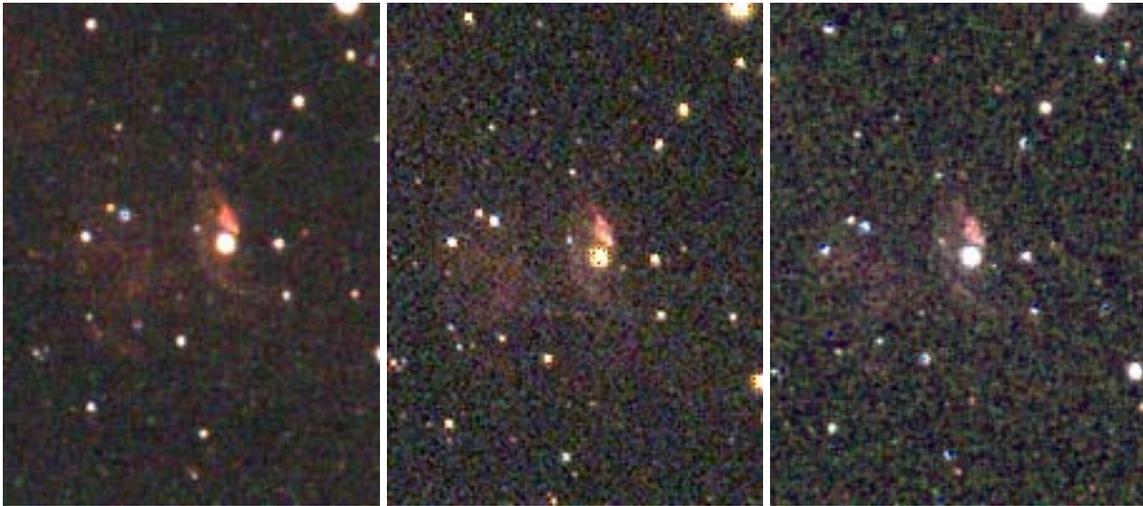
Outdoor Tests (Sep. 19th):

For the outdoor tests I chose two deepsky targets that were well placed high in the sky: NGC7635 Bubble Nebula, and M31 Andromeda Galaxy. All images of the Bubble Nebula were collected using a Meade O-III filter on the FLT98 scope (f/4.2), while the images of M31 were collected with no filter on the ZS66 (f/3.9). My images of M31 were a little flat (lower contrast) due to a nearly full Moon that was starting to rise during my data gathering. I used the dark frame subtraction tools for both the Ultrastar and StarVision cameras. On the StarVision camera GAIN was set to 50x on the Bubble and 12x on M31. The StarVision GAMMA was set to 0.45. The auto white balance setting was used for all three cameras, except with the StarVision on M31 when I forgot to engage it. Because the StarVision software does not yet have the capability to align frames during stacking, I collected both the live stack image as well as the sequence of single frames that generated the live stack, and aligned-stacked them afterwards outside of the StarVision software using Registax 6. The resulting image crops are presented below in Figures 9 and 10.

I observed much the same behavior when looking at live targets outside as I did when observing the test patterns indoors. The Infinity presents the smoothest image of the three cameras, followed by the Ultrastar and then the StarVision. I did notice however that when viewing M31 using the StarVision, because I had to reduce the camera GAIN to 12x (image was saturating), that the noise was much reduced. The resulting stack from the StarVision was very comparable to the other two cameras at the reduced GAIN setting. Note that I did forget to click the auto white balance button on the StarVision when I switched to M31, thus explaining the odd white balance (my fault). As observed indoors, the Ultrastar presented a sharper higher contrast image than the Infinity. I did notice however that on the Ultrastar the brightest stars have an odd pixelated halo (see Figure 11). This halo smooths out a bit with stacking but it is still very evident. There is also a star related artifact when using the StarVision, a horizontal line bleeding from the star, but only on the very brightest of stars (see Figure 12). Hopefully future software or firmware updates can remove these artifacts.

The impact of not being able to align frames during stacking with the StarVision camera is quite evident. The stars are nice and round and have good colour when the frames can be aligned, but not so when frames are not aligned depending on the quality of mount tracking. The star trailing would have been worse at longer focal lengths than what I was using, 414mm and 260mm for the FLT98 and ZS66 respectively. Hopefully this feature is added to the StarVision software soon.

Single Frame



Infinity

Ultrastar

StarVision

Live Stack 10 Frames



Infinity

Ultrastar

StarVision



StarVision Stack 10 Frames in Registax 6

Figure 9 *Crop View of NGC7635*

Single Frame



Infinity

Ultrastar

StarVision

Live Stack 10 Frames



Infinity

Ultrastar

StarVision



StarVision Stack 10 Frames in Registax 6

Figure 10 *Crop View of M31*

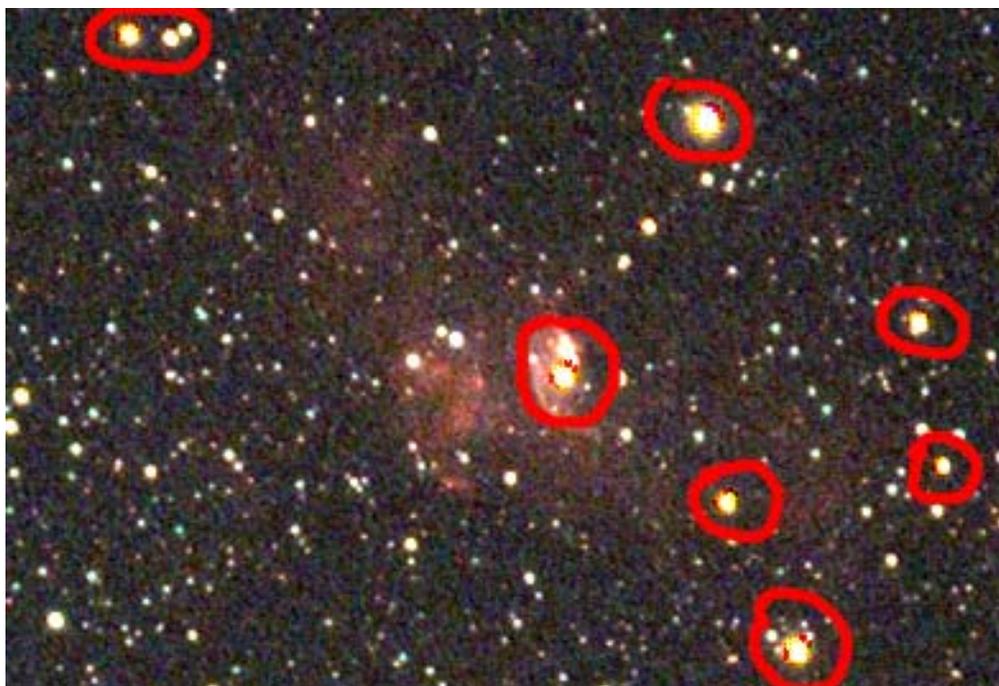


Figure 11 Example of Bright Star Artifacts on Ultrastar



Figure 12 Example of Bright Star Artifact on StarVision

Indoor & Outdoor Re-Test (Oct. 4th):

After I completed my initial tests I shared the results with Rock Mallin at MallinCam. He suggested that I test a second production StarVision camera to confirm that the observed performance was consistent from camera to camera. The timing and weather was good to perform this testing the evening of Oct. 4th. At that point I had already shipped the Infinity C back to its owner, so I was only able to do a side-by-side comparison between the StarVision and Ultrastar. Indoor testing was performed on the same setup as described above. Outdoor testing was performed side-by-side, with the StarVision on my FLT98 reduced to f/4.2 and the Ultrastar on my ZS66 at its native f/5.9. Exposure times with the StarVision were set to 1/2 those of the Ultrastar in order to account for the difference in f-ratio. Both cameras used a Meade O-III filter to deal with my local light pollution. Images captured from this evenings testing have been uploaded to the Flickr album mentioned above.

For all the colour images I captured I found very much the same relative performance between the two cameras as I found in my earlier testing. The Ultrastar was less noisy than the StarVision, with the difference being more apparent the higher I had the GAIN set on the StarVision camera. A new observation occurred however when I switched both cameras into monochrome mode, something I did for the first time this evening. When I did so the noise level on the StarVision dropped dramatically, to the point where it was pretty much the same as the Ultrastar; the StarVision was clearly better when Ultrastar had pixel blend setting off, but the Ultrastar was a little better when pixel blend was on. It would appear that a large part of the noise observed with the StarVision is in the colour channel only. Thus using techniques such as monochrome mode or simply reducing the colour saturation will be effective at improving the image from this camera. Coincidentally I found that a GAIN setting of 50x (out of 100x) on the StarVision produced an image of roughly equivalent relative exposure and noise (monochrome mode) to the Ultrastar. Crops of the images captured during this batch of testing can be found below in Figures 13 to 18. Images are all taken with Ultrastar pixel blend setting off.

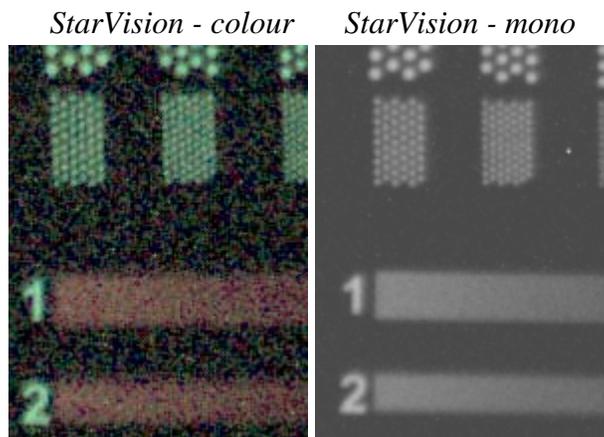


Figure 13 *Crop View #2 of Test Pattern #1 - Single Frames*

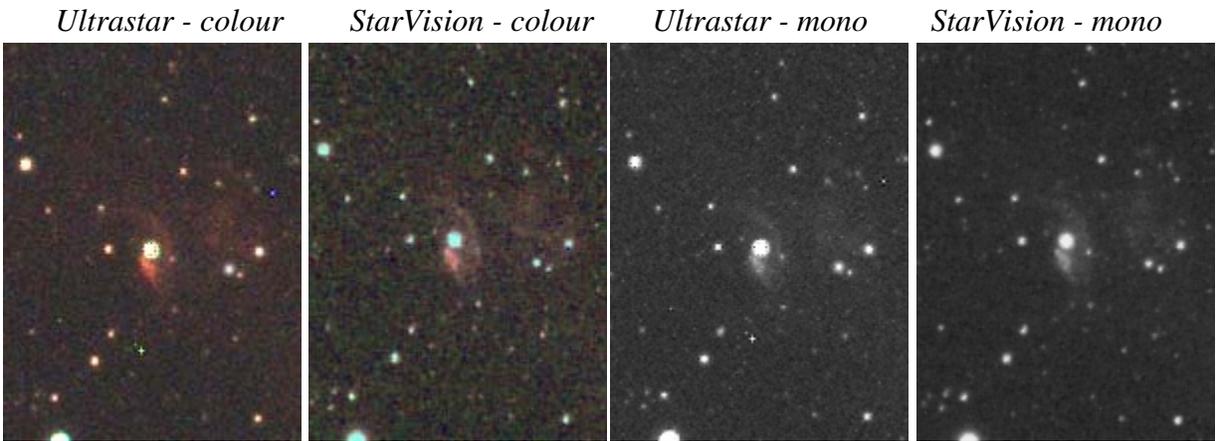


Figure 14 *Crop View #2 of NGC7635 - Single Frames*

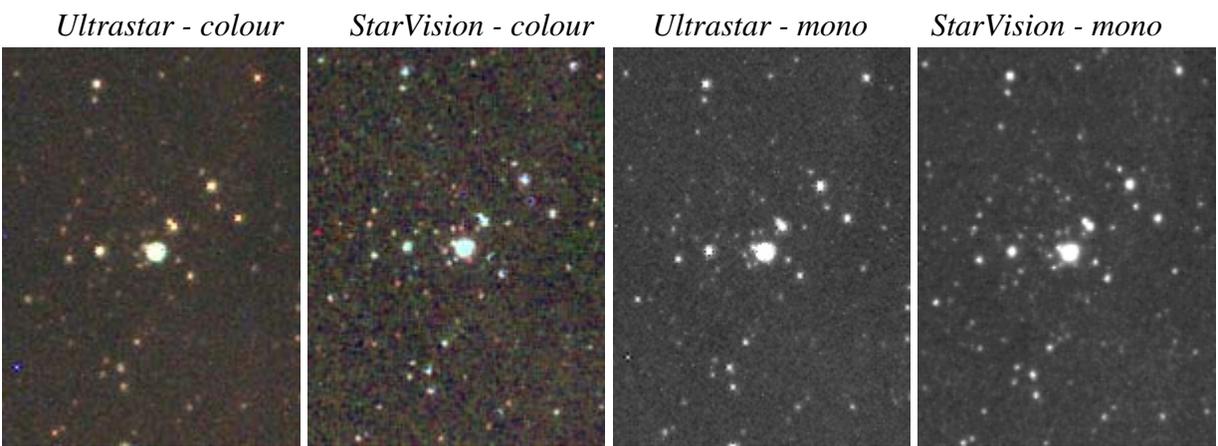


Figure 15 *Crop View of NGC281 - Single Frames*

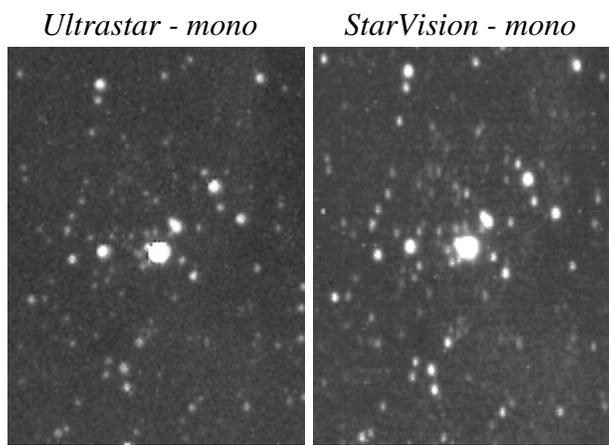


Figure 16 *Crop View of NGC281 - Live Stack 5 Frames*

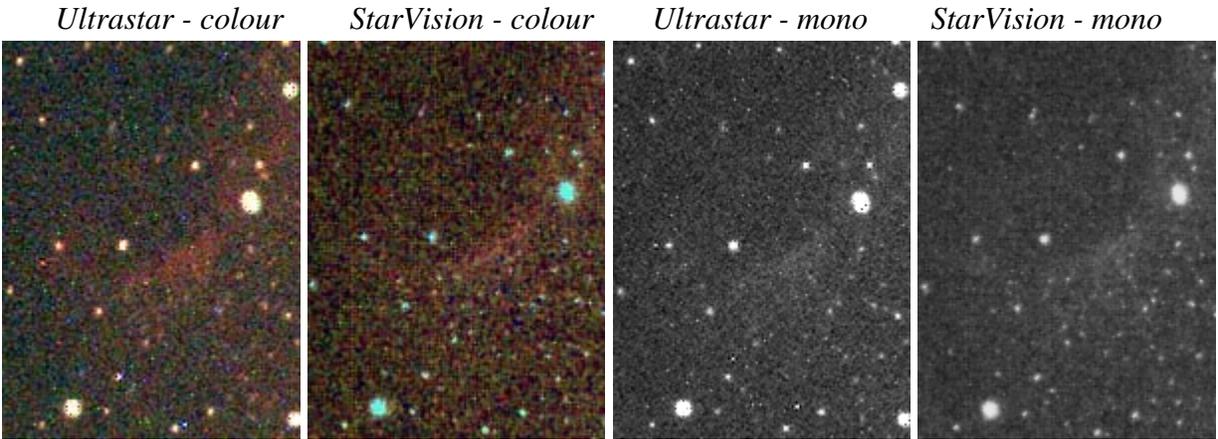


Figure 17 *Crop View of NGC7000 - Single Frames*

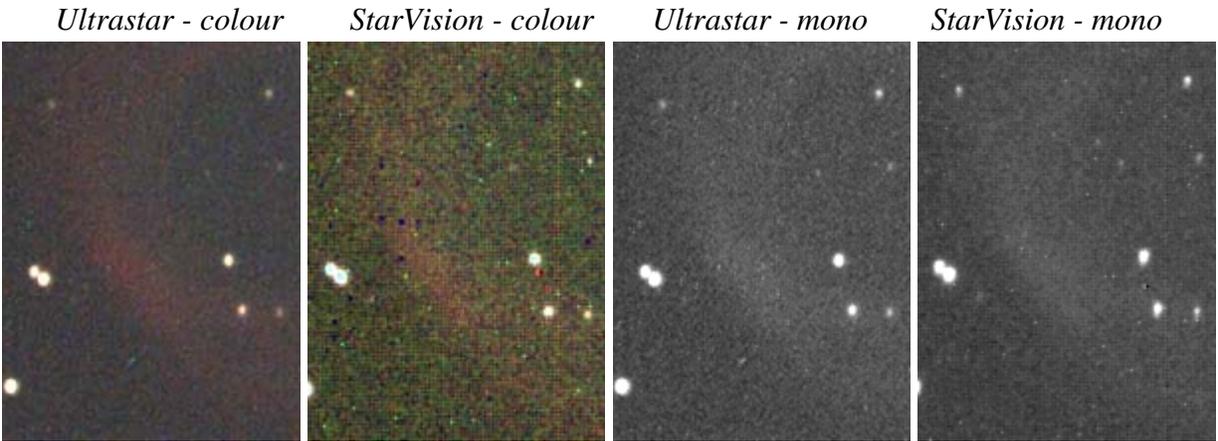


Figure 18 *Crop View of NGC7293 - Live Stack 5 Frames*

Solar System Imaging (Sept. 5th & 24th):

All of the test results presented above have been for longer exposures - deepsky observing. Another important aspect of camera performance is how they would do if they were used on a solar system object such as the Sun, Moon or planets. In this area the StarVision has a distinct advantage over the other two cameras. The StarVision has a much faster frame rate of 15 to 20 fps (depending on your computer) versus the 1 to 2 fps generated by the other two cameras. The StarVision also has a minimum exposure time per frame of 0.04 ms compared with 1 ms for the Infinity and 20 ms for the Ultrastar. There are also tools for noise reduction and sharpening in the StarVision software which make this camera much better suited to solar system observing and imaging than the other two cameras. I tested the camera on a number of solar system targets, including: Sun in CaK, white light and Halpha; and Moon in white light and infrared. The camera worked very well on all of these targets, and I found the monochrome and invert tools along with the noise reduction and sharpening tools to be very effective. Some examples of the type of imaging that can be achieved has also been uploaded to the Flickr album mentioned earlier in this report. Figure 19 is one of the images I have uploaded. My only want would be

for the software to provide an option to record AVI's to an uncompressed video format for later processing.

In my opinion the Infinity and Ultrastar are not usable for solar system observing or imaging. Their refresh rates are simply too slow, and their minimum exposure times are too long requiring extra filters to be added to attenuate the signal so it is not over exposed. The longer exposure times also means that poor seeing conditions are much harder to avoid.



Figure 19 Example of Infrared Lunar Imaging w/ StarVision

Conclusions:

I am very happy to have been given the opportunity to perform this test. Just a handful of months ago I would have said it probably wouldn't of ever happened. My thanks go out to the friends who have generously loaned me their cameras so that I could make this test happen.

To be honest I was surprised by the performance of all three cameras. My opinion going in to the testing was that the ICX825 sensor was too noisy to be used affectively for EAA. I now see that I was wrong. A high quality image can be produced using this sensor, and the addition of live stacking can produce some spectacular views. Each camera has strengths and weaknesses, so much so that I have generated a comparison table: <825 camera comparison_18Sep2016.xlsx>. This table summarizes all the physical features of each camera as well as the features of each camera's software. The highlights of my observations are summarized below:

Infinity:

- Much larger and heavier than other two cameras (had focuser problems);
- Extra cable for 12VDC, uses simple DC jack that allows plug to pull out occasionally;
- Generated the smoothest lowest noise images with the least amount of time and effort;
- In my opinion not usable for Solar, Lunar & Planetary observing/imaging;
- Software easiest to use but at the cost of fewer features. Software also found to be least stable of the three, to the point of being a little annoying.

Ultrastar:

- Very small and lightweight, easiest to use with focal reducers;
- Noisier images than Infinity (more stacking req'd) but image is sharper;
- Odd artifact around brighter stars;
- In my opinion not usable for Solar, Lunar & Planetary observing/imaging;
- More features in software but still relatively easy to use. Very stable software.

StarVision:

- Performance suffers due to lower bit depth (should be 12-bit but operating at 8-bit);
- Lack of star alignment of frames during stacking also limits performance;
- In monochrome mode performance equivalent to Ultrastar or slightly better (N.B. Infinity has no monochrome mode);
- Software is feature rich, making it not as easy to use as other two but still reasonably easy to use. Software also one of the most stable used;
- Very good performance on Solar, Lunar & Planetary observing/imaging;
- This product and its software is not as mature as the other two (released July 2016). A software update fixing the bit depth issue and frame alignment with stacking will make this camera perform even better.

My final recommendation for these three cameras are: pick Infinity if you want very smooth low noise images using software that is extremely simple to use and don't mind the limited features, pick Ultrastar if you want good all round deep-sky performance with useful features and more flexibility, or pick StarVision if you want the most software features and the ability to do solar system objects. I hope my work is useful to the EAA community. If you have any questions, please feel free to contact me at: top-jimmy@rogers.com

Cheers,

Jim Thompson
AbbeyRoadObservatory