COMPARISON OF RUNCAM NIGHT EAGLE CAMERA TO OTHER CCD VIDEO CAMERAS – WAT910HX; PC164C-EX2; AND RUNCAM OWL PLUS

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GENERAL DESCRIPTION OF CAMERA COMAPARISON

RunCam Night Eagle:

Parameters

Model	RunCam Night Eagle
Image Sensor	1/1.8" Black & White CMOS Sensor
Horizontal Resolution	800TVL
Lens	140° F2.0
Signal System	NTSC/PAL Switchable
Synchronization	Internal
OSD Set	Yes
S/N Ration	>50dB
Electronic Shutter Speed	Auto
Min.Illumination	0.00001Lux@1.2F
WDR	Global WDR
Day/Night	Only Black & White
Video Output	CVBS
Power Input	5-17 VDC
Housing Material	Magnesium Alloy
Net Weight	14.5g
Dimensions	26mm * 26mm * 28mm

The RunCam Night Eagle may be purchased here:

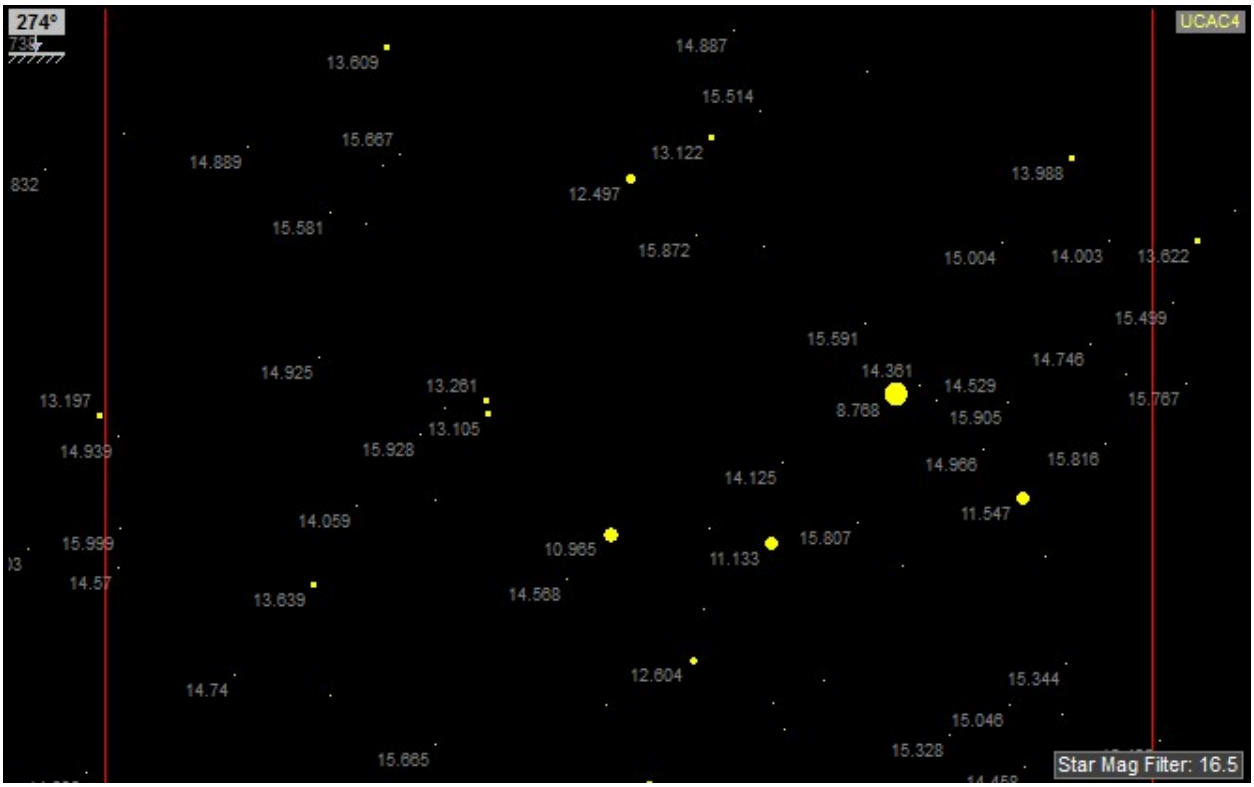
http://shop.runcam.com/runcam-night-eagle/

A separate M12-Cmount adapter is required and may be purchased here:

http://www.ebay.com/itm/like/111696334929?lpid=82&chn=ps&ul_noapp=true

The M12-Cmount adapter then mates to a normal 1-1/4-Cmount adapter which can be purchased on Amazon: Solomark C-mount to 1.25" Adapter Ring - 1.25 Inch Barrel Adapter for Telescope Camcorder and Video Camera

The following target star field was videoed with four different cameras:



The star field is centered at approximately: RA: 01h28m28s Dec: +32°14'25"

The star field was chosen so that it was high in the sky (66 degrees altitude) and contained a variety of stars with varying brightness within the range of the four cameras tested. Stars shown are from the UCAC4 Catalog. Stars down to 16.5 magnitude are shown. Magnitudes of stars with brightness above 16 are labeled.

A 12-inch Meade LX200GPS with f3.3 focal reducer was used as the telescope. Each camera was attached to the telescope with a 1-1/4 eyepiece adapter using either an M12-Cmount adapter or a Cmount adapter.

Note: while the same telescope and focal reducer were used for the video comparisons, the scale size of each camera may be different due to differences in CCD video chip size.

The four cameras used in this comparison are the:

RunCam Night Eagle; WAT910HX; PC164C-EX2; and RunCam Owl Plus

The WAT910HX is considered the higher-cost reference camera. The PC164C-EX2 camera was the low-cost production camera used for multiple site mobile deployments and as the entry level camera for new occultation observers. The PC164C-EX2 is no longer manufactured and a replacement camera is sought for future purchase by new observers. The RunCam OWL Plus was previously reviewed but found to have some deficiencies. The RunCam Night Eagle is the newest most-sensitive camera

available at a price below $100. This report will evaluate the RunCam Night Eagle in comparison to the other three cameras.

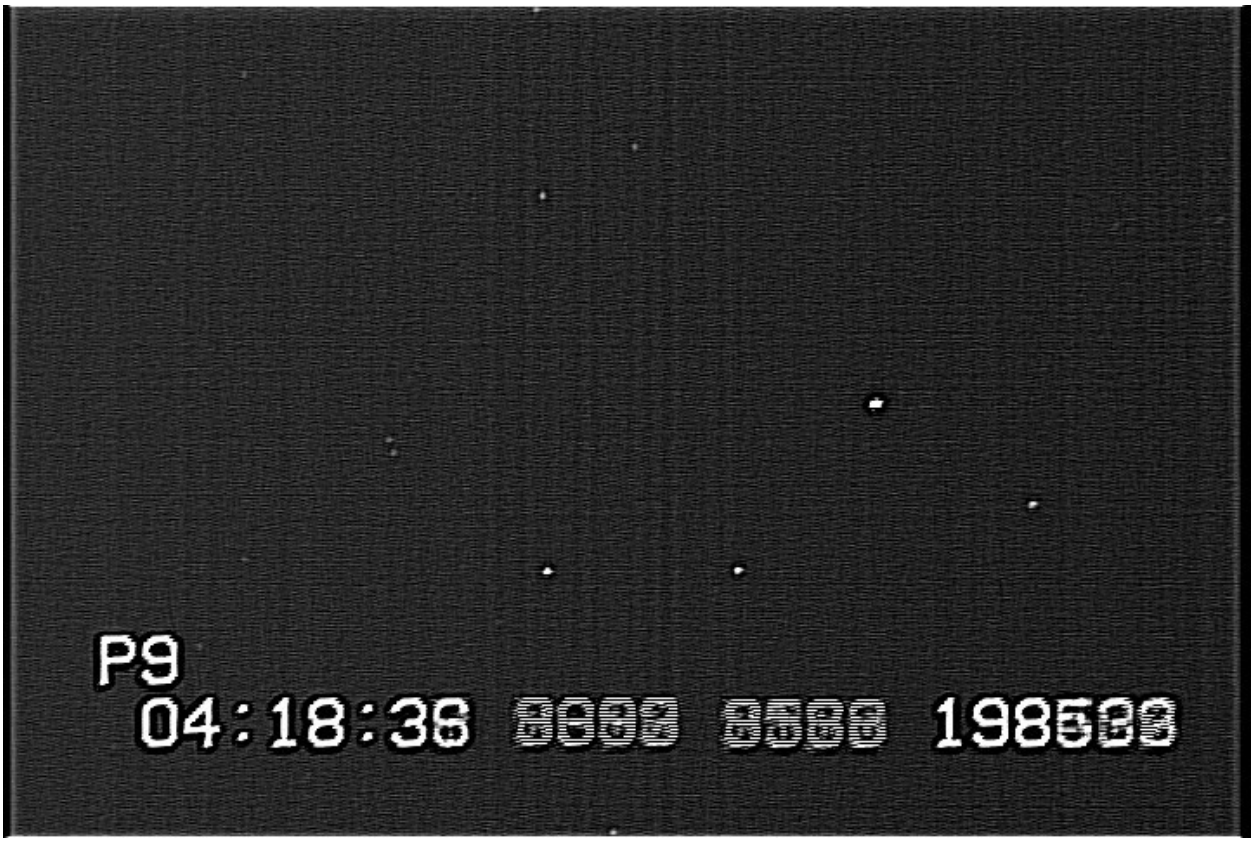
COMPARISON OF REGISTAX STACKED IMAGES

1-minute videos from the four cameras were obtained. 100 frames from each video were stacked in Registax5, image enhanced, and then saved in both a jpeg and bmp file format. Here are the jpeg images from each camera:

WAT910HX

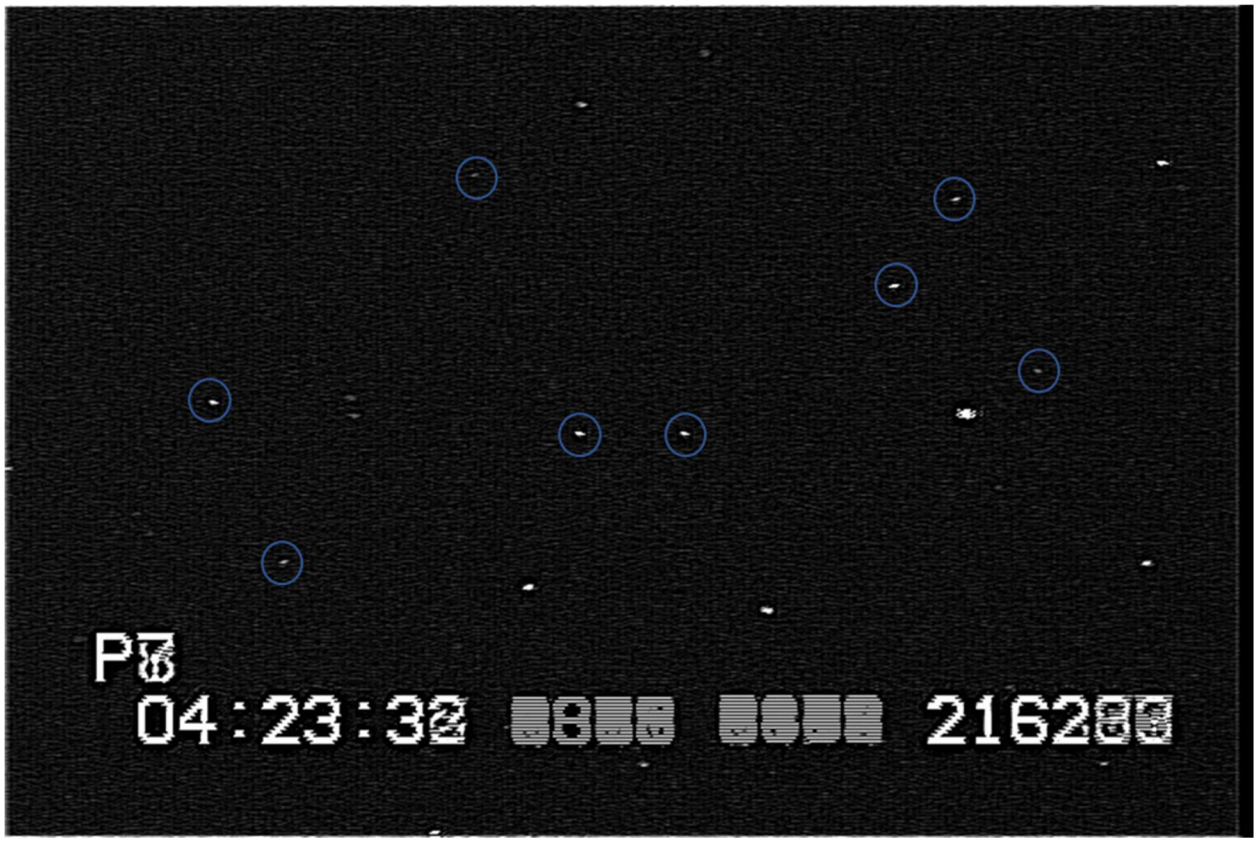
Stars down to 13.6 magnitude are readily apparent. Stars down to 14.0 magnitude are faintly visible. This is the reference image for comparison to the other cameras.

RunCam Night Eagle:



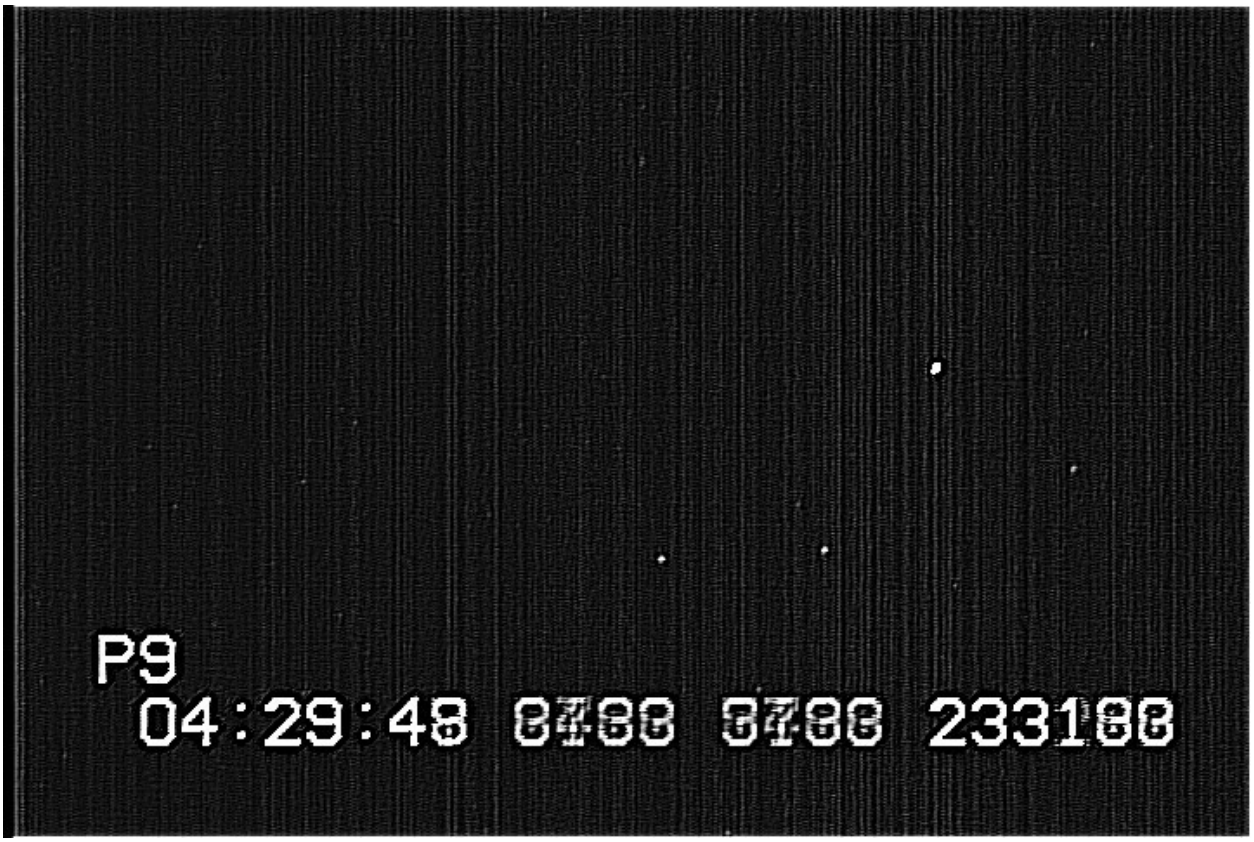
Stars down to 13.6 magnitude are clearly apparent, as is a star at 14.0 magnitude. Stars below 14.0 are faintly visible with one 14.6 magnitude star faintly visible. While there is some background noise, it does not appear to interfere with the overall detection of stars. This camera appears to gain about 0.5 magnitude of sensitivity compared to the WAT910HX, although it is not clear if this magnitude gain will transfer to evaluation of actual light curves. No hot pixels were observed.

PC164C-EX2:



This camera on loan from Ted Blank had a large number of hot pixels (circled in blue). Once these were identified, the sensitivity of the camera could be determined. No stars of 14.0 magnitude or lower are clearly apparent. The background noise appears mottled and can mimic stars.

RunCam OWL Plus:



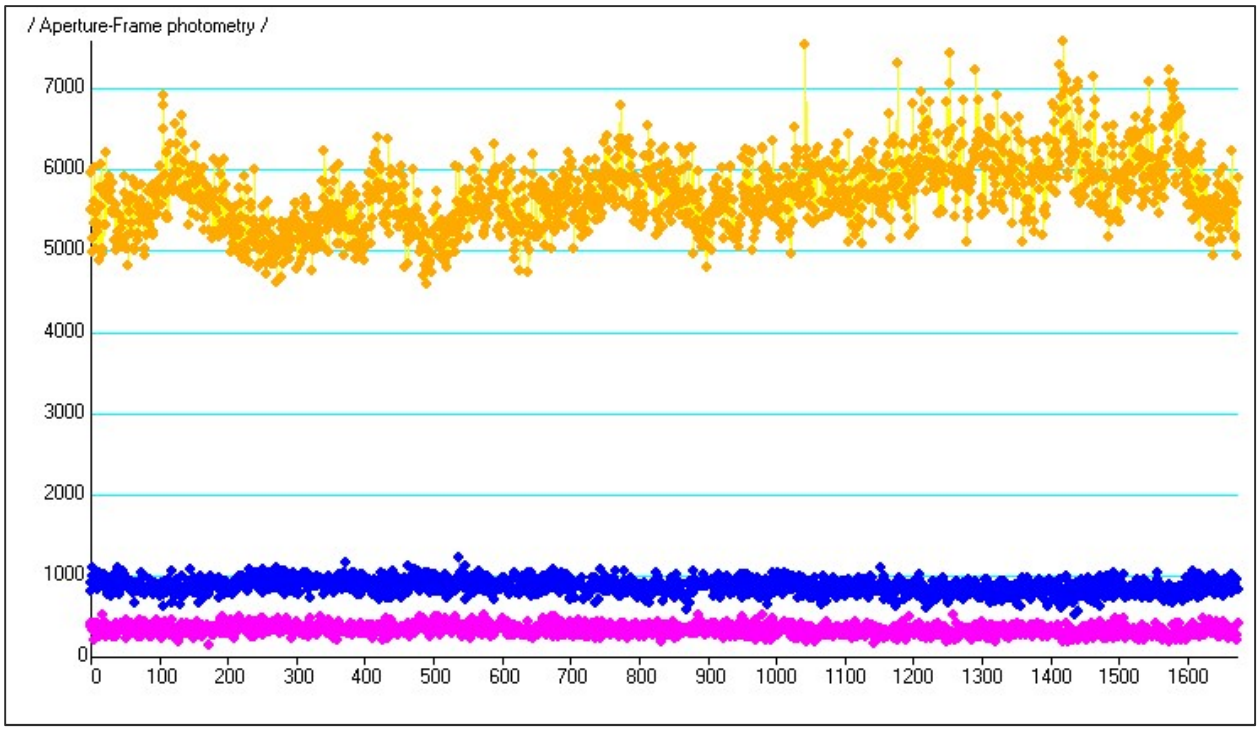
Stars down to 12.5 magnitude are clearly apparent. Stars down to 13.0 are faintly visible. The background noise appears as vertical lines and interferes with the overall detection of stars. As was found when this camera was reviewed previously, it loses about 1 magnitude of sensitivity compared to the WAT910HX.

COMPARISON OF LIMOVIE LIGHT CURVES OF 3 FIELD STARS

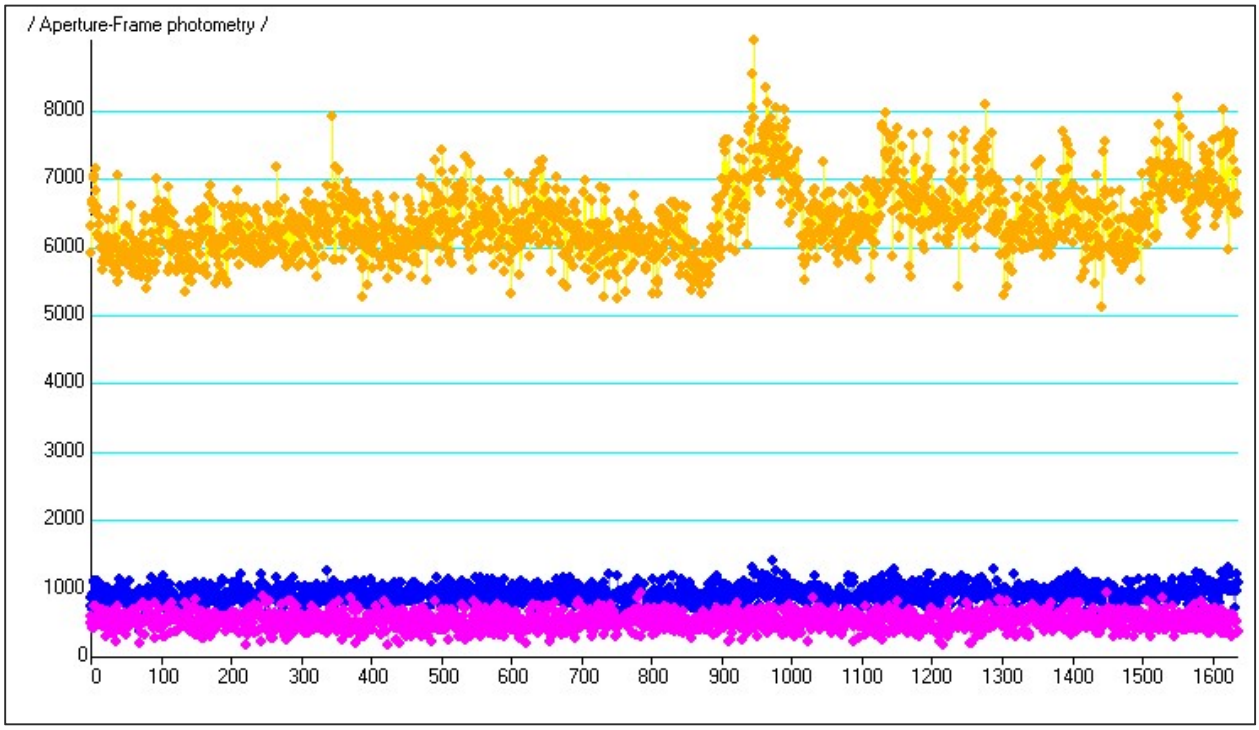
Three field stars were analyzed in each video to determine the quality of their light curves. Here is a field image of the three stars tested in the WAT910HX video:

The same three stars were tested in each video. Here are the light curves:

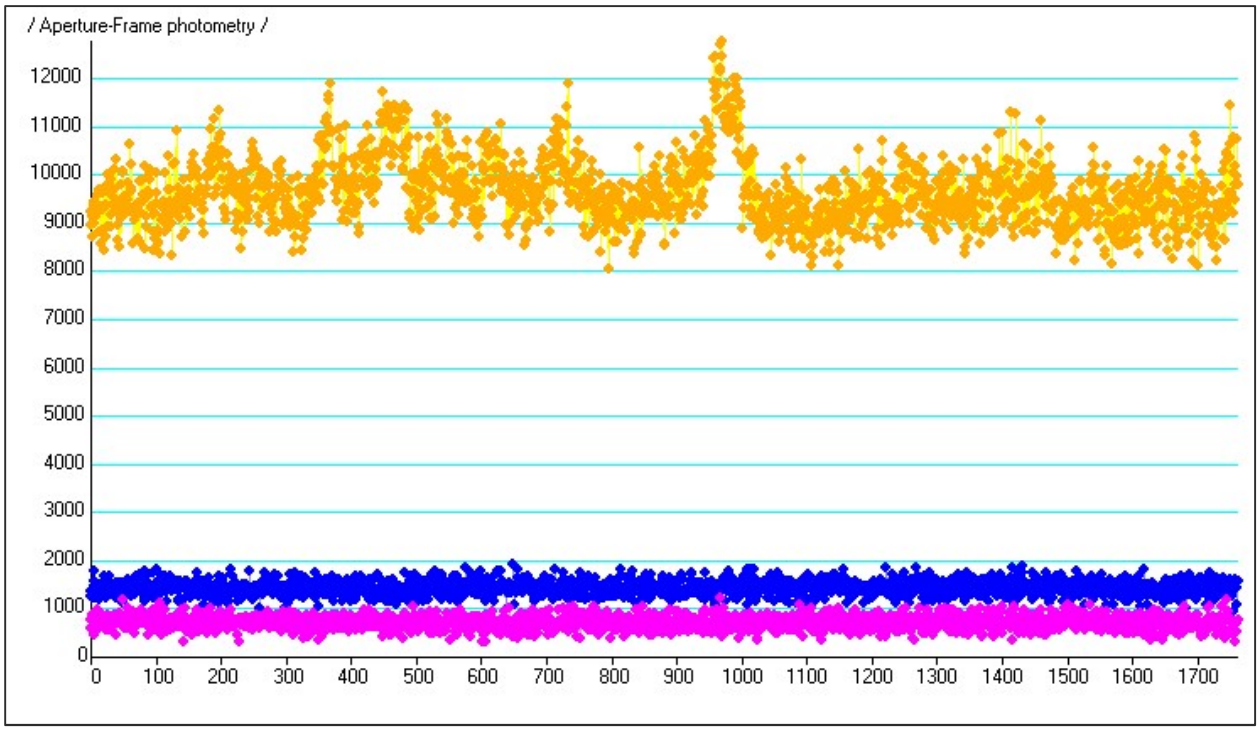
WAT910HX:



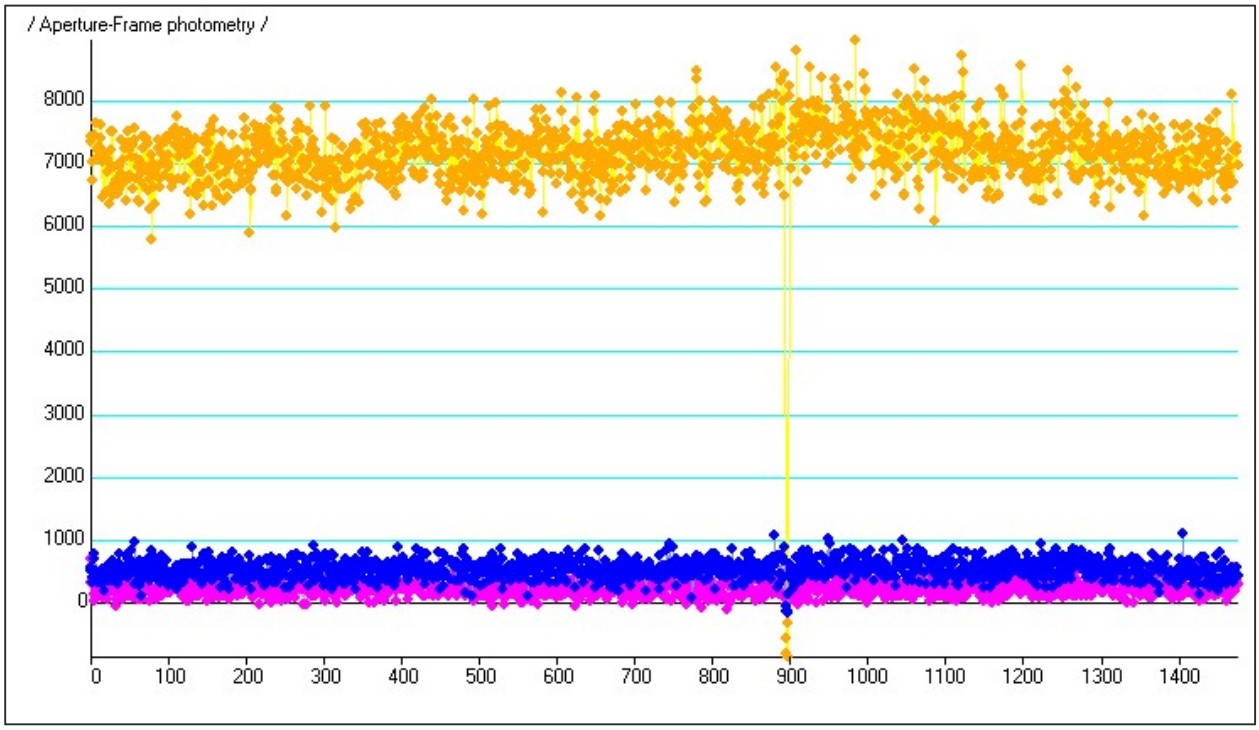
RunCam Night Eagle:



PC164C-EX2:



RunCam OWL Plus:



The blue and magenta traces of each of the above light curves (corresponding to stars of magnitude 10.965 and 11.547 respectively) were analyzed for average intensity level and noise sigma level. Here are the results:

Comparison of CCD Camera Light Curves						
Camera	Baseline Level		Noise Sigma		Measured Magnitude Drop	Measured Minus Actual UCAC4
	10.965 Star	11.547 Star	10.965 Star	11.547 Star		
WAT910HX	869.15	335.83	84.66	57.732	1.03	0.448
RunCam Night Eagle	919.24	516.82	124.94	122.68	0.625	0.043
PC164C-EX2	1434.9	700.75	151.08	134.36	0.778	0.196
RunCam OWL Plus	555.97	236.28	154.29	117.75	0.929	0.347

The WAT910HX is the control camera in the set of comparisons. It has the lowest noise sigma levels of all four cameras tested, almost lower by 1/2. The RunCam Night Eagle performs well in this comparison. It has baseline measured intensities comparable to the WAT910HX and noise sigma levels that are lower than both the PC164C-EX2 and the RunCam OWL Plus. The RunCam Night Eagle measured magnitude drop was closest to the actual UCAC4 magnitude drop, however, this may just be a coincidence, since other star catalogs produce different actual magnitude drops, some lower and some higher. The key learning here is that the RunCam Night Eagle photometry appears to be at least as good as the PC164C-EX2 that it would be commissioned to replace.

COMPARISON OF CAMERA IMAGE SCALES

Each video field was examined to determine the image scale of the camera on the Meade LX200GPS with f3.3 focal reducer. The distance between two stars was measured in arc seconds of sky distance. This distance was then scaled to the image distance and the scale factor computed. The results are shown below:

Comparison of CCD Camera Scale Factors			
		Image Scale	
Camera	Plate Scale between stars	Arc Seconds	Arc Minutes
WAT910HX	13	948	15.8
RunCam Night Eagle	14	881	14.7
PC164C-EX2	17.5	705	11.7
RunCam OWL Plus	12	1028	17.1

The RunCam Night Eagle has a field scale of 14.7 arcminutes edge-to-edge – very close to the WAT910HX. The RunCam OWL Plus has the largest field scale at 17.1 arcminutes edge-to-edge. The PC164C-EX2 has the smallest field scale at 11.7 arcminutes edge-to-edge.

ESTIMATION OF CAMERA LIMITING MAGNITUDES VS. TELESCOPE APERTURE

The use of the RunCam Night Eagle as an occultation video camera requires that the target star magnitude when merged with the asteroid magnitude exceeds the limiting magnitude of the camera/telescope combination used. The limiting magnitude of a 12-inch LX200GPS telescope with an f3.3 focal reducer was determined to be approximately 13.0 [this would be the magnitude for an event where the star virtually disappears when occulted by a very faint asteroid].

So new observers can estimate whether or not their equipment can be used with the RunCam Night Eagle for an event, a table of limiting magnitude verses telescope aperture was calculate from the limiting magnitude of 13.0 measure for an 12-inch LX200GPS telescope. Here are the results:

Estimate of Camera Limiting Magnitude vs. Telescope Aperture
Camera: RunCam Night Eagle
Limiting Magnitude for 12-Inch LX200GPS w/ f3.3 focal reducer = 13.0

Telescope Aperture assuming f3.3 (inches)	Limiting Magnitude
12	13.0
10	12.6
8	12.1
6	11.5
4	10.6
2	9.2

GENERAL OBSERVATIONS AND CONCLUSIONS

The RunCam Night Eagle has been tested in comparison to three other cameras. It has proved to be an acceptable replacement camera to the PC164C-EX2. At a cost of US$79.99 it is affordable for new occultation astronomy observers as well as for mobile deployment systems.

The RunCam Night Eagle is very light weight, so could easily be used with Dobson mount systems. The titanium case is lightproof, an improvement over the RunCam OWL Plus that had a translucent plastic case. The NTSC video output produces unique images for each field. This is an improvement over the RunCam OWL Plus which duplicated fields in each frame. The OSD menu display is easy to use with the provided single-button dongle.

The RunCam Night Eagle uses a CMOS CCD video chip. This camera configuration uses a rolling shutter. With the rolling shutter, each horizontal line in the video field is recorded sequentially, one at a time, at the rate of the number of horizontal field scan lines divided by the NTSC (or PAL) field rate of 1.001/60. When a brightness change in a star is noted by the chip depends on where on the chip the star is located. Stars near the upper left corner of the chip will be scanned sooner than a star in the lower right corner of the chip. The effect of the position of the star on the timing of the event can be

compensated for based on the location of the star on the chip. The effects of the rolling shutter are described in a paper by Bob Anderson.[i]

The camera can accept DC power supply between 5V and 17V. The camera testing in this report was powered at 12V DC. Any voltage greater than the minimum 5V requires the camera chip to dispose of unused energy as waste heat. At 12V the camera operated quite hot, but the heat was readily dissipated by the titanium case.

The image scale is similar to the WAT910HX, so would be superior to the PC164C-EX2 when used for drift scan observations (telescope is fixed and sky drifts through the field as the event is recorded).

The RunCam Night Eagle was used on a Meade LX200GPS with an f3.3 focal reducer. The same camera could be used on other telescopes with other types of barrel focal reducers used in place of the 1-1/4-Cmount adapter. These focal reducers must be tested by the user on their specific telescope to determine if focus can be achieved. It is anticipated that further testing will be performed by both Ted Blank and David Dunham on fixed focus Might-Mini and Mighty-Midi type refractor telescopes coupled with OWL fo.5 focal reducers.

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[i] ArtStar test results for: RunCam Owl Plus, Bob Anderson September 22 2016 IOTAoccultations
https://groups.yahoo.com/neo/groups/IOTAoccultations/files/Light-curve-analysis-papers/RunCamOwlPlus-report.pdf