RUNCAM NIGHT EAGLE ASTRO EDITION (OLD) CAMERA
RUNCAM NIGHT EAGLE 2 PRO ASTRO EDITION (NEW) CAMERA
CAMERA REVIEW, OPERATING GUIDLINES AND COMMENTS
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INTRODUCTION

This paper documents camera review data, operating guidelines and other comments for the original Night Eagle Astro Edition camera as well as the newer version Night Eagle 2 Pro Astro Edition. Both cameras were developed in a joint program between RunCam and IOTA. While the older Night Eagle Astro Edition is no longer available for purchase, the Operating Guidelines and Comments are still valid and presented here for those who own those cameras. Where there is new data, Operating Guidelines and Comments specific to the newer edition Night Eagle 2 Pro Astro Edition, these new sections are labeled, or notations added.

GENERAL DESCRIPTION OF CAMERA

RunCam Night Eagle Astro Edition:

[Note: Night Eagle Astro Edition is no longer available]

RunCam Night Eagle 2 Pro (IOTA) Astro Edition

[Note: 'Astro Edition' is not stenciled on the back plate of the Night Eagle Pro 2 at the factory. Look for 'IOTA Astro Edition' notations provided by IOTA reseller. Only cameras with the 'IOTA Astro Edition' stickers will have the special 'Astro Edition' firmware installed.

Parameters

Model	RunCam Night Eagle 2 PRO
Image Sensor	1/1.8" CMOS Sensor
Horizontal Resolution	800TVL
Lens	FOV 140 2.5mm
Screen Format	4:3
Signal System	NTSC / PAL Switchable on OSD menu
Integrated OSD	Yes
Integrated MIC	Yes
S/N Ratio	>50dB
Electronic Shutter Speed	NS1(2x), NS2(4x), NS3(8x)
Max Gain	1-9
Min. Illumination	0.00001Lux@1.2F
WDR	Global WDR
Day/Night	Only Black & White
Power	DC 5-36V
Working Current	12V@90mA / 5V@200mA
Housing Material	ABS
Net Weight	15g
Dimensions	L28mm*W26mm*H27mm

The RunCam Night Eagle 2 Pro Astro Edition may be purchased here:

http://occultations.org/test-night-eagle-ordering-page/

The Night Eagle 2 Pro camera comes with a wide-angle lens, a mounting bracket system, cables (RCA power and VGA), as well as a Dongle for operating the OSD Menu.

A separate M12-Cmount adapter is required to attach the camera to a telescope. The M12-Cmount adapter then mates to other adapters as needed for your specific telescope and focal reducer system. The M12-Cmount adapter, focal reducer, and adapter rings are sold as part of a package, if desired. To order the basic camera, or one of the optional packages, as well as details on how to set up your Night Eagle Astro Edition for your specific telescope system, see the above webpage link.

MENUS

Here is the Night Eagle Astro Edition and Night Eagle 2 Pro Astro Edition starting menu when you press the Dongle Button:
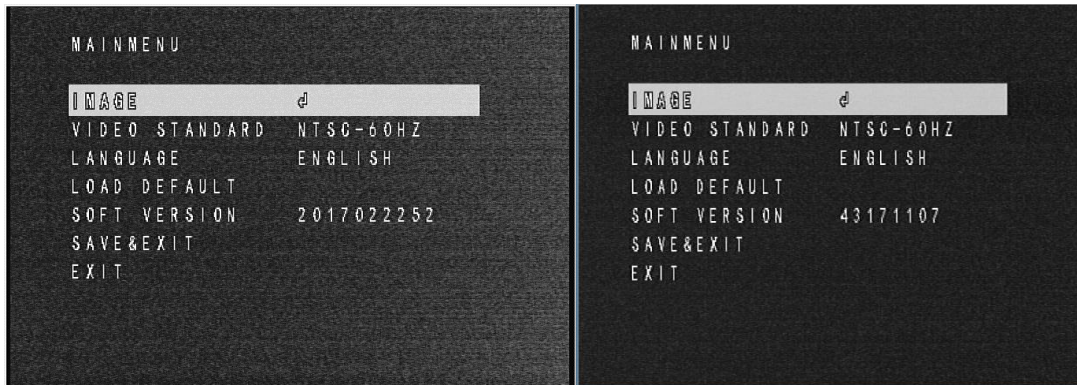
The menus are exactly the same, except for the firmware version number, which was changed on the Night Eagle 2 Pro camera.

The 'IMAGE' menu is the most important in this camera and will be discussed specifically below.

The 'VIDEO STANDARD' menu is only set once to the video standard used in the country in which the observer resides, although either setting can be used if preferred by the user. For USA and Japan, use NTSC – 60 HZ. For Australia and Europe, use PAL – 50 HZ. For other countries, use the setting best for your area, considering what other observers around you are using. If you have the choice to use either, such as those using a StarTech or similar capture device that can accept either NTSC or PAL, you may want to use PAL, as it is more sensitive, since it integrates slightly longer than NTSC.

The 'LANGUAGE' menu is only set once. At the time of this manual, only two options are available – Chinese/or/Japanese? and English.

The 'LOAD DEFAULT' menu reloads the factor 'DEFAULT' settings into the camera.

The 'SAVE & EXIT' menu is self describing. Once you have settings you want saved you can save them by pressing the button on this menu. The setting will be the same when the camera is restarted, until you press the 'LOAD DEFAULT' button.

The 'EXIT' button exits the menu. Changes made in the menu selections will be saved for the current session but lost when powered off. For permanent changes, use SAVE and EXIT.

'IMAGE' MENU

The 'IMAGE' menu is the same for both cameras. Here is the menu when you press the 'IMAGE' menu:

The Menu item recommended settings are summarized below:

SETTING		The DEFAULT setting is for:		The RECOMMENDED setting is:	
MAX GAIN	=>	9		9 (for occultations) lower settings as needed to avoid saturation if defocusing is not desirable	
NIGHT SHUTTER	=>	1		Minimum needed to show target star without saturation	
WDR	=>	ON		OFF	
IMAGE ENHANCE	=>	SHARPNESS:			
		DETAIL: AUTO		AUTO	
		EDGE: AUTO		AUTO	
		SATURATION: AUTO		AUTO	
MIRROR	=>	OFF		OFF (unless image reversal is needed for a Dobson or mirror diagonal)	
BRIGHTNESS	=>	36		250	
ZOOM IN	=>	0		0 or AS NEEDED	

Individual observer preferences/needs may be different between observers and their specific equipment. The author has adapted the above settings for use with a 12-inch Meade LX200GPS

telescope fitted with an f3.3 focal reducer. Other telescopes and focal reduction may require different settings. It should be noted that while Night Shutter Settings greater than 1 will extend the range of faint stars visible, they will also reduce the time resolution of the Disappearance and Reappearance timings, so use the lowest Night Shutter setting that still shows the target star without large brightness dropouts due to scintillations. Be sure and record which Night Shutter setting is used in your report.

CAMERA SHUTTER, SHUTTER SPEED, AND CAMERA DELAY CORRECTIONS

Both the RunCam Night Eagle Astro and Night Eagle 2 Pro use a CMOS CCD video chip with 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 the star is located on the chip. 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 papers by Bob Anderson[1]. As noted in my previous report, the timing of an event must be adjusted based on the position of the target object on the screen.[2]

The overall shutter speed for this camera is 1/29.97 second per frame (NTSC) or 1/25 second per frame (PAL). This shutter speed is 'automatic'. That is, we expect that the exposure can be reduced as needed by the camera to balance the exposure. This automatic feature might cause our users of standard NTSC (or PAL) CCD cameras to worry that vital temporal information could be lost. Fortunately, with a rolling shutter, each scan line in each field of the video is timed sequentially and read out to the recorder sequentially, regardless of the duration of the exposure for each scan line. The resulting image is therefore unlike a normal CCD video where all scan lines in the field are recorded simultaneously, and if there is a shorter than normal NTSC (or PAL) exposure, part of the event timing can be lost, or if the event is short enough, it can be missed while the shutter is not open. With the rolling shutter used in the CMOS CDD of the RunCam Night Eagle Astro Edition, this cannot occur. Objects in the upper left corner of a frame will be observed and timed sooner than objects on the lower right corner of the frame. Of course, if a significant change in brightness occurs after the star was scanned by the rolling shutter, then it won't be detected until the start of the next field scan for that star location on the chip.

Bob Anderson created a series of camera delay corrections for the rolling shutter. These corrections are designed around the use of the Night Shutter settings provided with the camera. Night Shutter provides integration at the NS1 (2x), NS2 (4x), and NS3 (8x) rates for both PAL and NTSC. The camera delay with the rolling shutter is different for each Night Shutter setting. In order to get the correct camera delay for a specific setting, the video must be analyzed in 'Field' mode and the .csv file then analyzed by integrating the fields into frames. This can be done with various light curve analysis programs such as Occular, R-OTE or AOTA.

Here are the correction equations for both PAL and NTSC:

PAL		
NS1 Correction ->	$=(\ 74.24+(-0.063143 * Y\text{-}POSITION)) * 0.001$	
NS2 Correction ->	$=(114.12+(-0.062652 * Y\text{-}POSITION)) * 0.001$	
NS3 Correction ->	$=(194.94+(-0.062463 * Y\text{-}POSITION)) * 0.001$	
NTSC		
NS1 Correction ->	$=(\ 69.03+(-0.066744 * Y\text{-}POSITION)) * 0.001$	
NS2 Correction ->	$=(102.68+(-0.067282 * Y\text{-}POSITION)) * 0.001$	
NS3 Correction ->	$=(169.24+(-0.066563 * Y\text{-}POSITION)) * 0.001$	

Where Y-position is the Y pixel coordinate of the star position on the video image as measured by Limovie or Tangra – zero at top of image, max at bottom of image. These corrections incorporate both the camera delay due to the rolling shutter and camera delay due to the lag in the output of the video from the camera. The only place where you will find these corrections automated for your convenience is in the IOTA Excel Report Spreadsheet (available through OccultWatcher or IOTA North America Web Page).

http://www.asteroidoccultation.com/observations/Forms/AsteroidReportForms.html

The spreadsheet is the only reporting system in IOTA that supports the RunCam Night Eagle Astro Edition (and Night Eagle 2 Pro when you use the Night Eagle camera designation) with automated camera delay corrections. We expect this form will be incorporated into OccultWatcher.

AUTOMATIC GAIN CONTROL

The RunCam Night Eagle Astro Edition and the Night Eagle 2 Pro Astro Edition both have automatic gain control, with 9 Gain settings to control the max Gain used by the AGC. There is no manual gain setting for this camera. In normal asteroidal occultation astronomy, the camera will most likely set the gain to the maximum allowed by each Gain setting, however, if bright objects such as the moon are in the field of view, the automatic gain control can take over and change (reduce) the overall gain of the video to an equivalent lower gain setting. This behavior is similar to the PC164C-EX2 camera when operating in EI mode. Since the RunCam Eagle is expected to replace the PC164C-EX2 camera, there is no overall change in camera response due to AGC when using this camera. The 9 existing Gain control settings will allow the user to suppress the brightness of saturated stars, if desired, or the brightness or solar system objects such as Venus and Jupiter. Brightness setting changes may also be necessary to get the proper overall setting to view the object as desired.
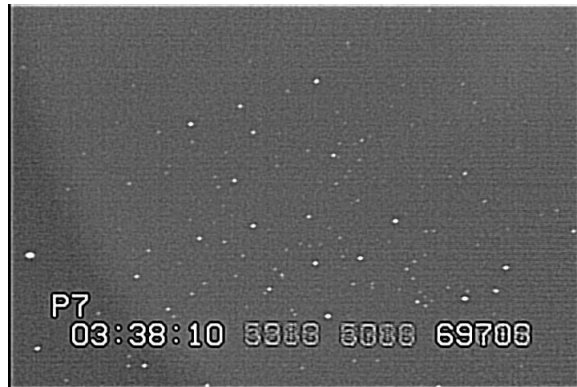
WDR (WIDE DYNAMIC RANGE)

WDR – the menu has two settings – ON and OFF. ON has the effect of adding Gamma to the image, that is, enhancing low intensity light and reducing high intensity light. We recommend that the setting most conducive to the best visibility of the target star be used if photometry is not a factor, such as

when a simple occultation is expected. If photometry is a factor, use OFF, which should make the photometry of small mag drops or double stars more precise.
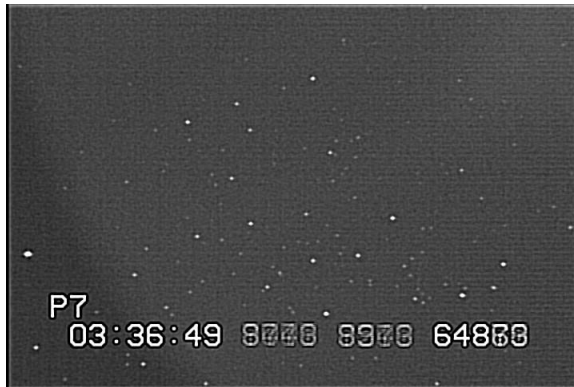
Night Eagle Astro – WDR OFF   Night Eagle Astro – WDR ON
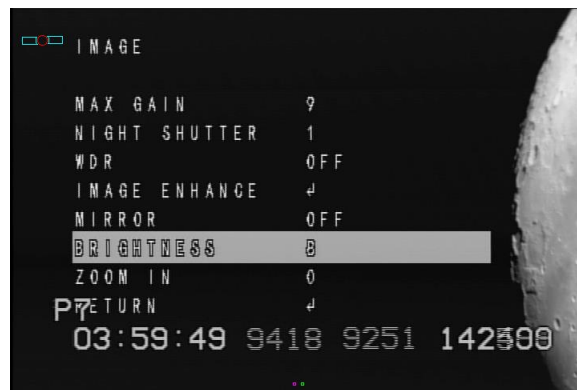
MIRROR

Mirror has two settings: ON and OFF. OFF is normal view. ON, the image is reverse mirrored.

BRIGHTNESS CONTROL

The Brightness setting was tested for use in lunar occultations. Here are two samples:

Brightness set to 250, brightest areas of the image are saturated. However, fainter stars may be seen approaching the moon at the expense of lunar surface detail.

Brightness set to 8, now the glare and saturated areas are gone and the lunar detail is visible. However, only brighter stars will be seen approaching the lunar limb.

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Observers of lunar occultations will have to find the best balance of Brightness setting to use for the brightness of the moon's limb and the brightness of the approaching star.

ZOOM IN

A feature available on both the Night Eagle and Night Eagle 2 Pro cameras that may be of use and interest to asteroidal occultation astronomers is the 'ZOOM IN' menu. Here two examples of a normal view taken at ZOOM IN = 0, one of an office view, the other of M67 star field:

Now, with the camera in the same position and/or subject matter, with ZOOM IN at the max value of 5, here is a new full-frame image:
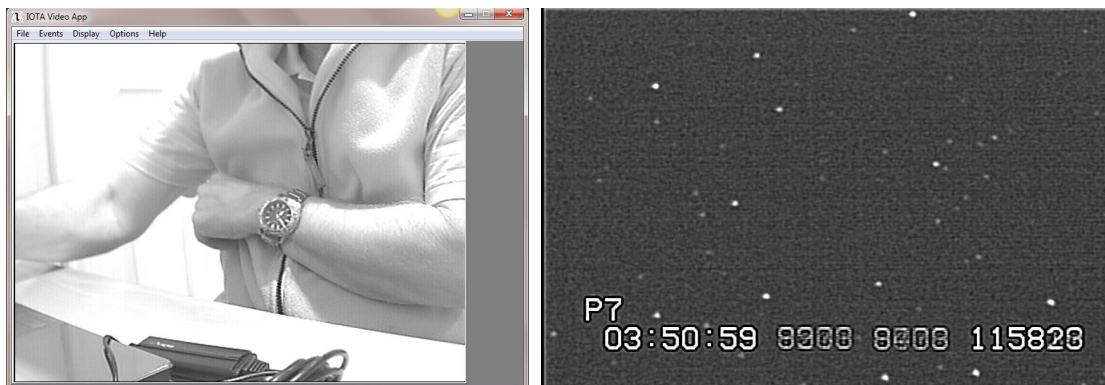

Notice the enlargement of the watch face and the similar star field from M67. The ZOOM IN feature might prove useful when focusing or if the star field is very dense and the separation of stars within the field is desired. ZOOM IN only magnifies the field of view, the pixels are blown up to a larger size on screen. What is seen on screen is what is recorded on the video. It is OK to use the zoomed video format in recording an occultation, such as for a lunar occultation to reduce glare, but if you do so, make that notation in your report.

COMPARISON OF REGISTAX STACKED IMAGES TO UCAC4 CATALOG MAGNITUDES

The UCAC4 star catalog was used to determine the limiting magnitude of the RunCam Night Eagle Astro Edition camera. A 10-second video was recorded. From the video, 100 frames were selected and stacked in Registax5, image enhanced, and then saved in jpeg file format. Here is the comparison star catalog image and stacked jpeg image:
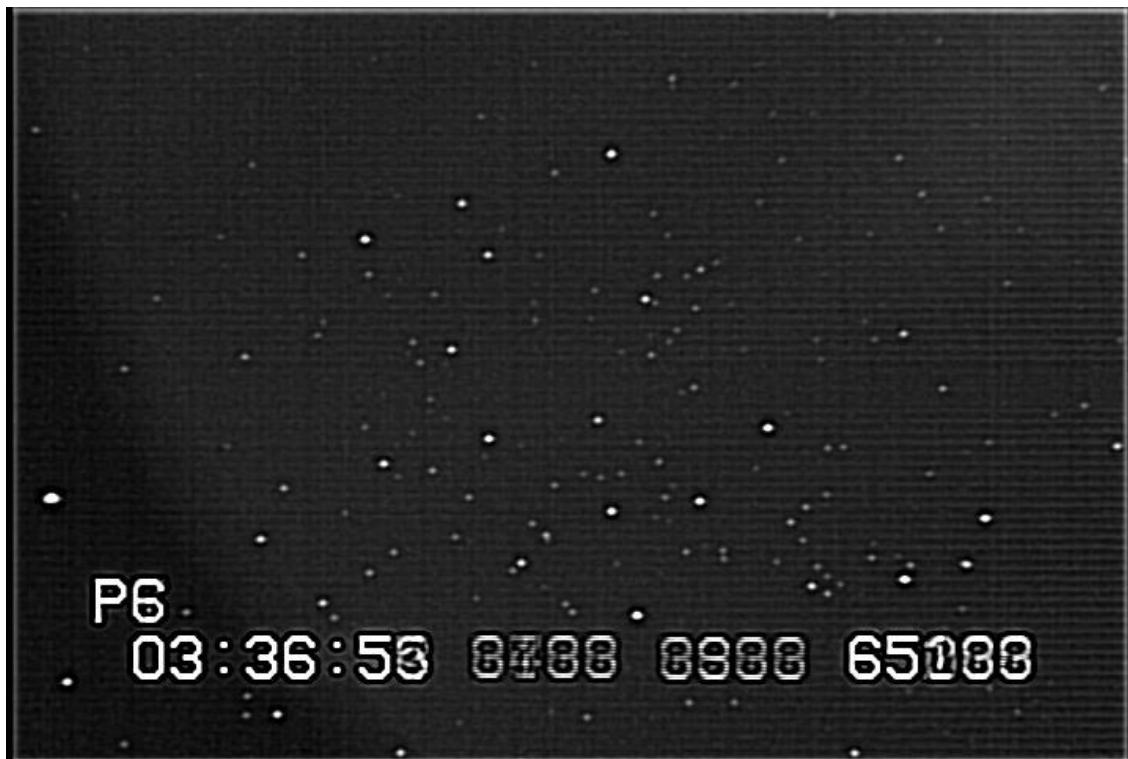
M67 Star Field UCAC4 Catalog
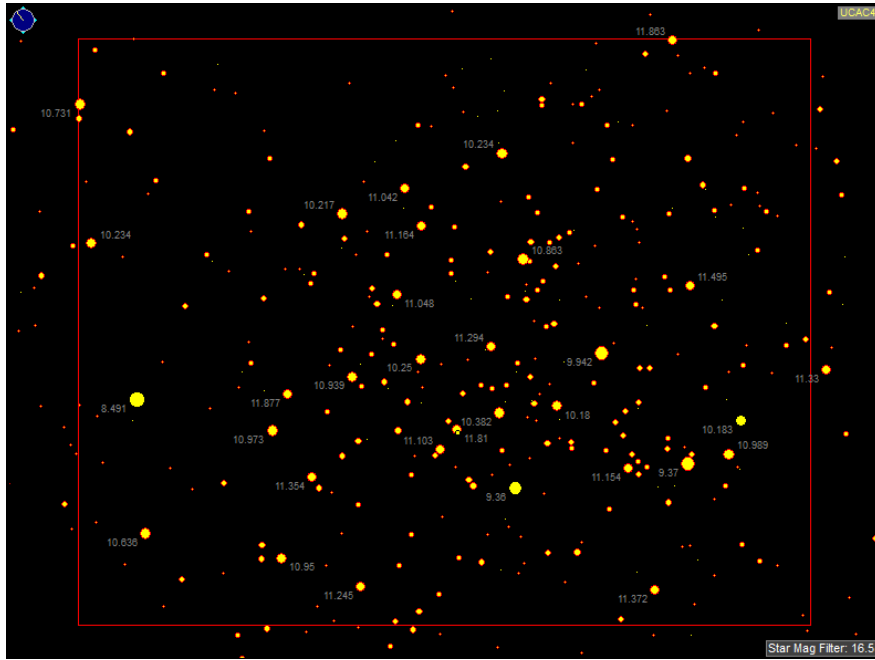
In the above catalog star chart, stars down to 14th magnitude are readily apparent as small dots without magnitude labels.

RunCam Night Eagle 100-frame stacked image:

Stars down to 13.8 magnitude are clearly apparent, as are many stars at 14.0 magnitude. Stars below 14.0 are visible with one 14.8 magnitude star visible. While there is some background noise, it does not appear to interfere with the overall detection of stars. There is an overall horizontal raster pattern in the image. These can be due to two items:

1. a slightly brighter background on the right side of the screen (presumably a glow caused by an amplifier or heat source)
2. a differential in the gain characteristics of field scan lines

This camera appears to gain about 0.5 magnitude of sensitivity compared to the WAT910HX at 1.0 Gamma and no integration, although it is not clear if this magnitude gain will transfer to evaluation of actual light curves. No hot pixels were observed.

The above results were obtained with the Night Eagle Astro Edition. The Night Eagle 2 Pro Astro Edition is about 0.5 magnitudes more sensitive.

[Note: a 100-frame stacked image was used to determine limiting magnitude as this was determined, based on the experience of the author, to accurately represent actual occultations that could be detected in videos, even when the star is not clearly visible on-screen with the video running.]

RUNCAM NIGHT EAGLE ASTRO EDITION CAMERA IMAGE SCALE

An NTSC 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 compared to other cameras:

RunCam Night Eagle Astro Edition Camera Scale Factor Determination			
		Image Scale	
Camera	Plate Scale between stars	Arc Seconds	Arc Minutes
WAT910HX	13	948	15.8
RunCam Night Eagle Astro Edition	14	881	14.7
PC164C-EX2	17.5	705	11.7
RunCam OWL Plus	12	1028	17.1

The RunCam Night Eagle Astro Edition has a field scale of 14.7 arcminutes edge-to-edge – very close to the WAT910HX. The field scale of your specific telescope and imaging system may be different from those shown above, but the relative difference in size between the various cameras and the Night Eagle Astro Edition will be the same.

ESTIMATION OF CAMERA LIMITING MAGNITUDE VS. TELESCOPE APERTURE FOR DIFFERENT NIGHT SHUTTER SETTINGS

The use of a video camera for occultation astronomy requires that the target star magnitude, when merged with the asteroid magnitude, is brighter than the limiting magnitude of the camera/telescope

combination used. The limiting magnitude of the Night Eagle Astro Edition at NS1 when placed on a 12-inch LX200GPS telescope with an f3.3 focal reducer was determined to be approximately 13.0 [this would be the magnitude for a 3-second or longer event where the star virtually disappears when occulted by a very faint asteroid]. The limiting magnitude is for optimum sky conditions, with a dark sky, high zenith angle, and no atmospheric extinction due to clouds.

So new observers can estimate if their equipment can be used with the RunCam Night Eagle Astro Edition for an event, a table of limiting magnitude verses telescope aperture was calculated using the original Night Eagle Astro Edition camera. Here are the results:

Estimate of Camera Limiting Magnitude vs. Telescope Aperture – RunCam Night Eagle Astro Edition				
Telescope Aperture assuming f3.3 (inches)	Limiting Magnitude Original Night Eagle	Limiting Magnitude Night Eagle Astro Night Shutter 1	Limiting Magnitude Night Eagle Astro Night Shutter 2	Limiting Magnitude Night Eagle Astro Night Shutter 3
12	13.0	13.5	14.0	14.5
10	12.6	13.1	13.6	14.1
8	12.1	12.6	13.1	13.6
6	11.5	12.0	12.5	13.0
4	10.6	11.1	11.6	12.1
2	9.2	9.7	10.2	10.7

The Night Eagle 2 Pro Astro Edition is approximately 0.5 magnitudes more sensitive than the original Night Eagle Astro Edition, so add 0.5 to the values in the above table when using the Night Eagle 2 Pro Astro Edition camera.

POST-PROCESSING GUIDELINES

The RunCam Night Eagle Astro Edition provides more sensitivity than the PC164C-EX2 that it is designed to replace. With this extra sensitivity goes some additional processing procedures. These procedures are outlined as follows:

1. For recordings where NS1 is used, observers may determine the Disappearance (D) and Reappearance (R) times directly from a time-stamped video by reading the time stamp on the frame where the D and R occur and then reporting error bars of +/- 1-frame. This is the least accurate method and cannot be used with NS2 or NS3 settings
2. For recordings where NS2 or NS3 are used, or for recordings where NS1 was used and greater accuracy is desired with smaller error bars, use the following method:
   a. In Limovie (or Tangra – example not shown), set the program to perform a reverse gamma correction at the 0.45 gamma level:
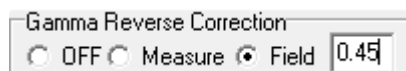
Using the reverse gamma correction turns the Gamma = 0.45 response curve into a Gamma = 1.0 response curve and allows for precise timing analysis, including sub-frame timing if appropriate. Here is an example of the camera response curves tested by Bob Anderson's ArtStar device:
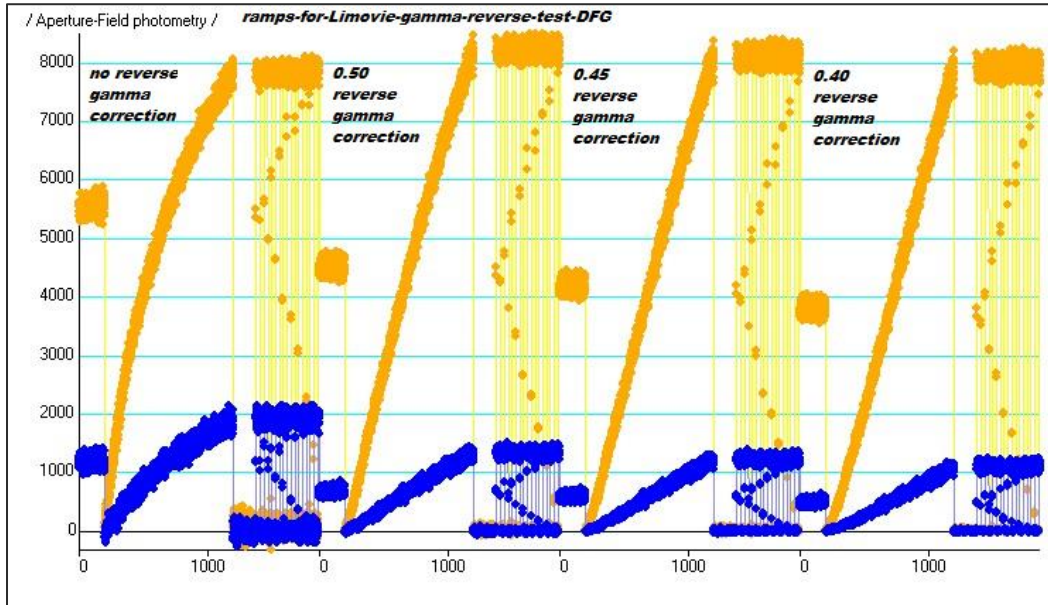

A light curve generated by ArtStar with a 'linear' ramp and several simulated occultations was analyzed in Limovie with various inverse gamma corrections. The gold trace is a brighter 'target' and the blue trace is a dimmer 'star'. With no gamma correction, it can be seen that the gamma response of the Night Eagle Astro Edition is non-linear. The 0.45 inverse gamma correction was found to result in the best linear response.

b. In Limovie (or Tangra – example not shown), analyze the video at in the Field Measure mode as allowed in the Measurement / View Option
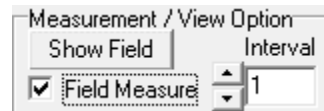
c. Once a Field Measure .csv file is saved, find the fields that are of common brightness and recombine (integrate) these fields using the commonly available light curve analysis software such as R-OTE, Occular, or AOTA [consult the various User Manuals for proper integration procedures]. Here is an
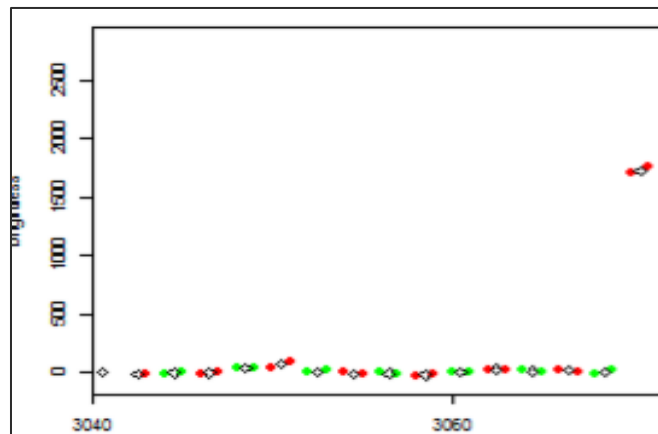
example of combining fields in R-OTE:

The matching fields shown in alternating read and green data points will be integrated into one 'frame' data point and saved in a new .csv file. Similar procedures are available in Occular or AOTA [examples are not shown consult the User Manual or Help menu in the program].

d. Once a new frame .csv file is saved, normal light curve analysis processing can ensue, either in R-OTE, Occular, or AOTA to derive the event Disappearance (D) and Reappearance (R) times. Use the error bars generated by the light curve analysis software at the 0.9973 confidence level.

The RunCam Night Eagle Astro Edition and the Night Eagle 2 Pro Astro Edition produce videos with 'horizontal striping' in the background. This could be due to the rolling shutter used or due to the algorithms programed into the chip to simulate NTSC video (or PAL) in the video output. This horizontal striping will not adversely affect the accuracy of the light curve measured if the correct post-processing procedures are followed. The horizontal striping can be mitigated with Limovie (Tangra does not have the necessary background aperture configuration and cannot correct for the horizontal striping), if done in the following manner:

1. Use Meteor/Lunar Limb aperture as shown below
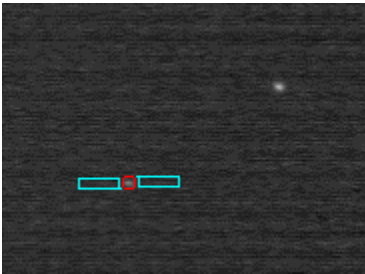
2. The aperture needs to be horizontal to the banded lines and no larger than the measurement aperture. Here are the typical settings:

Notice that the 'Width' of the background aperture is equal to the 'Radius' of the measurement aperture.

With the proper background aperture used in Limovie, the effects of the horizontal striping are greatly reduced or totally mitigated.

GENERAL OBSERVATIONS AND CONCLUSIONS

The RunCam Night Eagle Astro Edition has been tested in comparison to the RunCam Night Eagle, the earlier version of the same camera, and several other cameras.[3] The Night Eagle 2 Pro has been tested against the WAT910HX. Both cameras are an improvement as a replacement camera to the PC164C-EX2. The RunCam Night Eagle 2 Pro Astro Edition is only available for purchase through IOTA. At a 2018 cost of US$79.00 (camera only), it is affordable for new occultation astronomy observers as well as for mobile deployment systems.

The RunCam Night Eagle 2 Pro Astro Edition is very light weight, so could easily be used with Dobson mount telescopes. The ABS case is lightproof (although some light leaks have been found to occur around the connector mountings), an improvement over the RunCam OWL Plus that had a translucent plastic case. The NTSC or PAL 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 camera can accept DC power supply between 5V and 17V. The camera testing in this report was powered at 12V DC. At 12V the camera operated somewhat hot, but the heat was readily dissipated by the case.

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

The RunCam Night Eagle Astro Edition 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.

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[1] 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
Test report: RunCam Night Eagle Astro (prototype), Bob Anderson, 20 April 2017
http://occultations.org/documents/RunCam-Night-Eagle-Astro-test-report.pdf
[2] Testing RunCam Night Eagle, Tony George, December 2016, The RunCam Night Eagle CCD Video Camera is tested against three other cameras: WAT910HX, PC164C-EX2, and RunCam OWL Plus
http://www.occultations.org/documents/NightEagle-Comparison.pdf
[3] Dunham Hyades Comparison, David Dunham, January 2017, Test of RunCam Night Eagle vs PC164C-EX2 on the Hyades star field without and with 0.5X focal reducers (two suppliers)
http://www.occultations.org/documents/HyadesComparison.pdf