Motion Picture Science Shootout

Blackmagic Cinema Camera vs Canon 5D Mark III

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***Abstract*— The Blackmagic Cinema Camera (2.5K) and Canon 5D Mark III's performance were put to the test via a sequence of scenes designed to illustrate image quality attributes. Color reproduction, dynamic range, exposure latitude, noise, MTF, sharpness, and ease of compositing are all aspects of each imager that were compared. These topics were explored both qualitatively and quantitatively. The aim of this comparison is to determine which camera would best suit a low-budget production, amateurs, or independent filmmakers. It was found that the 5D excelled in strictly image quality, but came at the expense of ease of use. If looking for the most simplistic workflow, the Blackmagic camera would be preferred.**

I. Introduction and Objectives

As digital cameras have slowly begun to overshadow film in the professional cinema world, these electronic cameras have also quickly inserted themselves into the prosumer market. Digital single lens reflex cameras (DSLR's) are now common place within the still photography and video world. With prices varying from $500 to $10,000+ dollars for everything you need to start shooting, it has become common for these powerful still and video capture devices to make their way into the hands of amateurs, independents, and cost-wary professionals.

With the steady increase in demand for visual media across our ever-growing digital world, the push for these low budget cameras has intensified. The ability for content creators to have media moving from their cameras to editing suites within minutes has become an expected reality. As manufactures have steadily increased the power of these compact cameras due to consumer demands, a few "high end" models have emerged touting workflows and technical specifications resembling that of professional cinema cameras. These cameras are beginning to feature RAW workflows, something only previously found in the professional scene. With these professional-grade workflows becoming more readily available, amateurs and independents are now able to experience and generate truly polished media. However, these are still prosumer-grade cameras with plenty of limitations and when these content creators need to make an informed purchase decision, they need more information than simple technical specs (that can often be misleading themselves). This is where the camera shootout comes in.

The two motion picture cameras being compared for the shootout are the Blackmagic Cinema Camera and the Canon 5D Mark III. These two cameras were chosen for the shootout for multiple reasons, but primarily for their similarity in price. These sub $3,000 cameras make them prime candidates for the budget conscious indie filmmaker. Other cameras exist at this price point, but very few with RAW video capability. Both the Blackmagic and the 5D Mark III can shoot RAW albeit the Canon requires third party software (Magic Lantern) installed on the device. By comparing these two devices, the team hopes to reveal the strengths and weakness of each camera via side by side shooting followed by technical analysis. By evaluating key differences between each camera, independent filmmakers will be able to make an informed decision on which camera to use for their projects.

II. Equipment Background and Theory

A. Blackmagic Cinema Camera (2.5K)

Although founded in 1984 by Grant Petty, Blackmagic only recently entered the motion picture camera space. After years of acquiring other companies and software such as Da Vinci, Echolab, and Cintel they decided to construct video cameras aimed towards low budget filmmakers. In 2012 Blackmagic released the Cinema Camera for $3,000, which is the model being used for the shootout. Only a year later they released the Pocket Cinema Camera and the Production Cinema Camera 4K. The pocket, as the size infers, is a smaller and stripped down version of the of the original Cinema Camera. The Cinema Camera 4K shares the same body of the original, while upgrading its sensor to a "Super 35" and therefore increasing its resolution to 4K. Currently, the Cinema Camera being used can be considered the "middle child" of the Blackmagic camera lineup, both from a cost and performance perspective.

Fig. 1. Blackmagic Cinema Camera with Canon EF Lens

The Blackmagic Cinema Camera's (BMCC) technical specifications are quite robust given its target audience and price point, especially relative to the competition. With an effective sensor resolution of 2400 x 1350 the BMCC can shoot both 12-bit 2.5K RAW and H.264 (Rec 709) shooting modes. Being able to record in these shooting modes means filmmakers can alter their workflow to color correct the log (flat) RAW footage if desired. This was a low budget option that filmmakers did not have access to before the BMCC came to fruition in 2012. The ability to capture 12-bit color is another feature that reflects the professionalism of the camera, as "prosumer" video cameras and DSLRs natively only capture 8-bit color. The relatively small CMOS 16.64mm x 14.04mm sensor has a lens crop factor of 2.2, meaning the lenses focal length will be scaled by a factor of 2.2 when calculating the effective focal length that will impact framing. As an example, if a 50mm lens is used on the Blackmagic the effective focal length would be 110mm. This rather large crop factor can be considered a negative, because wide angle shots require ever wider angle "fisheye" lenses that may distort the final image. Another specification that attests to the Cinema Camera's image quality is its 13 stops of dynamic range. This rather large dynamic range should lead to better latitude and low light shooting capabilities. Other notable features pertaining to image quality of the the BMCC are its multiple frame rate options and its integrated focus peaking / zebra quality.

Effective Sensor Resolution
2400 x 1350

Effective Sensor Size
15.81mm x 8.88mm

RAW Resolution
12-bit RAW files recorded at 2400 x 1350

Shooting Resolutions
2.5K RAW at 2400 x 1350. ProRes and DNxHD at 1920 x 1080

Frame Rates
HD 1080p23.98, 24, 25, 29.97, 30.

Dynamic Range
13 stops

Focus
Focus peaking and auto focus.

Iris Control
Iris button automatically adjusts the lens iris settings so no pixel is clipped.

Lens Mount
EF and ZE mount compatible with electronic iris control.

Screen Dimensions
5" and 800 x 480 resolution

Screen Type
Integrated LCD capacitive touchscreen

Metadata Support
Automatic camera data and user data such as shot number, filenames and keywords

Controls
Onscreen touch menus and physical buttons for recording and transport control

Microphone
Integrated mono microphone

Speaker
Integrated mono speaker

Mounting Options
3 x 1/4"-20 UNC thread mounting points on top of camera.
1 x 1/4"-20 UNC thread tripod mount with locator pin.

Power
Integrated Lithium-ion Polymer rechargeable battery.
12V-30V DC port for external battery power or use included 12V AC adapter.

Battery Life
Approximately 90 minutes

Battery Charge Time
Approximately 2 hours when not in use.

Fig. 2. Blackmagic Cinema Camera Technical Specifications

Fig. 3. Blackmagic LCD Screen

Fig. 4. Blackmagic User Interface

The Cinema Cameras user interface is intended to be easy to use, lightweight, and unobtrusive. The 5 inch touchscreen and clean UI make changes such as shooting mode (RAW aka 'film' or h.264), frame rate, and shutter angle. Within minutes, anyone with the knowledge of properly exposing a scene can punch in their desired settings and begin shooting. Once looking through the LCD as a viewfinder, the current camera settings are displayed along the bottom of the screen.

B. Canon 5D Mark III

Canon has been a major player in the photography industry since its founding in 1937. Initially creating cameras and camera lenses, the Japanese based company has since grown to manufacture products ranging from computer printers to professional motion picture cameras. It was only in the last 20 years that Canon introduced its EOS camera line, which were the company's first steps into the SLR and later DSLR market. These photographic cameras later gave birth to one of the first DSLR video cameras. Although their first SLR was created in 1987 and their first DSLR in 2001, it was not until 2008 with the Canon 5D Mark II that DSLR video was a possibility on a Canon. Since then almost a dozen Canon DSLRs can shoot native h.264 1080p video. The Canon 5D Mark III, ultimately replacing the Mark II, was introduced in 2012 and from a price perspective is ranked second in the Canon DSLR lineup only to the Canon 1Dx. The 5D Mark III is currently priced at $2,500.

Fig. 5. Canon 5D Mark III

Natively the 5D Mark III, as well as all current Canon DSLRs, only shoots H.264 compressed video. For some filmmakers, not having the ability to shoot RAW is a hinderance in the color correction phase of the professional modern workflow. Therefore, a DIY community formed on the internet to create custom firmware for most Canon EOS cameras. This custom firmware, known as Magic Lantern, lets filmmakers who are using the 5D Mark III to shoot RAW as well as adding other performance and UI features. Some notable features of Magic Lantern include the addition of a focus peaking / zebra feature, active zoom to properly focus images, and the ability to overlay screen markers such as ⅓ or "broadcast safe" gridlines. Besides the one time installation of Magic Lantern, a faster 100 mbps CF card is needed to properly record RAW on the camera. Although not officially supported by Canon, the Magic Lantern firmware is considered safe, stable, and widely used in the industry. The 5D Mark III being used had Magic Lantern version 1.2.3 installed and shot RAW for all scenes unless otherwise specified.

From a technical standpoint, the Canon camera is very similar to the Blackmagic with a few notable exceptions. Although having a CMOS 22 megapixel sensor for photographic capabilities, the camera can only shoot in 1080p. With 2K, 4K, and even 8K content being produced, having a 1920x1080 resolution can seem lackluster. Additionally, its original 8-bit color depth and 10 stops of dynamic range may have negative consequences for color reproduction and latitude. Luckily with Magic Lantern, it is possible to capture 14 bit color data. A noticeable plus over the Blackmagic is its full frame sensor, meaning no crop factor is being applied to the image. Also being a DSLR, the Mark III has a viewfinder with 100% coverage opposed to the Cinema Camera's 5 inch LCD display, which regularly receives criticism.

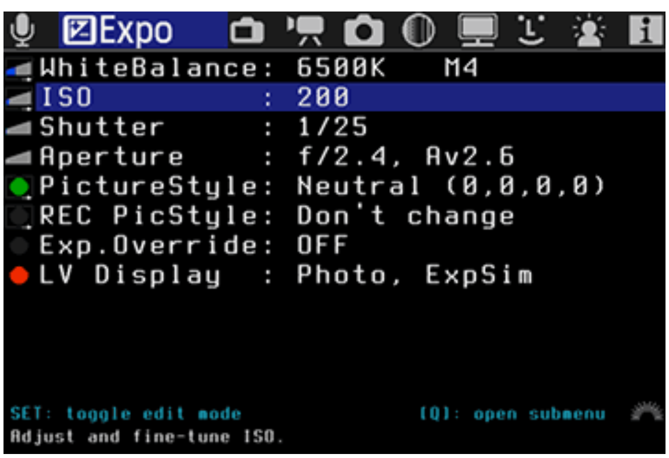

Fig. 6. Magic Lantern "Exposure"

Table I
Blackmagic Cinema Camera and 5D Mark III Technical Specifications Comparison

	Cinema Camera	5D Mark III (ML)
Video Format	RAW (CinemaDNG) ,Pro Res 4:2:2 ProRes Proxy, and DNXHD	RAW (.RAW file extension) with ML Hack and native h. 264 Rec709
Resoloution	2400 X 1350	1920 X 1080
Sensor Size	Actual: 16.64 x 14.04 mm Active: 15.6 x 8.8 mm	36 x 24 mm (windowed for video)
Bit Depth	12	14
Storage Method	SSD	CF and SD Card (Using CF)
Battery Life	90 Minutes (Non Replaceable)	2 Hours (Replaceable)
Viewfinder / LCD	LCD	Both (100% Coverage)
Crop Factor	2.3X	None (1.0X)
Lens Compatibility	PL, EF, MFT	EF
Lens Mount Used	EF	EF
Max FPS	30	30 or 60 @ 720P

Fig. 7. Magic Lantern Live View Mode

The Magic Lantern user interface is far from ideal. What is gained in image quality features is lost in usability. Extensive research is required to fully understand all of the nine tabs and even more submenus. While the initial setup for the Mark III is considerably longer prior to shooting it should be comparable to the Blackmagic in regard to usability after initial shooting settings are punched in.

C. Hypothesis and Industry Experience

Both the Mark III and the BMCC are considered relatively low budget cameras. Therefore they have been sparsely used on professional television and film shoots. Where these cameras do thrive is for use in commercials, independent films, and content produced for YouTube and other online avenues. This ever growing and very vocal community of “no budget” filmmakers have taken to the internet. Therefore there are numerous videos online about the image quality, usability, and overall feel of both the Blackmagic and Mark III. By reviewing these videos, researching articles, and comparing technical specifications it is possible to form a hypothesis of the performance of the two cameras.

Specified below are numerous scenes that the Canon and Blackmagic camera shot in order to assess and compare various aspects of image quality. Some features being compared are the systems sharpness, color / skin tone reproduction, dynamic range, and noise. All scenes were shot in a RAW file format as to mimic a more professional workflow. Additionally, the color assessment scene was shot in both RAW and various H.264 color modes (for the Canon) to compare the differences between the two video modes. Given the larger resolution of the Cinema Camera and its extra three stops of dynamic range, we expected it to greatly outperform the Mark III in well lit scenes as well as be able to record both spatial and color detail in the highlights and shadows better compared to its DSLR rival. In low light is where the competition becomes a bit more heated. Based on user reviews, the 5D Mark III is known as the “low light king” in the low budget scene while the BMCC has been criticized for its habit of shooting poorly in the dark. Although the “on the surface” technical specifications say otherwise, a few reasons the Mark III may shoot better in low light is due to its larger overall sensor size or the potentially larger individual pixels on the Canon sensor. Inline with what the tech specs infer and what filmmakers in the industry say, it is believed that the Blackmagic Cinema Camera will outperform the Canon 5D Mark III in all aspects of image quality except for low light capability where the Mark III may have less noise present and therefore a cleaner image.

III. Image Quality Assessment Plan

A. Charts

1) Description of Scene, Layout and Lighting

This scene contains the capture of 3 different image assessment charts. The setup for each of the three charts is the same. The chart of choice will be raised to a height of 6 feet from the ground with the camera at the same height. The camera of choice will be placed 6 feet away from the chart with two 2K lights with half-diffusion beside and equidistant from the camera, and 6 feet from the camera on the axis parallel to the wall. With the help of a light meter, each chart should be uniformly lit to an f-stop of f/4. The f-stop of f/4 will be the baseline exposure for each scene.

The various scenes were shot at different exposures in order to ensure full tone scale and to see how qualities such as noise, aliasing, latitude, and sharpness would be effected at these these different exposures. The 5D also captured the Macbeth Chart and color reproduction scene at different color modes in order to provide qualitative assessment and color correction reference aim. These preset modes include: standard, portrait, landscape, neutral, and faithful.

Table II
Scene Exposure and Color Temperature

	Blackmagic 2.5K		Canon 5D Mark III	
Scene	f-Stops (with 0.6 ND)	Color Temp	f-Stops	Color Temp
Color	4	3200	4	3200
Composite	4	3200	4	3200
HDR	Normal = 4 -2 = 8	3200	Normal = 4 -2 = 8	3200
Sharpness	Normal = 5.6 (with 0.9 ND) -1 = 8 (with 0.9 ND) -2 = 11 (with 0.9ND) +1 = 4 (with 0.9 ND) +2 = 4 wide = 8	3200	Normal = 5.6 (with 0.3 ND) -1 = 8 (with 0.3 ND) -2 = 11 (with 0.3 ND) +1 = 4 (with 0.3 ND) +2 = 4 wide = 8	3200
OECF	-2 = 8 -1 = 5.6 Normal = 4.8 (5 was the desired) +1 = 2.8 +2 = 2	3000 (Actual 3021)	-2 = 8 -1 = 5.6 Normal = 4 +1 = 2.8 +2 = 2	3000 (Actual 3021)
Gray Card	+2 = 2 -2 = 8 Normal = 4	3200	+2 = 2 -2 = 8 Normal = 4	3200
Macbeth	4	3200	4	3200
Slant-edge	4	3200	4	3200

2) Justification

The ISO12233 chart provided images necessary for MTF, sharpness, resolving power, and aliasing analysis for each camera. The MacBeth chart provided images necessary for color reproduction analysis for each camera. Finally, the OECF chart provided images necessary for analyzing dynamic range and tone reproduction for each camera.

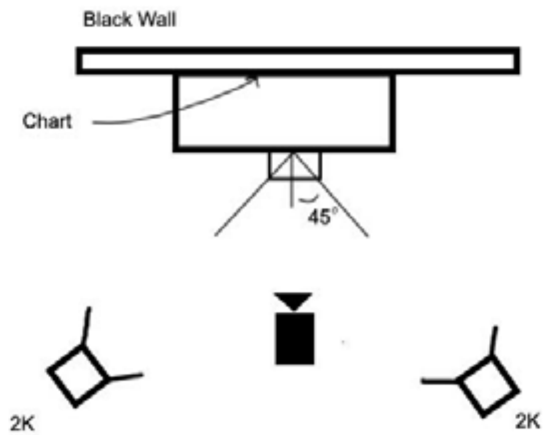

Fig. 8. Chart Scene Lighting Diagram

B. *High Dynamic Range*

1) Description of Scene, Layout and Lighting

To accomplish a high dynamic range scene, the set was dressed to resemble a jail, comprised of a dark cell contrasted with a bright spotlight in an interrogation-like setup. Inside the cell in the background a model R2-D2 was placed in a shadowy region, about 4 stops darker than normal. Outside the cell at the interrogation table, a bright light illuminated objects on the table to about 8-9 stops brighter than normal exposure using multiple lights. The objects on the table included a mug and papers, both with text on them with the purpose of determining whether either of the cameras can capture these details at such overexposed conditions.

Fig. 9. HDR Scene with Overlaid Exposure Values

As seen in the diagram, two additional actors were stationed at the interrogation table, one acting as the investigator and the other as the suspect being interrogated. Their interaction will add some interest and movement to the scene. The camera was on a dolly that moves from right to left, and allows for the frame to view all of the dark and light content of the scene over a period of time, instead of trying to fit it all into one frame. From an aesthetic perspective, the harsh lighting was indicative of the discomfort felt by suspects during interrogation while the dim jail cell represented the bleak outlook of a prisoner.

To achieve this lighting, two Arri 5K lights were positioned on one side to create a harsh light on the two actors in the foreground. As seen in the diagram, two Arri 5K's and an Arri 2K were used as a fill lights for the same two actors. While this created a very bright scene for the actors in the foreground, none of this light was directly incident on the "prisoner" in the background. By using very directional / focused light, it was possible to create a high dynamic range scene.

Additionally, each camera recorded the scene at a normal exposure and then underexposed by two stops. The Under exposed scene was then processed by a colorist back to normal exposure to see if any highlight or shadow detail was lost during this process to simulate how much detail in these regions is salvageable if a shot is underexposed accidentally.

2) Justification

This scene allowed us to compare the dynamic range and latitude of each camera. Qualitative comparisons were made to determine how much detail information is contained in both the highlights and the shadows. It is important to also asses the noise content in the shadows using the uniform areas in the walls that surround the scene.

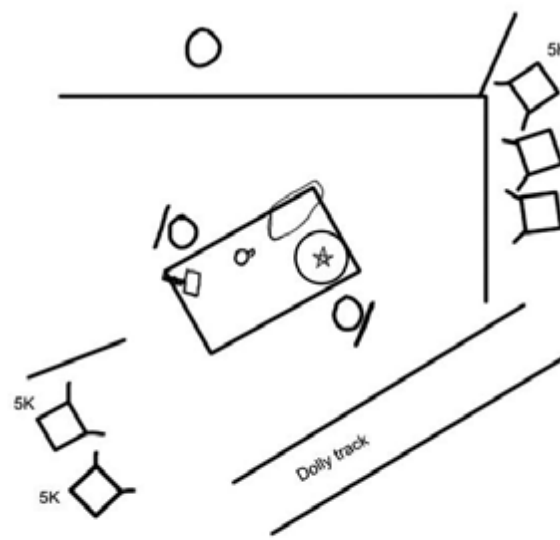

Fig. 10. HDR Scene Lighting Diagram

C. *Composting*

1) Description of Scene, Layout and Lighting

This scene takes place in front of the Studio A Green Screen Wall at the Rochester Institute of Technology. The primary goal was to exploit the positives and negatives of compositing with the footage created by both cameras. The actor stood in front of the green screen, dressed in a Jedi Knight robe that consists of loose, free flowing materials. The actor had long hair that appeared to be 'blowing in the wind' through the use of multiple fans. This not only allowed for a more believable key when placing the footage on top of another image source, but also provided for dynamic, high frequency content, that was used to asses the quality of the post-production key. The actor will stand stationary and hold a lightsaber as to appear in the Star Wars universe.

The green screen was be lit with the green screen lights that are already hanging from the grid, for the purpose of lighting the green screen. These lights were be controlled by the dimmer board. The actor was lit with numerous key, fill and a back lights. This gave the actor separation from the green screen allowing for a proper key, and gave a soft and more professional look that allowed for the keyed footage to compose well with background footage source. An f-stop of f/4 was used in order to blur the background for the compositing post-processes.

2) Justification

This scene was processed in post-production for the use of assessing the ability of cameras to acquire an image that will create a good key and composite. Dynamic, high-frequency content from the Jedi's hair was available in the scene in order to assess the noise associated with keying that specific type of content. The detail in the actors hair and robe were also used to asses sharpness and resolving power information.

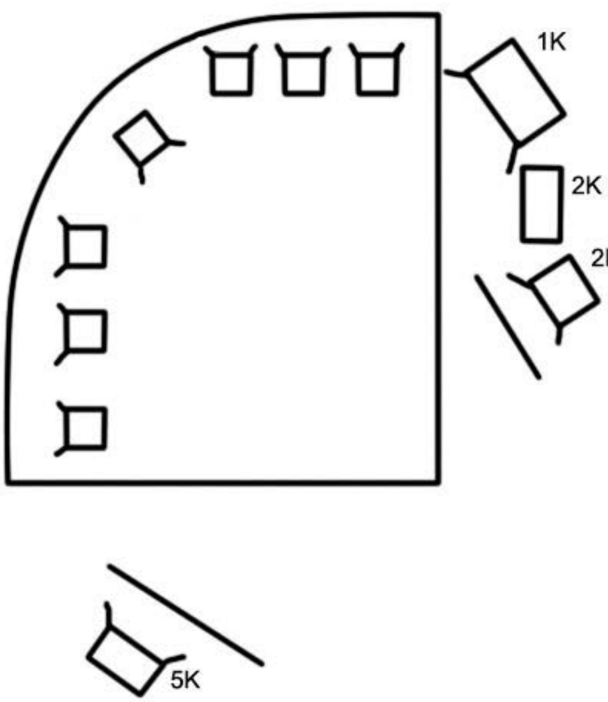

Fig. 11. Compositing Scene Lighting Diagram

D. Color Reproduction

1) Description of Scene, Layout and Lighting

To investigate system color reproduction, a cooking scene featured a "chef" (actor dressed in a white chef coat and hat) standing behind a table lined with a variety of colorful, recognizable fruits and vegetables. The chef will be used a large knife to chop ingredients for a fruit salad. The scene will also included recognizable packaging (such as a Honey Oats snack box) in the background. The scene consisted of two takes of the same scene. The first take of the scene was a medium static shot of the chef and the food. The second take of the scene was a close up shot of the food in which the camera will move from one side to the other via a small slider dolly.

In order to achieve a scene f-stop of f/4, a three-point lighting setup was implemented for this scene. A key light (5K light) was placed behind the camera positions to the right. A fill 5K light placed behind a silk was placed behind the camera positions to the left. Finally, numerous backlights were placed near the right and left side of the wild walls.

2) Justification

The reason for shooting these particular items is because the colors should be easily recognizable to the majority of people, acting as "memory colors," which will be instantly indicative of the color reproduction capabilities of each camera.

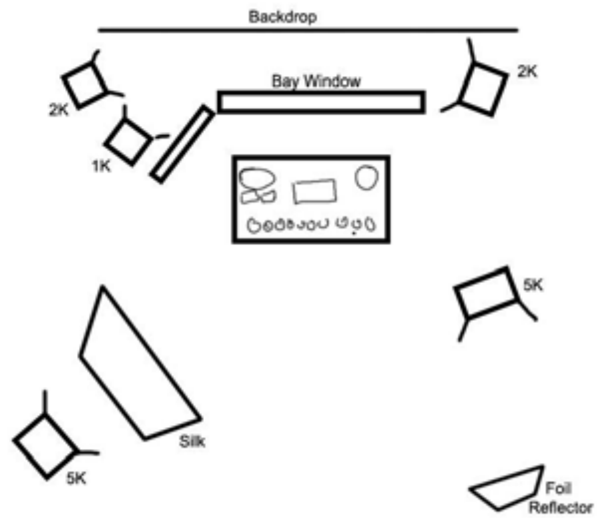

Fig. 12. Color Reproduction Scene Lighting Diagram

E. Sharpness, Aliasing, and Skin Tone Reproduction

1) Description of Scene, Layout and Lighting

The scene consisted of a simple, plain background with a group of four people standing in front of it and a photographer, armed with a DSLR, attempting to capture a group photo. The perspective of the wide shot is from over the photographer's shoulder. There was also close shots to get a better look at skin tone reproduction and aliasing. The talent was wearing shirts with varying high frequency patterns which resulted in chromatic and spatial aliasing in the imagery captured by the two cameras at normal exposure.

Implementation of a typical 3 point lighting setup was used. This provided the overall image with properly balanced shadows, and represented the most common lighting setup to represent skin tones. The following normal exposure shots were also under and over exposed by -1/-2 and +1/+2 respectively.

2) Justification

The primary purpose of this scene was to provide a scenario in which there is an decent color tone representation of various skin types. An additional factor to this scene was to asses the sharpness within the scene created by the selection of bright and high frequency patterned shirts. The scene was also under and over exposed to see the effect mis-exposure has on skin tone reproduction and aliasing.

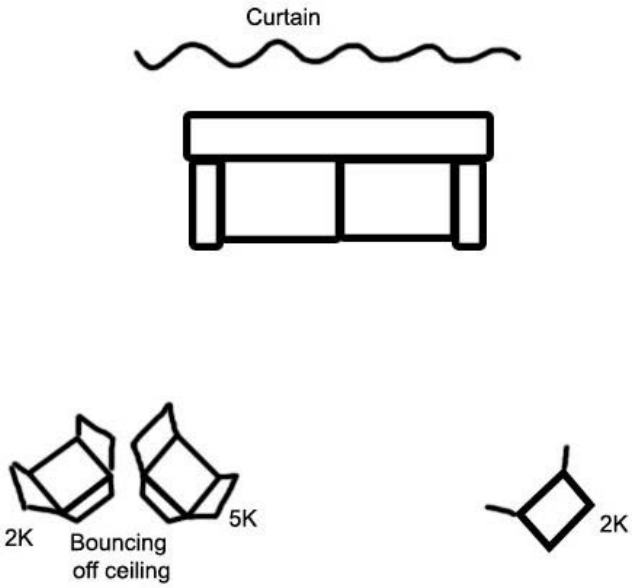

Fig. 13. Sharpness Scene Lighting Diagram

IV. Shooting Matrix

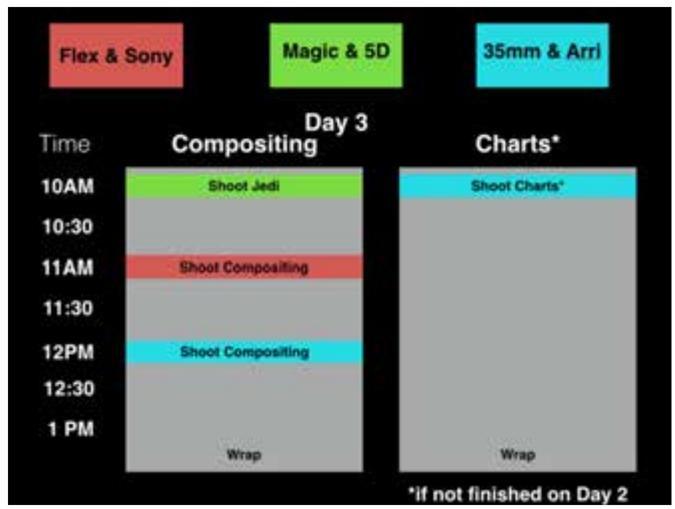

Fig. 14. Three day Shooting Schedule / Matrix

A) Camera Scripts

Table III
Color Reproduction

Camera	Black Magic Camera	Canon 5D Mark III
Lens	35mm EF	24-70mm EF (@ 70mm)
Aperture	f/4	f/4
Shutter	1/48	1/48
ISO	200 (800 with 0.6 ND)	200 (160 Native)
Exposure Plan	+/- 0	
White Balance	3200K	
Resolution	1920 X 1080	
Frame Rate	24	
Processing	RAW and ProRes 4:2:2	RAW and various color modes
Shot Duration	30 Seconds in Closeup, 60 Seconds in Medium	

Table IV
Sharpness

Camera	Black Magic Camera	Canon 5D Mark III
Lens	35mm EF	24-70mm EF (@70mm)
Aperture	f/4	f/4
Shutter	1/48	1/48
ISO	200 (800 with 0.6 ND)	200 (160 Native)
Exposure Plan	+/- 0, +/- 1, +/- 2	
White Balance	3200K	
Resolution	1920 X 1080	
Frame Rate	24	
Processing	RAW	
Shot Duration	20 Seconds in Medium, 20 Seconds in Wide	

Table V
Charts

Camera	Black Magic Camera	Canon 5D Mark III
Lens	35mm EF	35mm EF
Aperture	f/4	f/4
Shutter	1/48	1/48
ISO	200 (800 with 0.6 ND)	200 (160 Native)
Exposure Plan	+/- 0 (+/- 2 for grey card only)	
White Balance	3200K	
Resolution	1920 X 1080	
Frame Rate	24	
Processing	RAW	
Shot Duration	3 Seconds for Each Setting	

Color Modes will also be tested in this shot for the 5D which will be compared to ProRes 4:2:2 Footage from the Blackmagic

5D Shooting Modes Tested: Automatic, Standard, Portrait, Landscape, Neutral, Faithful

Table VI
High Dynamic Range

Camera	Black Magic Camera	Canon 5D Mark III
Lens	35mm EF	24-70mm EF (@70mm)
Aperture	f/4	f/4
Shutter	1/48	1/48
ISO	200 (800 with 0.6 ND)	200 (160 Native)
Exposure Plan	+/- 0, -2	
White Balance	3200K	
Resolution	1920 X 1080	
Frame Rate	24	
Processing	RAW	
Shot Duration	30 Seconds for each Exposure	

Table VII
Compositing

Camera	Black Magic Camera	Canon 5D Mark III
Lens	35mm EF	24-70mm EF (@70mm)
Aperture	f/4	f/4
Shutter	1/48	1/48
ISO	200 (800 with 0.6 ND)	200 (160 Native)
Exposure Plan	+/- 0	
White Balance	3200K	
Resolution	1920 X 1080	
Frame Rate	24	
Processing	RAW	
Shot Duration	30 Seconds	

V. POST PRODUCTION SUMMARY

A. *Workflow*

When dealing with post-production workflows, there were two different avenues of attack for this shootout. Shooting scenes with simple pre-processed video files featured a relatively simple workflow. However, the scenes shot RAW required a few extra complexities. Both workflows took advantage of the same set of software.

Fig. 15. Logos of the Various Post tools used

For all non-linear editing, Adobe Premiere Pro was used, initially Adobe Speedgrade was the grading suite of choice (eventually replaced by DaVinci's Resolve), and Adobe After Effects covered all compositing and visual effects needs. The initial "all Adobe" lineup was conceived in order to allow footage to be used flexibly across software with minimum information loss due to compression (no cross-platform rendering necessary).

As stated previously, scenes featured pre-processed media were straightforward. Media was taken directly off the cameras and placed on multiple secure storage devices (in order to prevent data loss). This footage was then imported directly into Adobe Premiere Pro for editing. For scenes that featured more complex comparisons (shots that could not be easily built within Premiere, such as the 5D color mode comparisons), Adobe's Direct Link feature was used in order to associate the Premiere edit with an After Effects composition. Once the link was established, changes made to individual media clips within After Effects automatically updated their associated media in Premiere's timeline. Direct link ensured that all changes made to a specific clip did not affect the overall quality of any final edit.

For the majority of the shootout scenes however, a RAW-friendly workflow was implemented. This workflow featured additional steps that were not necessary in the pre-processed roadmap. The 5D natively creates a Magic Lantern Video (.RAW) RAW file format which is nearly identical to CinemaDNG besides the fact that a lossless compression is used for faster data transfer rates to the Mark III CF card. Once offloaded to a computer the .RAW files needed be converted to CinemaDNG via a program called RAWMagic. Doing so did not affect image and color quality and only converts the RAW file. Unlike the pre-processed media, the RAW files from the cameras (CinemaDNG) could not be directly imported into Premiere; therefore, this workflow required an intermediate step. Our preliminary thoughts were that our RAW workflow would both start and end in Speedgrade. However, once color grading was attempted within Speedgrade, it was quickly made apparent that Speedgrade did not offer the flexibility with file extensions that was present within Resolve. Furthermore, Resolve is also Blackmagic's software package, and comes built in with Blackmagic presets (which makes neutral color grading extremely simple). Resolve also allows the colorist to dial in specific shooting information such as color temperature of the media and what type of camera was used (configuration settings Speedgrade does not have). Once the decision to move away from Speedgrade was made, our workflow no longer involved proxies and edit decision list (EDL) files. RAW footage was simply imported directly into Resolve and then exported out as lossless Apple ProRes 4444 QuickTime files (minimal compression to preserve as much color data as possible) once color grading had been completed. These QuickTime files were then imported into Premiere for editing.

For the sake of time and ease of production, post-production efforts were divided among the group:

Ben Zenker – Compositing, Visual Effects, Graphics, Editor and Script Writer of Compositing Scene

Nate McFarlin – Colorist, Editor and Script Writer of Color Scene, Narrator

Max Pope – Colorist, Editor and Script Writer of Sharpness Scene

Alex Pattison – Editor and Script Writer of HDR Scene

Matt Setlow – Narrator, Script Writer of Introduction / Conclusion

Each team member was given responsibility over a particular scene. Narration was recorded using Audacity software. Audio files were exported and distributed to their appropriate editor for integration into their specific scene. Once each member had completed his individual edit, the file was exported out of Premiere as an Apple ProRes 4444 or Apples "None" lossless uncompressed codec Quicktime file and then imported into a "master" Premiere file for final placement and audio mastering. The completed final edit was exported out of the master Premiere file as a 1920x1080 QuickTime format with H.264 codec as specified by RIT's screenings' standard. Although our final post-production workflow featured slightly more transferring between programs than initially planned, it allowed the individual group members to focus on particular aspects of the final product, an aspect that significantly sped up post-production efforts.

B. Color Correction

As stated previously, both cameras were graded with DaVinici Resolve. The Blackmagic was relatively easy to grade to neutral. Within Resolve, there are several preset LUTs for Blackmagic cameras. In order to achieve a neutral color grade within the Blackmagic, the most recent version of the Blackmagic LUT was placed on top of the RAW footage. Next, a minimal lift, gamma, and gain adjustment was performed in order to equalize the waveform parade scope (this ensures that the gray card represents a truly neutral object within the given scene).

Fig. 16. A Screenshot of DaVinci Resolve and Waveform Balancing

Because of these built-in presets, grading the RAW footage from the Blackmagic camera was relatively straightforward. The ease of correction experienced was very evident after previously having tried to recreate the same look with Speedgrade, as footage there was both harder and more time consuming to manipulate. Although Resolve made the Blackmagic's grading process rather simple, it came at the cost of accurate reproduction. Compared to the 5D and the camera's pre-processed video modes, the RAW footage had a noticeably hard time rendering red hues. To correct for this, extensive secondary correction had to be utilized or a disregard of the preset LUT in general. Besides the trouble preset within red hues however, the Blackmagic workflow was certainly both quick and simple, the files could easily be read into Resolve and made to look aesthetically pleasing within seconds.

On the assumption that the Blackmagic was corrected reasonably well (Resolve is Blackmagic's software, this comes with assumption that their preset LUTs are trustworthy), the neutral graded RAW footage from the Blackmagic was used as a hero reference for the 5D's color grading. This was relatively straightforward to accomplish within Resolve, as it has a feature to compare any still to the footage you are currently grading (this feature will even split the waveforms on the scopes for an easy matching process). In order to best match the neutral grades, the gray card was the primary point of comparison. Via waveform manipulation as well as visual interpretation, the appearance and neutralities of the each gray card were made to match as closely as possible to ensure a fair color rendition comparison between the two cameras.

Fig. 17. A side by side comparison of neutral graded raw footage from the Canon (left) and the Blackmagic (right)

Although the rendition of the colors may have been more aesthetically pleasing on the 5D when compared to that of the Blackmagic, this definitely came at the cost of time and difficulty. Not only does Resolve lack presets for Canon cameras, but the RAW media from the Magic Lantern firmware has to be ran through a conversion software to convert the files to CinemaDNGs that can be read by Resolve, adding an additional step to the 5D's workflow. However, even though the 5D takes longer to grade initially, due to its more accurate reproduction creating a creative grade to achieve a more aesthetically pleasing image is easier to obtain (not as much tweaking necessary as the Blackmagic).

In conclusion, the decision to switch from Speedgrade to Resolve proved to be an intelligent one. Resolve offered more flexibility and control over individual clips. Options to dial in specific file extensions, color temperature, and LUTs that were not within Speedgrade greatly improved the efficiency and accuracy of color grading. The 5D proved to more difficult and time-consuming to grade but rendered a more pleasing image. However, if the user is a novice and is concerned with RAW workflow complexities, the Blackmagic would be the clear choice.

VI. Qualitative Analysis

A. Color Reproduction

Fig. 18. Canon 5D Normal Exposure

Fig. 19. Blackmagic Normal Exposure

Both cameras are RAW-capable. Straight RAW outputs maintain most color metadata but are muted when imported. Both cameras were graded using DaVinci Resolve. For the Blackmagic, this was rather simple. Because DaVinci Resolve is Blackmagic's software, it comes built in with BM presets. To achieve a neutral look for the Blackmagic, a Blackmagic camera specific color look up was applied to the image. Then, a minimal lift, gamma, and gain adjustment was implemented to ensure the grey card represented a truly neutral object. The 5D required a bit more rigorous grading process. No preset LUT is inherent in resolve to easily grade these files. The 5D was graded with the BM as a hero reference, the neutrals were made to look the same for an accurate color reproduction comparison (Fig. 17).

Fig. 20. Canon 5D MacBeth Chart Normal Exposure

Fig. 21. Blackmagic MacBeth Chart Normal Exposure

Right away it’s apparent that the Blackmagic has issues with red scene content (Fig. 21). When looking at the Red Macbeth chart patch, the apples, and the flesh tones it is obvious that the BM gives these hues a more washed out/ pinkish look. As seen in figure 21, This even bleeds into other hues such as browns.

Fig. 22. 5D Capturing ProRes:4:2:2 (Left) vs Blackmagic Capturing DNXHD (Right)

Both cameras also have the ability to shoot in pre-processed video modes as well. These modes are what the companies deem to be “accurate” colorimetry. The two BM modes we choose to compare for BM were ProRes 4:2:2 and DNXHD (Fig. 22). Although both formats are initially more pleasing than the ungraded RAW footage, they quickly are made to look flat/washed out compared to the neutrally graded RAW media (Fig. 19). However, it is important to note that neither pre-processed formats have issues with Red hues like the RAW footage. A simple saturation boost clearly shows these formats red superiority over their RAW counterpart.

Fig. 23. The Various 5D Color Modes

The 5D has different “picture modes”, a trait common among DSLR cameras. The 5 different modes were: faithful, neutral, landscape, portrait, and standard. The neutral mode was observed to be the most aesthetically pleasing, but unlike the BM, none of these pre-processed formats could best their RAW neutral graded counterpart in any regard (Fig. 23).

Fig. 24. Canon 5D Creative Color Grade

Fig. 25. Blackmagic Creative Color Grade

Overall, when comparing the color reproduction of these two imagers, the 5D gives a more aesthetically pleasing rendition. However, this look also comes at the price of ease of gradability, the 5D has a much more rigorous grading process. Further more, our team was frankly not impressed by either cameras neutral color reproduction. Figures 24&25 shows a creative color grade showcasing the colorimetry you could achieve if given more time .

B. Sharpness and Aliasing

Fig. 26. Canon 5D Normal Exposure

Fig. 27. Blackmagic Normal Exposure

This scene was developed analyze skin tone reproduction, sharpness, frequency, and aliasing in both cameras at normal and misexposure. At a normal exposure (Fig. 26 & 27), both cameras handle skin tone reproduction very differently. Because of the problem of infrared pollution on the black magic, each skin tone came with a noticeable red caste. This is even noticeable in the couch which is supposed to be a light brown. Each variation of skin tone also seems washed out and sometimes indistinguishable as seen with the two persons in the middle. The Mark III seems to preform better in regards to skin tone reproduction. Each skin tone is distinguishable and matches scene colorimetry much better than the Blackmagic.

The sharpness of the image can be seen within the edges of the shoulders vs the couch in the background (Fig. 26 & 27). The 5D reproduces edges much sharper than the Blackmagic. This is due the 5D's much higher pixel count. The light captured in each RAW mode are be down-resed to an HD image which means if there are more pixels at capture, more information is maintained.

Fig. 28. Close up of Aliasing on 5D (left) and Blackmagic (right)

Additionally, the 5D's image has a significantly less amount of aliasing within the higher frequency shirts and jeans than the Blackmagic's image (Fig. 28). Chromatic aliasing is much more prevalent with the Blackmagic while spatial aliasing is more prevalent with the 5D. The aliasing is much less noticeable with the 5D because of its use of an anti-aliasing filter where the Blackmagic lacks this filter.

Fig. 29. Blackmagic Normal Exposure

Fig. 30. Blackmagic -1 Exposure

Fig, 31. Blackmagic -2 Exposure

Fig. 32. Blackmagic +1 Exposure

Fig. 33. Blackmagic +2 Exposure

Fig. 34. 5D Normal Exposure

Fig. 35. 5D -1 Exposure

Fig. 36. 5D -2 Exposure

Fig. 37. 5D +1 Exposure

Fig. 38. 5D +2 Exposure

With a one stop underexposure, some of the defects with both cameras are more prevalent (Fig. 30 & 35). The chromatic aliasing in the Blackmagic and the spatial aliasing in the 5D become much more noticeable. With one more stop under exposed (Fig. 31 & 36), the amount of light reaching the sensor actually improves the aliasing but with loss of distinguishable skin tones in each image. Additionally with over exposures a steep increase in visible aliasing and loss in skin tone color information (Fig. 33 & 38).

It is important to note that the aliasing come from the combination of the different imaging components of each camera. Because we used different lens for both cameras, the aliasing can come from a multitude of components from the sensor to the lens used. Different lenses were used due to availability and to maintain a similar field a view to compensate for Blackmagic's crop factor.

C. High Dynamic Range

Fig. 39. 5D Normal Exposure HDR Scene with Overlaid Exposure Values

Fig. 40. Blackmagic Normal Exposure

At normal exposure, Both the Blackmagic and the 5D were unable to capture all of the highlight and shadow detail in the scene, meaning clipping and crushing did occur. As seen in Figure #, each camera performed inversely to each other. The 5D excels in shadow detail over its counterpart, potentially due to the 5D's larger overall sensory size. On the flip side, the Blackmagic maintains greater highlight detail. In the shadows, take R2D2 top half for example, who is underexposed by -4 stops. He is much more visible and stands out from his dark surround in the 5D take. Even the underexposed C-stand, cup, and door are all visible in this low lit area. The Blackmagic provides very different results in which R2's background is completely crushed to black hiding the door and a variety of other props. Additionally, R2D2 himself is crushed and blends into the black surround. Visually there are no regions in the 5D's footage where crushing occurs except on the underexposed back door in the background.

Fig. 41. Blackmagic Normal Exposure

There are certain regions, such as the lab coat overexposed by 7.6 stops, that were clipped to white by both cameras. Additionally, the ND filter used on Blackmagic caused a double image on the blown out lab coat (Fig. 41). As seen in the bagel in on table in Fig. 39 & 49 some detail is preserved with the Blackmagic while the highlights are completely blown out on the 5D.

Fig. 42. Blackmagic -2 Exposure Graded to Normal

With the underexposed blackmagic footage, the entire background is crushed and the Jedi blends into its dark surround. In the hands of a colorist, the scene can be brought back up to normal exposure and therefore saving shadow detail (Fig. 42). Some shadow detail is brought back into the scene, but not as much as the original correct exposure. Also, the highlights in the bagel are not as blown out on the exposure corrected scene.

Fig. 43. 5D -2 Exposure Graded to Normal

Figure 43 shows when exposure is corrected on the 5D's take, some shadow detail is restored but the blacks seem to be washed out compared to its properly exposed counterpart. It seems at normal exposure that the 5D produces deeper black but with an underexposed shot it is easier to restore shadow details with the Blackmagic footage.

D. Compositing

Fig. 44. Blackmagic Composite

Fig. 45. 5D Composite

In this scene before assessing the quality of the chroma key, we notice that the red hair of our actress doesn't stand out against the colors in her robe and in her skin, this can be an issue for any type of scene because the color of hair is a deep red, and her skin is a pale white (Fig. 44). Losing this distinction with respect to her robe takes away from the aesthetic of the scene. Unfortunately the blue of the lightsaber appears less saturated in the 5D than that of the Blackmagic (Fig. 45).

Chroma keying is the process of removing green content of the scene and replacing them transparent or empty pixels in its place. Both of the following chroma keys were performed within ten minutes in Adobe After Effects using two color keys followed by a Keylight 1.2. Settings used were similar but not identical.

Fig. 46. Blackmagic Close up of Hair

Edge quality, both spatially and temporally, keyed out well with the Blackmagic (Fig. 46). There is still a small amount of greenspill which can be seen on the robe, but the hair of the actress has very little green left in the high frequency areas. Unfortunately the keylight plugin left fuzzy content as a way to compensate for the removal of the green screen. One of the most noticeable failures of the key is the noise, which can be seen in the uniform areas of the robe.

Fig. 47. 5D Close up of Hair

This noise content seemed even worse in the 5D key (Fig. 45). The noise was amplified by the removing of semi-transparent content from the robe during the keying process, which caused a crushing of the shadows. However, the 5D more than makes up for this failure through an amazing key in both the edge content and the high frequency areas of the hair. Sharpness of the hair seems preserved much more in this key, giving it a more realistic look. The lightsaber edge appears to be cleaner as well. Lastly, almost no green spill can be seen on the actor from this key.

VII. QUANTITATIVE ANALYSIS

A. OECF Analysis

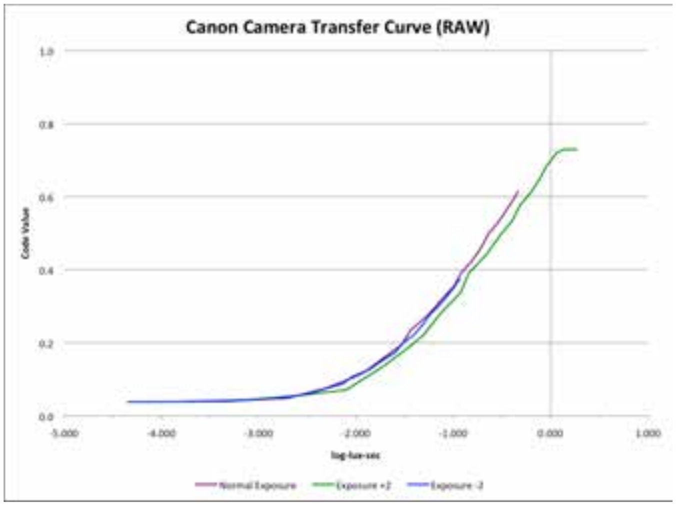

Fig. 48. Three Canon exposures relating radiometric sensor plane illuminance to camera generated code values

Through analysis of the OECF functions generated by each camera, we see that the Canon 5D clips its highlights around 0 log-lux-seconds and it begins to crush shadows around -2 to -2.5 log-lux-seconds. Figure 48 was captured in Canon's RAW camera mode, through the magic lantern firmware, allowing us to access the cameras native camera response.

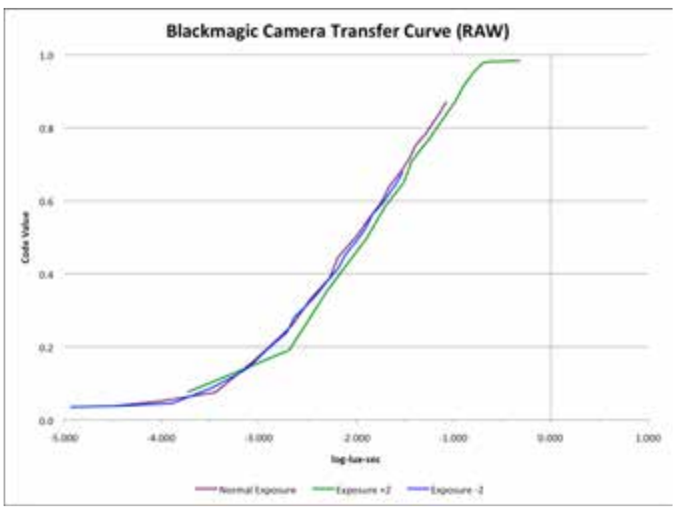

Fig. 49. Three Blackmagic exposures relating radiometric sensor plane illuminance to camera generated code values

A comparative curve that was created for the Blackmagic Cinema Camera shows a slightly steeper slope, or greater contrast than that of the Canon. For this camera's native response, it is visible that highlights begin to clip around -0.8 log-lux-seconds and shadows begin to crush around -4 log-lux-sec. This metric, while not 100% accurate or discrete, still reveals that the Blackmagic has a slightly greater full dynamic range than that of the Canon.

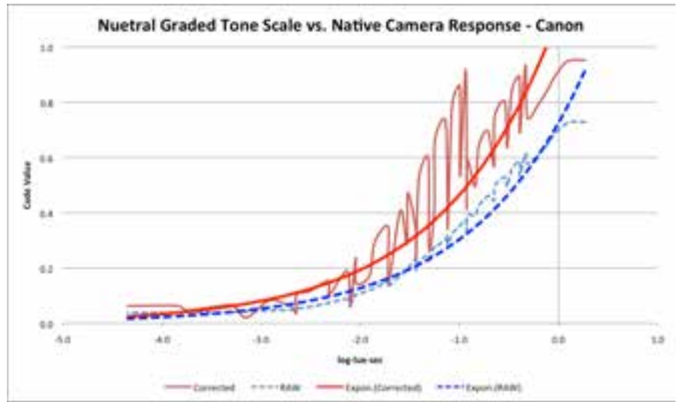

Fig. 50. Comparison of two Canon tone scale functions that connect radiometric values to code values

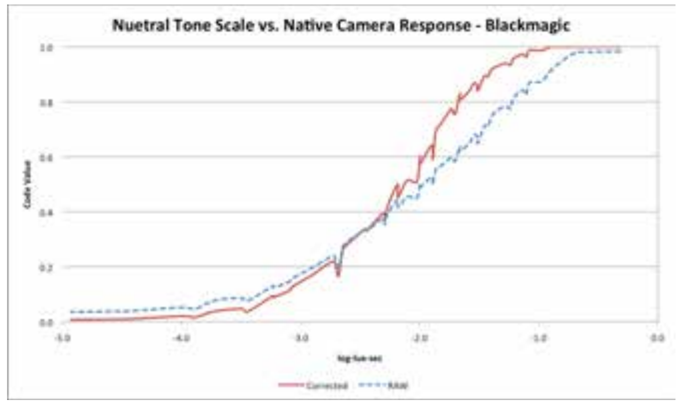

Fig. 51. Comparison of two Blackmagic tone scale functions that connect radiometric values to code values

The figures above (figure 50 & 51) represent a comparison between neutrally graded OECF tone scale charts with respect to the native camera responses. These graphs help to show how a simple color-grading step can change the response of your image values. The Canon camera had to be neutrally graded by hand, giving it strange artifacts as seen in the line plot. To overcome these inconsistencies, a best-fit line was plotted. The correction that was applied to the Canon acts like a lift/offset in the terms of a colorist. The neutral image will utilize more of its full range of pixel values and have a higher contrast. Some slightly different conclusions are drawn from the Blackmagic graph, which was neutrally graded using a Blackmagic LUT that was built into the color grading software. Again, the contrast is boosted in the graded tone scale, but the most noticeable advantage is the optimization of the clip and crush points to the max and min of the 8-bit colorspace. You also notice a large shoulder or knee function towards the top of the graph. This section of the graph represents a slow transition from the main pixel values of the image towards the pixels values where clipping occurs. In respect to the native camera response, the neutral tone scale of the Blackmagic presents a much more aesthetically pleasing look, and we know this without even looking at a single image.

B. MTF Analysis

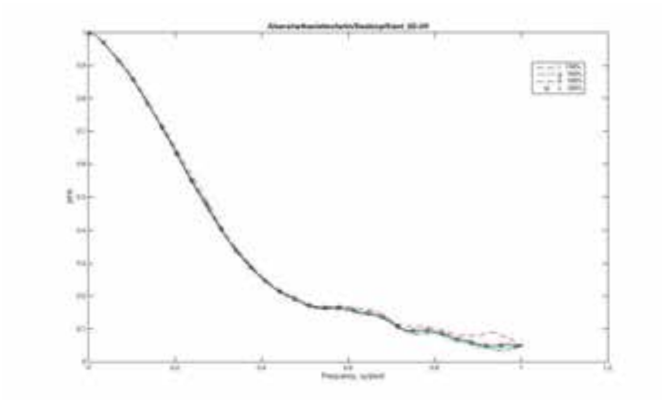

Fig. 52. Canon 5D slant edge analysis MTF curve

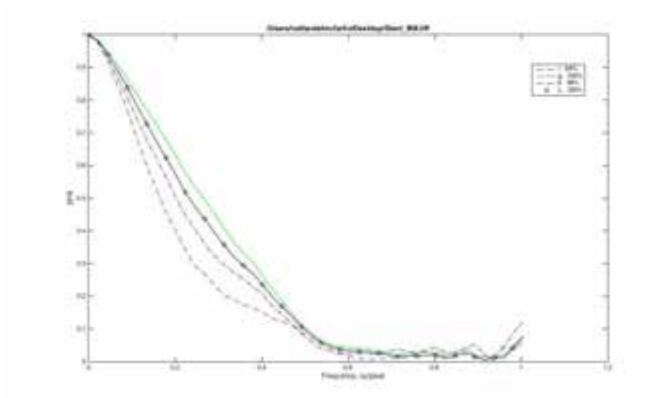

Fig. 53. Blackmagic slant edge analysis MTF curve

The modular transfer function or MTF describes the ability of an imaging system to preserve contrast at varying frequencies. The MTF comes from the different components of the imaging system including the lens used. The lens choice for each camera was the same so the performance of each camera can be comparable. The MTF was calculated with the help of the Slant Edge given on the ISO12233 chart. Both MTF curves from each camera follow a similar path, although the Blackmagic tapers off in the shorter frequencies before the Canon 5D Mark III. The curves' degradation could be due to a multitude of factors from the imaging processing to the lens used to the LUTs applied in post-production.

C. Aliasing Analysis

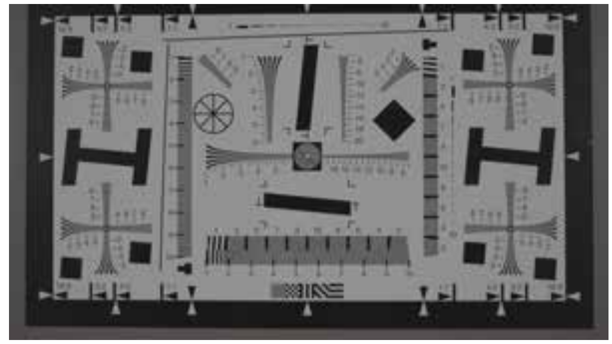

Fig. 54. ISO 12233 chart captured by Canon 5D

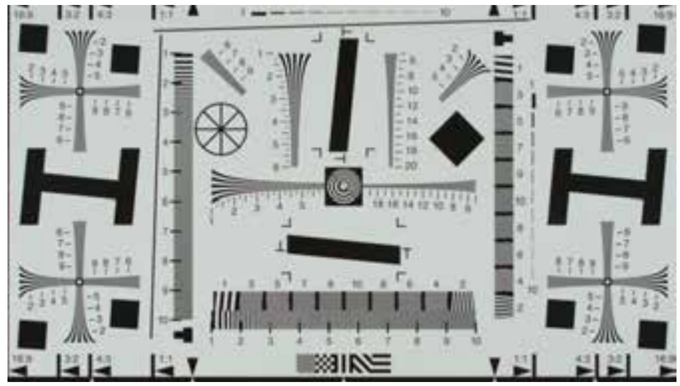

Fig. 55. ISO 12233 chart captured by Blackmagic

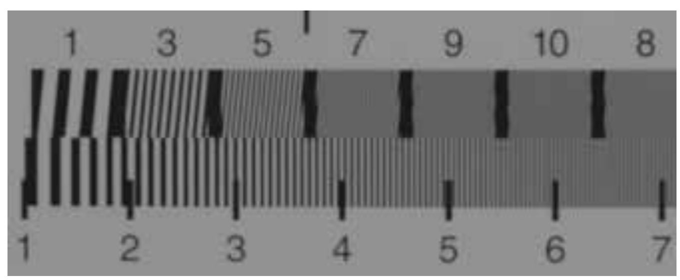

Fig. 56. Zoomed in ISO 12233 chart capture by Canon 5D

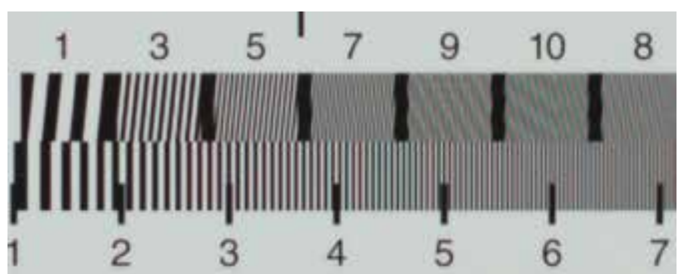

Fig. 57. Zoomed in ISO 12233 chart capture by Blackmagic

Both Figures 54 and 55 show the images on the ISO 12233 chart taken by both the Canon 5D and Blackmagic, respectively. Although hard to tell at first, a closer look can show that the Blackmagic has better resolving power in the higher frequency lines. Figures 56 and 57 zoom in on the bottom test lines that are either slanted or straight. They are also shown at varying frequencies to test the resolving power and aliasing that comes with each camera. The patch that has the number nine above it is a great example of comparing resolving power between the two cameras. The 5D's image has no distinguishable lines which makes the patch of lines a uniform gray area. The Blackmagic's image, however, produces noticeable lines.

Although the Blackmagic has better resolving power, it has a serious problem with chromatic and spatial aliasing in the higher frequency patches. Looking at the same number nine patch on the Blackmagic's image, there are bands of color that are in between the black lines. The spatial aliasing can be seen as the white bands that lie perpendicular to the black lines. The 5D's patch 9 does not have aliasing because there is not a frequency resolved. Although the 5D's image has lower resolving power, the aliasing within each patch is barely noticeable. Again this is due to the anti-aliasing filter that comes with the 5D where the Blackmagic lacks the said filter.

D. Noise Analysis

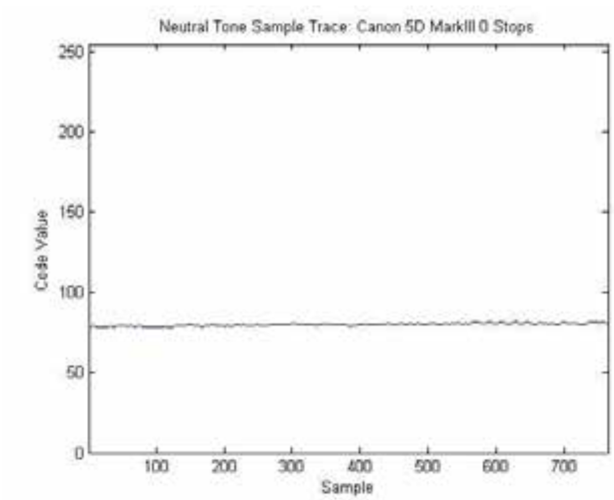

Fig. 58. Noise profile of 5D at normal exposure

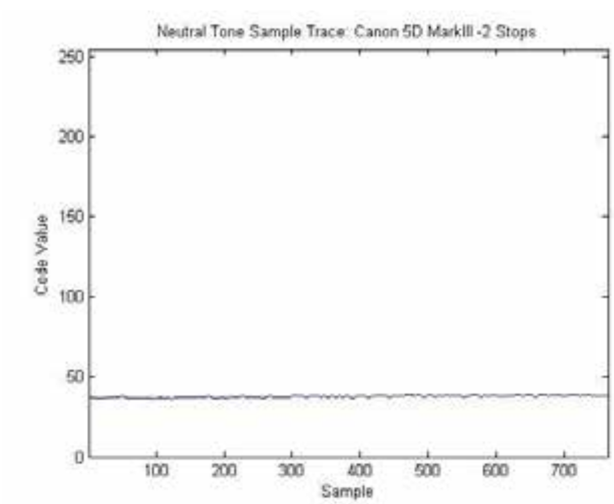

Fig. 59. Noise profile of 5D at -2 exposure

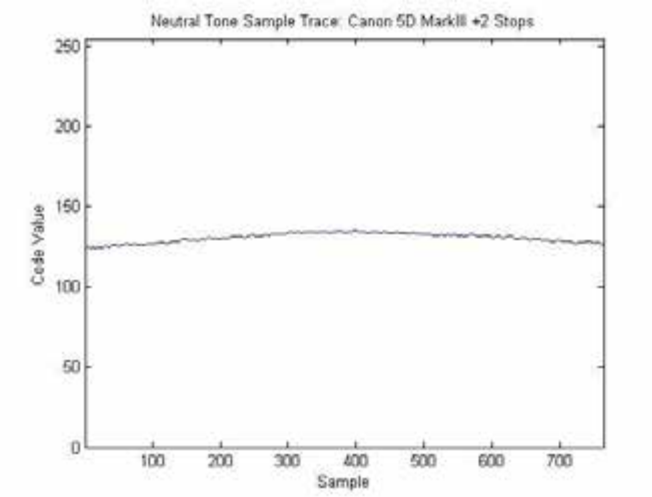

Fig. 60. Noise profile of 5D at +2 exposure

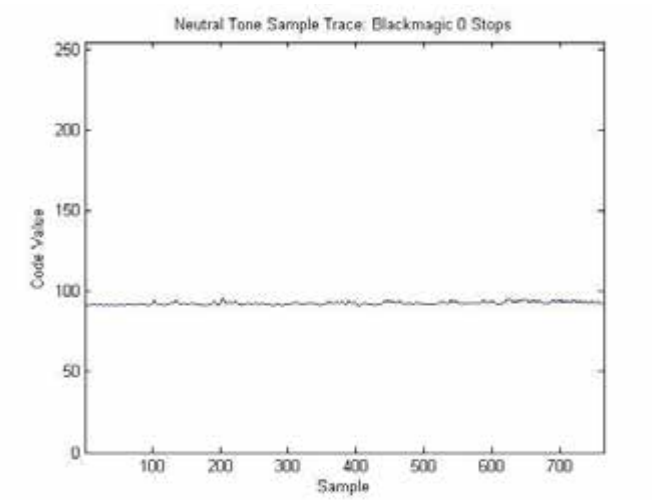

Fig. 61. Noise profile of Blackmagic at normal exposure

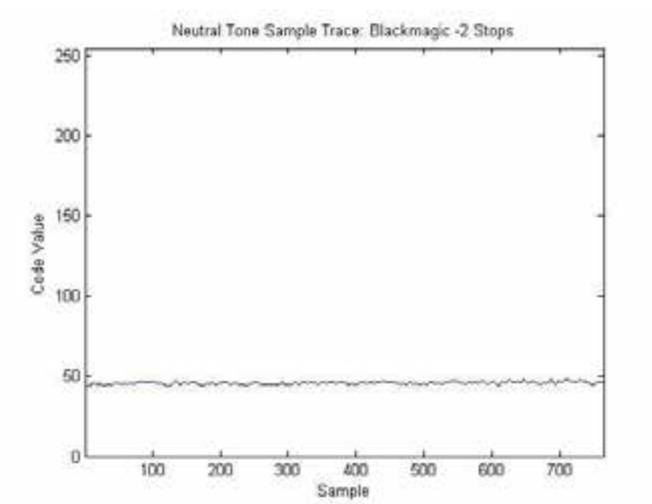

Fig. 62. Noise profile of Blackmagic at -2 exposure

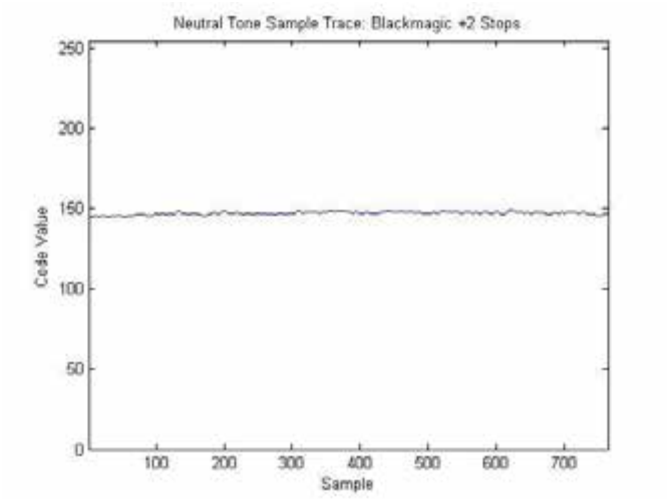

Fig. 63. Noise profile of Blackmagic at +2 exposure

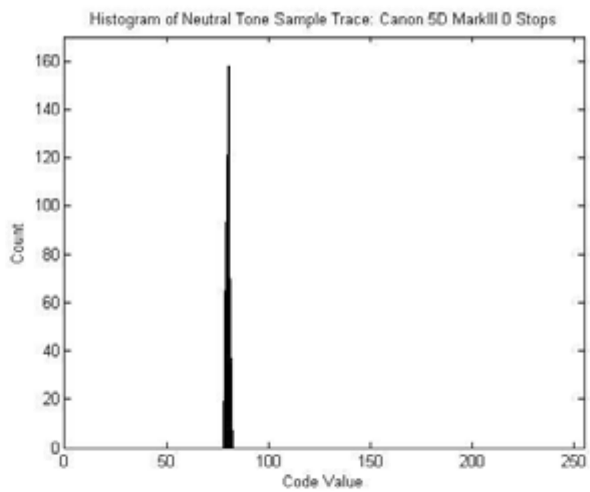

Fig. 64. Histogram of sampled grey card patch shot with 5D at Normal Exposure

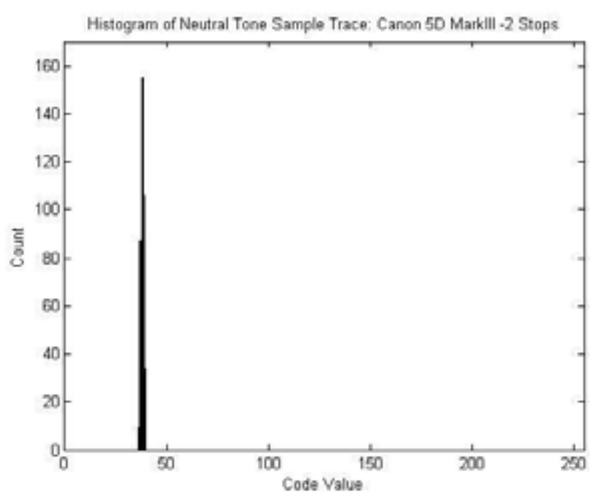

Fig. 65. Histogram of sampled grey card patch shot with 5D at -2 Exposure

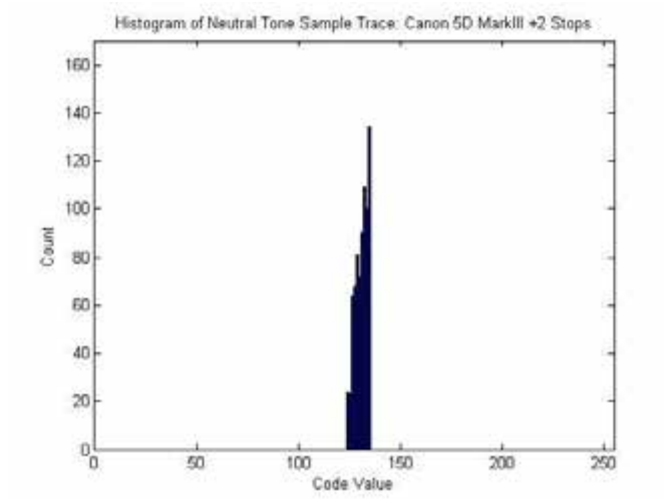

Fig. 66. Histogram of sampled grey card patch shot with 5D at +2 Exposure

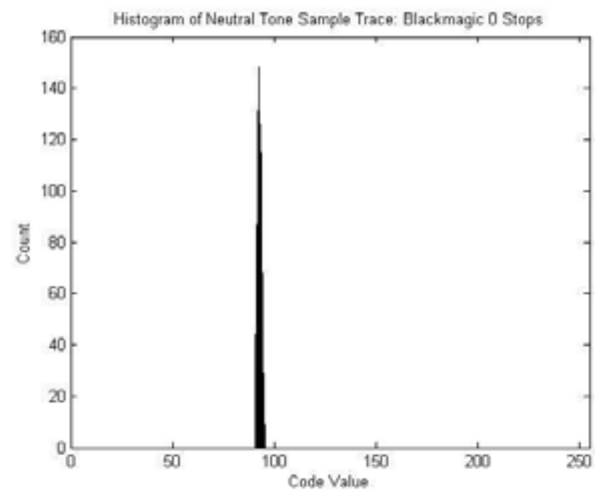

Fig. 67. Histogram of sampled grey card patch shot with Blackmagic at Normal Exposure

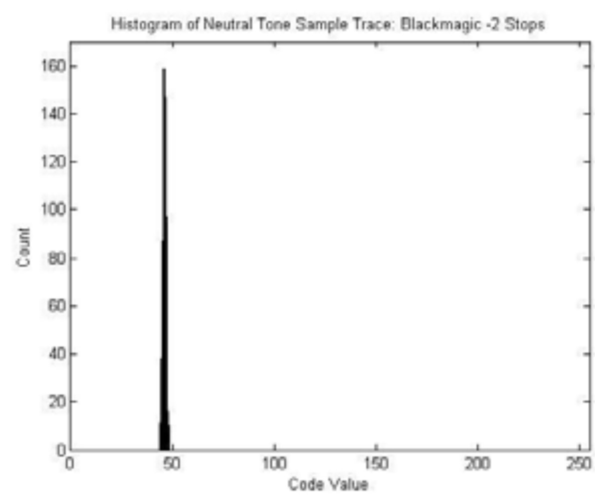

Fig. 68. Histogram of sampled grey card patch shot with Blackmagic at -2 Exposure

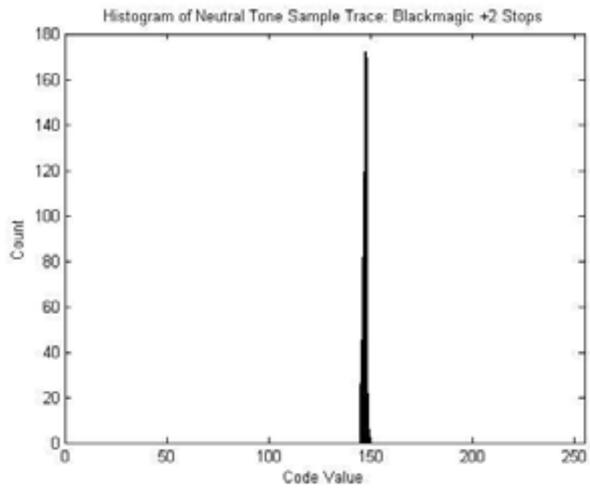

Fig. 69. Histogram of sampled grey card patch shot with Blackmagic at +2 Exposure

The noise was calculated with the gray card images from both cameras. Each camera captured the gray card at normal exposure and then two stop over and underexposed. The noise is calculated within the green channel for each image due to the how the human visual system perceives green light more than other light. The sample of the gray card that was used to calculate noise was five pixel heights by 765 pixel widths (which almost spans the whole width of the gray card). By moving a 5x5 area over the sample from the gray card pixel by pixel, an array of averaged values were taken. The standard deviation of this array would then provide the noise of the uniform area of the gray card. The noise values from the calculations are in the table below.

Table VIII
Standard Deviation of Grey Card Sample Representative of Noise

Stop	Canon 5D Mark III	Blackmagic
0	0.8604	0.9031
-2	0.6674	0.7994
+2	2.9168	0.8934

Further, the noise profiles of each set of images can be seen in the figures above. The noise profiles of each exposure condition with each camera seem to be the same with the exception of the gray card captured at +2 stops with the 5D. The 5D also has a slightly lower code value count because of the inherently darker image from the camera. The noise with each image is incredibly low. This shows that the noise associated with each camera may not even be noticeable without a trained eye. Capturing an overexposed scene with the 5D produced a bow in the noise profile. Although the standard deviation says otherwise, the image is not as noisy. The bow that manipulated the data could've been caused by non-uniformity in the lighting set-up.

The histograms above were produced to show the uniformity of the code values across the gray card. Each image produces a histogram indicative of a uniform gray value. The overexposure of the 5D has the widest distribution of code values which further confirms that the lighting on the gray card was slightly non-uniform.

E. Composite Edge Line Analysis

Fig. 70. Cropped and zoomed in sections of both cameras composite scene

In our first comparison (figure 70), we look at the edge between the lightsaber and the green screen. By analyzing a 1D edge scan of this area (outlined in red), we can view the pixel counts in each color channel. This allows us to determine the quality of the edge with respect to being "clean", meaning that it will provide a useful key during the compositing process. In our first graph (figure 71), you can see that the green channel persists across the pixel range, which is to be expected. By viewing the distance between the lower and upper asymptotes of the edge scan, you can determine how clean an edge is. The Blackmagic clearly has a larger range between the lower and upper asymptotes in the blue channel, with respect to the Canon. This further proves our visual analysis of the lightsaber having a "cleaner" key with the Canon 5D.

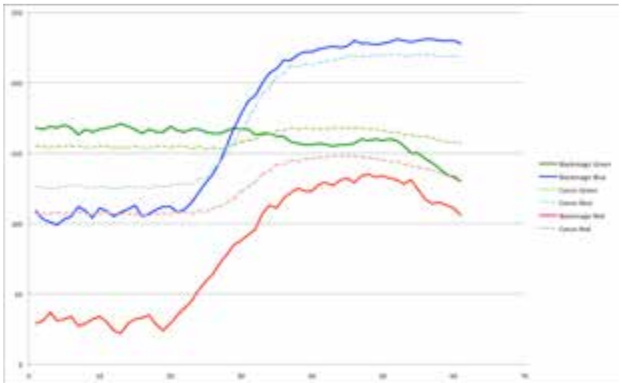

Fig. 71. Edge scan comparison of blue lightsaber on green screen

Fig. 72. Cropped and zoomed in segments of high frequency hair

In our second comparison (figure 72), we attempt to assess the detail in the high frequency content of the hair. Unfortunately this content is so high-frequency that an edge scan comparison is too noisy to be of use. Through visual comparison we notice a small amount of softness in the Canon that actually contributes to the solid and clean look of the hair. The Blackmagic appears sharper but also noisier, and has weaker defined edges for certain sections of the hair. It would be hard to tell from this picture alone which camera handled the test better, but in the Shootout comparisons, our team noted that the Canon 5D had a noticeable advantage in the compositing process.

Fig. 73. Cropped and zoomed in of low frequency robe

In our last comparison (figure 73), we are assessing a low frequency scene item that is moving at a high speed, in an attempt to capture the effect of motion blur on a "clean" edge. The red region of the figure shows the area of the robe that was used in the edge scan comparison. When looking at the curves (figure 74), we notice immediately both the short range and the steep slope of the edge produced on the Canon5D. Much more noise and variability is captured by the Blackmagic, leading to a lower quality and "dirtier" edge.

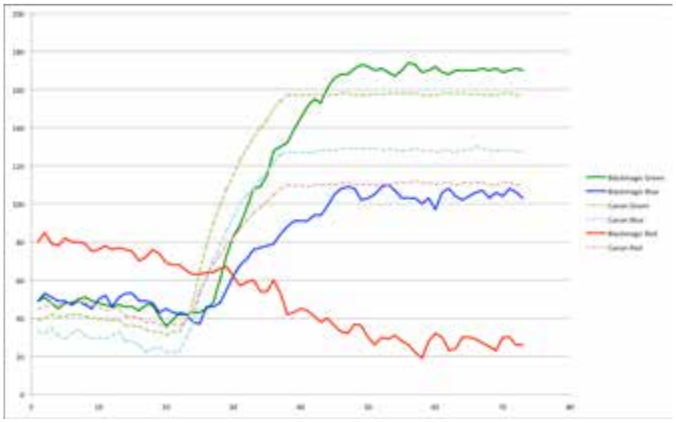

Fig. 74. Edge scan comparison of brown robe on green screen

Overall it is clear to see how our team assessed the Canon 5D Mark III as the superior camera for composting scenes in from of a green screen. And it's counterpart, the Blackmagic Cinema Camera, was not able to perform on the same level.

F. Color Reproduction Analysis

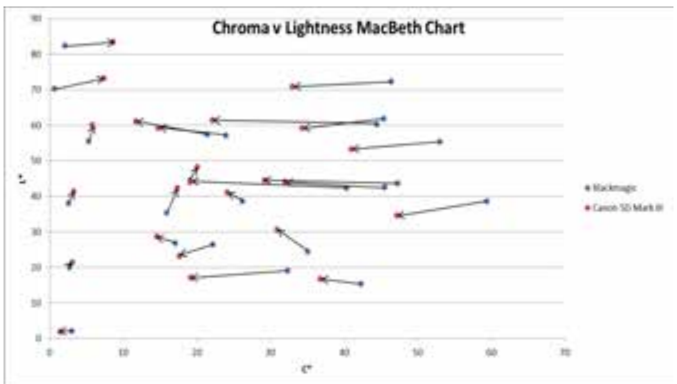

Fig. 75. Comparison of lightness and chroma in a L*a*b* colorspace

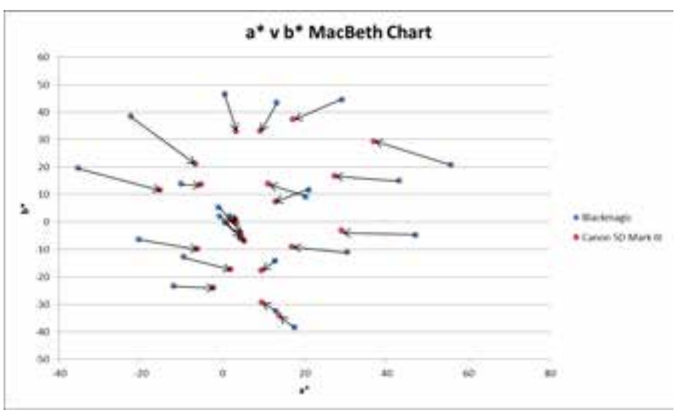

Fig. 76. Comparison of a* and b* in a L*a*b* colorspace

As you can see in the figures above, the appearances of the MacBeth chart captured by both cameras are confirmed. Figure 75 shows that the graph represents the Lightness and Chroma space of the MacBeth chart. All the points represented on the graph are the different patches from the chart. The arrows indicate a difference between both cameras in the lightness and chroma from the same patch. The trend from the graph shows mostly horizontal lines pointing from a higher chroma with the Blackmagic to a lower chroma with the Canon 5D. This is not the case with the gray-scale patches that can be seen on the far left of the graph. This is indicative of more saturation in all non-grayscale colors from the image captured by the Blackmagic. This is possibly due to the LUT applied to the Blackmagic which seems to give a saturation boost to the images. The 5D was hero-matched to match the grey-scale values shows on the graph. The lower gray-scale values are very close in lightness and chroma. The 5D's image however is still less saturated because the hero-match cannot exactly match the hues to the Blackmagic's hues.

In figure 765, the a* versus b* graph further confirms the more saturated look of the Blackmagic. All of the difference arrows are pointing towards the center which means the 5D has hues that have low a* and b* values which indicates a less colorfulness than the Blackmagic.

VIII. Conclusion and Recommendation

In conclusion, the 5D has better skin tone reproduction, more details in the shadows, creates a sharper image, and has an overall better color reproduction. In comparison, the black magic which is a less expensive camera, has more details in the highlights, has a greater exposure latitude, and is extremely easy to use. Based on these findings, the Canon 5D MK III was chosen as the better camera overall for strictly image quality, however this is only a viable conclusion when your workflow is RAW and contains the necessary knowledge to handle the color grading implications. The Blackmagic Cinema Camera has the best out of the box and easy to use workflow in relation to footage that is ready for exhibition straight out of the camera, when shooting in a pre-processed video mode.

Other recommendations in addition were that in using the Blackmagic Cinema Camera, the user should be aware of the chromatic aliasing issues as well as the functionality limitations when using lenses that lack a manual focus. It is also important to note that if choosing to use the Canon 5D Mark III, the requirement of magic lantern to achieve a RAW workflow will require research and work in order for full implementation.

IX. References

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[6]https://www.blackmagicdesign.com

[7]http://www.usa.canon.com/cusa/consumer/products/cameras/slr_cameras/eos_5d_mark_iii

[8]http://magiclantern.wikia.com/wiki/ISO

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X. Team Reflection

Our group functioned well as a team, with each member possessing skillsets that overlapped in terms of production capabilities. Everyone possessed individual strengths that were applicable to the final project. Also in terms of equipment, anything involved in the post-production workflow of the black magic was incredibly easy to use. The most drastic issue being the internal f-stop control requiring a "tricking" of the camera to adjust it to the desired aperture. This was due to the lack of a manual f-stop control on the blackmagic, meaning internal software would choose an f-number based on scene exposure when the "iris" button was pressed prior to shooting. We needed to aim the black magic at either a bright or dark surface and repeatedly press the iris button until the desired f-number was acquired.

The most difficult issues involved equipment. Overall, having to use ND filters as well as available lenses incurred a lot of problems (either in acquiring the necessary equipment or in the application of the equipment during shooting). Other difficult areas were related to time-management on sets, with our group often being the assumed "quick" group so often that we would be left with minimal time to do shooting. Ultimately, enough information was gathered for quantitative and qualitative analysis to the point that having to rush through scenes was not a significant issue.

Additionally, on the second day of shooting both the CF card and power cord were not present due to the owner's prior use. We had to quickly reach out to individuals with 100x CF cards and stores that would potentially carry the correct voltage charger. Luckily after a short time we were able to locate a friend with the proper CF card and buy another power cable. This could have been easily avoided by checking the equipment the night before.

Initially, pre-production went very well. Our team constructed a timeline, workflow, and scenes (with accompanying lighting diagrams) that would test varying image quality attributes in our two cameras. As this was a multi-team shoot, it was necessary to determine the best scenes from each group to be used by all. The general merging of pre-productions was a bit shaky due to scheduling issues and the adequate sharing of documentation. Although once complete, our pre-production planning was a great base to begin the production portion of the shootout.

As a whole, production went as good as can be expected given the large group size and simultaneous scene shooting. As a team we functioned smoothly and efficiently. Both camera operators learned the various functions and menus of of their respected shooting device days prior saving setup time. Additionally, the entire team either completed or was currently enrolled in a Production Processes class greatly increasing set efficiency. Again, given the large nature of the shoot, our team experienced a fair amount of down time while some of the more complex cameras, such as one team shooting 35mm film, took time to set up. Despite typical delays experienced on set, we wrapped set on time each of the three days of shooting while completing all of the necessary shots and takes.