ACADEMY OF PERFORMING ARTS IN PRAGUE

FILM AND TELEVISION FACULTY

Department of Cinematography

Master of Fine Arts in Cinematography

MASTER'S THESIS

LARGE FORMAT AND FILM LANGUAGE

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Examiner: Marek Jícha

Date of thesis defense: 30.1.2023

Academic title granted: MgA.

Prague, 2023

AKADEMIE MÚZICKÝCH UMĚNÍ V PRAZE

FILMOVÁ A TELEVIZNÍ FAKULTA

Katedra kamery

Master of Fine Arts in Cinematography

DIPLOMOVÁ PRÁCE

VELKÝ FORMÁT A FILMOVÝ JAZYK

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Oponent práce: Marek Jícha

Datum obhajoby: 30.1.2023

Přidělovaný akademický titul: MgA.

Praha, 2023

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Large Format and Film Language

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Acknowledgments

This thesis originated at the Academy of Performing Arts in Prague as part of the project “Large Format and Film Language”, supported by special-purpose funds intended for the specific tertiary education research provided by the Ministry of Education in 2021.

I would like to extend my gratitude to all of those who contributed to the completion of this thesis. Special thanks go to Dominik Dusek, Zoran Perič and from ARRI Rental Prague, Ondřej Teplý, Jin-Yuan Liu, Patrick Gregg, Riyana Lama, Bruno Grandino, Shubham Mhatre, Josef Kader Agha, Melania Hamasyan, Jan Matýsek, Jana Chmelařová, and Silvie Demartini, who made the test shoot possible.

Many thanks also to Richard Vacula, Benjamin Kolmačka, and Věra Hoffmanová at Studio FAMU, Marie Dostálová, as well as Prof. Vladimír Smutný for his valuable guidance and supervision, and Prof. Vidu Gunaratna for his consultation.

Keywords

Large Format, Digital, Cinematography, Camera Test, Film Language

Klíčová slova

Velký formát, Digitální, Kinematografie, Test kamer, Filmový jazyk

Abstract

Different formats of film and cameras have existed since the early days of cinema, ranging from 8mm to 70mm and IMAX. These formats have constituted an important choice for filmmakers and cinematographers to make in the early development of a film. The large format, defined as any size larger than the standard Super 35mm, was originally used for visual effects or more epic films on a grand scale. Since the introduction of digital large format cameras in 2014, they have been gaining popularity in film productions, having become more compact and accessible to filmmakers. The large format is no longer limited to a specific type of production or genre, as it can be used in both superhero action films and intimate dramas.

As the large format has gained popularity, it has also been a topic of discussion within the film industry, with many filmmakers and camera manufacturers advocating for it. However, there is a lack of in-depth research on the large format digital sensor, leading to various misconceptions and PR-driven descriptions. This study aims to provide a technical and artistic analysis of the digital large format sensor, as well as the factors that contribute to the so-called "large format look." This analysis is conducted through a visual comparison of a large format camera, the ARRI Alexa 65, and a Super 35 camera, the ARRI Alexa Mini. This helps to understand the appeal of the large format sensor today and whether or not the factors studied are a direct result of the larger size of the sensor.

Abstrakt

Od počátků kinematografie existují rozdílné formáty filmů a kamer, a to od 8mm do 70mm IMAX. Tyto formáty hrají důležitou roli pro filmaře a kameramany během brzkých vývojových stadií filmu. Velký formát, definovaný jako cokoliv větší než standardní Super 35mm, se původně používal pouze pro vizuální efekty a velké výpravné filmy. Od svého představení v roce 2014 získávají digitální velkoformátové kamery popularitu ve filmových produkcích, a to především pro svoji kompaktnost a celkovou dostupnost pro filmaře. Velký formát už není limitován žádným specifickým typem produkce nebo žánru. Své uplatnění najde jak v superhrdinských akčních filmech, tak v intimních dramatech.

Společne s jeho rostoucí popularitou se velký formát stal také tématem diskuzí uvnitř filmařské komunity. Děje se tak díky filmařům a především výrobcům kamer, kteří jsou propagátory tohoto formátu z mnoha důvodů. Nicméně i přes probíhající diskuzi existuje jen málo výzkumů, které se více do hloubky zaměřují na digitální velkoformátové snímače. Vede to nejen ke vzniku různých mylných představ, ale také textů psaných PR optikou. Tato studie si klade za cíl technickou a uměleckou analýzu digitálního velkoformátového snímače a současně zkoumá faktory přispívající k takzvanému “vzhledu velkého formátu.” Analýza je provedena prostřednictvím vizuálního srovnání velkoformátové kamery ARRI Alexa 65 a Super 35 ARRI Alexa Mini. To dopomohlo k lepšímu pochopení přitažlivosti dnešního velkoformátového snímače a též toho, zdali jsou zkoumané faktory přímým výsledkem velkého formátu snímače, či nikoliv.

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1. Introduction

Large format cinematography has gained popularity in recent years, with terms like "immersive," "changing film language," and "allowing closeness to characters" frequently used to describe it (Laxton; O'Falt). Since the introduction of the digital large format camera in 2014, filmmakers have increasingly opted for this option (Mendelovich, "2020: The Year of the Large Format Cinematography"), making it one of the most popular technologies in use and a constantly debated topic among cinematographers and at film festivals[1].

Large Format is defined as any format larger than the standard Super 35mm sensor size (18x24mm) (Holben 10). It should be noted that the term "format" refers here to the size of the sensor (or film) and should not be confused with aspect ratio, as it is referred to in some literature. In 2014, ARRI introduced the Alexa 65 (Fauer), marking the return of this format in digital form. ARRI was soon followed by major camera manufacturers including Sony, Panasonic, and Red.

Many productions now demand the "large format look" (Mendelovich, "The Artistic Fatigue of Large Format Cinematography") and large format has become a trend in the film industry worldwide (most films selected for the annual Cinematography-focused Film Festival Camerimage in 2022 as well as those nominated for the 2022 Academy Awards, and at least one third of the films in competition at the 2022 Cannes Film Festival were shot with a large format camera [Shachat]). However, there have been few

[1] At the cinematography-dedicated Camerimage Film Festival, a number of talks and masterclasses on the large format cinematography are held every edition for a few years now, such as "ARRI ACADEMY MASTER CLASS - How to master large-format digital capture with cinematographer James Laxton" and "New creative choices: Shooting Full Frame with Sony's CineAlta VENICE" in 2018, and "ARRI Rental Presentation: Meet the Historic 65mm Camera ARRIFLEX 765" and other SONY Venice presentations in 2021.

in-depth studies on large format beyond common misconceptions or marketing materials, and none that examine whether the common motivations for its use by filmmakers are technically accurate or the specific tools that create the "large format look," if such a thing exists. Most information about large format comes from articles covering its use in specific films and technical brochures or marketing materials from camera manufacturers. These sources have rarely been questioned or thoroughly examined. Two notable studies on the subject are cinematographer Steve Yedlin's (“Resolution Demo”), which focuses on resolution, and a study by Manuel Lübbers from the University of Television and Film Munich (Lübbers), which this study is partly based on. Lübbers refutes some misconceptions and confirms others without exploring the effect of his results on the viewer or film language.

Many commonly accepted ideas about large format today still come from its film days or medium format photography (Longwell). The rest is mostly based on its use by different cinematographers and filmmakers, who have often said that large format directly affects film language (Laxton; Mendelovich, “2020: The Year of the Large Format Cinematography”; O’Falt). Some have said it creates an immersive feel (Dillon 34), which they attribute to the larger film plane size and consequently larger field of view, shallower depth of field, higher resolution, and (as commonly accepted but not proven) a shift in perspective and different compression of space that puts the subject closer to the camera and creates more distance between the subject and the background (Tangcay).

While all these elements are important for shot composition and framing and therefore affect the viewer, how much of this is directly caused by the size of the sensor? In other words, how does the large format itself affect the viewing experience and film

language? This study aims to provide a technical and artistic analysis of the digital large format sensor and the factors that make up the "large format look" by visually analyzing a comparative test between the large format ARRI Alexa 65 and the Super 35 ARRI Alexa Mini. This helps understand the appeal of the large format sensor today and whether the factors studied are a direct result of the larger sensor size.

2. History

In order to understand the reason large format cinematography is taking over productions today, it is important to go back to the reason various larger formats have been a point of interest for many photographers and cinematographers throughout history. Ever since the early days of photography, photographers experimenting and attempting photographic reproduction have used large photosensitive plates and material ranging in size from 15 cm to 20 cm, as noted by Holben (10). As photographic films evolved, camera companies released new sizes and formats, such as Kodak Brownie (56x41.5mm) in 1901 and Leika's 24x36 mm film (what is known today as "Full Format" or "Full Frame") in the 1920s and so on. It allowed photographers to have the maximum amount of definition, great details, finer grain and better tones as well as the possibility of bigger enlargements of their pictures, with many applications in commercial, artistic and landscape photography (Yang 1789).

When it comes to cinema, even though the Super 35mm (18x24mm) is considered a standard in the film industry (Belton) and the 16mm film also commonly used (Goi & ASC, 2013, p. 120), the 65mm film was also introduced in the very early days of cinema. As Holben mentions in his article:

> As early as 1897, Enoch J. Rector exhibited Veriscope, a 63mm-wide film stock that captured a famous boxing match. We've had several waves of experimentation with larger film sizes, including more than a dozen formats that debuted during the 1920s and '30s, and, of course, those that appeared during the widescreen wars of the 1950s. (Holben 12)

The appeal of going larger when shooting on photographic film is linked to the fact that resolution on such a medium is largely defined by the actual size of the film plane, as well as the emulsion of the film and film speed, and, unlike in digital cinematography, less so by the choice of camera. Regardless of whether a film is being shot on 16 mm, 35 mm, or 65 mm film, the grain or silver halides are all the same size. However, once the film is projected, the smaller the format, the bigger the grain will appear on screen because it is subject to greater magnification. For example, the entire image on 16 mm film comprises a smaller number of grain in total than a 35 mm image, so when projected, the grain takes up a larger area of the screen and becomes more visible on 16 mm footage than on 35 mm. This results in larger formats appearing to have finer grain when viewed on the same screen, and therefore a higher resolution, leading to increased sharpness, contrast, and better color reproduction, as well as a higher resolving power, or the film's ability to capture fine detail (*The Essential Reference Guide for Filmmakers* 54–56). This also led to the use of 65 mm and 70 mm film stock for films or scenes featuring large sets or landscapes, in order to achieve the maximum level of detail that would not have been possible on 35 mm or 16 mm film.

According to Mieke and Schwärzel from ARRI Rental and KODAK, the use of 65mm and 70mm film reached its peak in the 1960s, with films like *Ben Hur* (1959) and *Lawrence of Arabia* (1962) being shot in these formats. At the same time, CinemaScope was trying to compete with the emerging threat of television. In this context, large format film presented an alternative for achieving better definition, finer grain, and a larger image to attract audiences to movie theaters. Later, Mieke explains that the French New Wave movement of the 1960s led to a shift towards smaller, more compact productions, including the cameras used. As a result, 65mm and 70mm formats took a back seat.

That changed with the digital revolution of the 2010s. The digital takeover of the film industry paved the way for a resurgence of large formats, as predicted by technology engineer Ed Lantz already in 2003. He pointed out that "the benefits of converting to digital are amplified by the large-format medium – large-format cameras are much more heavy and bulky than their 35mm cousins, and large-format film is expensive to process, scan, and print" and that "recent developments in large-format video projection are now approaching the performance required to reproduce large-format film resolution" (Lantz). In 2014, camera company ARRI released the first large format digital camera, the ARRI Rental Alexa 65, which was initially intended as an effects plate camera (Heuring 22). However, as the format gained popularity among filmmakers, more and more companies released their own large format digital cameras. The more compact size of these cameras made them more accessible to filmmakers.

Today, both 65mm film and large format digital cameras are popular among filmmakers (Mendelovich, “The Artistic Fatigue of Large Format Cinematography”; Mieke and Schwärzel). In recent years, numerous major productions, such as *Tenet* (2020) and *No Time to Die* (2021) among others[2], have been shot on 65mm film, while a large number of films and TV series have been shot using large format digital cameras, such as *Tár* (2022) (shot on ARRI Alexa 65), *Bardo, False Chronicle of a Handful of Truths* (2022) (ARRI Alexa 65), both winners at the cinematography-focused 2022 Camerimage Film Festival, as well as *Dune* (2021) (ARRI Alexa LF), *Nightmare Alley* (2021) (ARRI Alexa 65), and *The Power of the Dog* (2021) (ARRI Alexa Mini LF). These productions were nominated for the Best Cinematography Award at the 2022 Academy Awards,

[2] Between 2010 and 2021, 14 films have used 65mm film and shot on ARRI’s Arriflex 765, double the number from the previous decade. (Mieke and Schwärzel).

where over 65% of the nominated films were shot in large format cameras, compared to only 35% in 2020 (Mendelovich, “Large Format Cinematography as the New Standard”). Additionally, more than half of Netflix's original movies in 2020 were shot on large format cameras (Mendelovich, “The Cameras Behind Best Netflix Original Movies of 2020”). This trend raises the question: what is driving the new trend in digital large format cinematography? And does a certain look play a role, as some filmmakers and camera companies claim?

3. Comparative Test

3. 1. Approach

To understand the impact of large format cinematography on film language, we compared it with the standard Super 35mm format, which is the most common format in digital cinema cameras today. Our goal was not just to record a camera test with color and resolution charts, but to capture shots that would mimic on-set conditions with an actor performing an action on location, in multiple shot sizes, and specific changes chosen for the purpose of this research. By doing this, we were able to visually analyze and compare how the shots in each format differ, and isolate and identify the technical and creative elements that caused these changes. This study was based in part on Manuel Luebbers' study from the University of Television and Film Munich (Lübbers), with the goal of going further to understand the effects of certain changes on image composition and, subsequently, film language.

3. 2. Camera Choice

To ensure accurate results, the choice of cameras was important. ARRI's Alexa 65 and Alexa Mini were selected as they both feature the same ALEV III sensor (*ALEV Sensors*), including on the Alexa LF, which is made up of two sensors stitched together. This allows for the minimization of differences resulting from different sensors, such as color science, and allows for the use of the sensor's large pixels. Both cameras also have the same native ISO (800), same size of photosites (pixel pitch: 8.25 µm), and same dynamic range, recording a 16-bit image, as well as the same codec, allowing for a similar post-production workflow. The only difference is the total number of photosites due to the difference in sensor size.

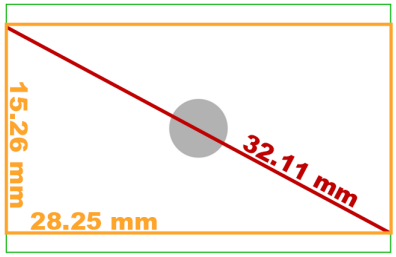
While all of the Alexa Mini, Alexa LF, and Alexa 65 cameras have a common sensor, comparing the Alexa LF would not result in differences which would be as visible, since the difference in sensor size is not as significant (in comparison to both the Alexa Mini and Alexa 65). To obtain the most visible results, it was necessary to use the sensors with the greatest size difference, leading to the selection of the Alexa 65 with a sensor size of 54.12 x 25.58 mm, versus the Alexa Mini (28.25 x 18.17 mm), which was made available through ARRI Rental Prague.

3. 3. Technical Realization

The basic idea of the setup was to record the same shot with both cameras, while matching the angle of view but changing different factors, in order to study the main effects of the large format digital sensor. To record simultaneously, without using a stereoscopic setup due to logistical reasons and potential issues with contrast, sharpness, and color differences, we created a custom plate with the help of Karel Peprny from ARRI Rental Prague that could hold both cameras as close as possible to each other at a certain angle, allowing us to have the same field of view at a certain distance from the camera. However, this setup only works for shots that don't involve perspective, space compression, or crop factor, and requires a certain minimal distance. For these studied factors, we either placed the cameras in the same position or calculated the necessary position and angle to study certain aspects. We also had to consider the different aspect ratios of the cameras, so we chose to shoot for a 1.85 aspect ratio, resulting in a digital crop for both. Using ARRI's Frame Line & Lens Illumination Tool, we determined the actual dimensions and resolution of the sensor area for shooting ARRIRaw and Open Gate on both cameras.

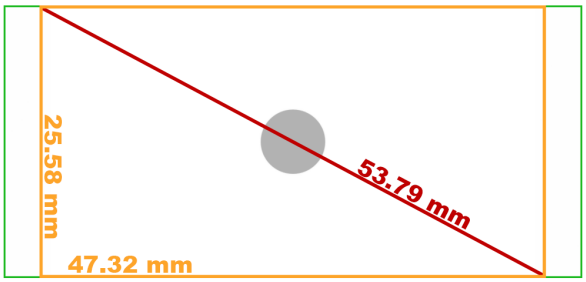
	Used Sensor Area Size (mm)	Used Sensor Area Resolution (pixels)
Alexa Mini	28.25 x 15.26 mm	3424 x 1850 pixels
Alexa 65	47.32 x 25.58 mm	5736 x 3100 pixels

To match the field of view of both cameras, we needed to calculate the crop factor, which is the ratio of the dimensions of a camera's imaging area compared to a reference format. In this case, we used the ratio of the diagonals of the used sensor areas, taking into account the 1.85 aspect ratio (“Crop Factor”).



ALEXA MINI

Figure 1 - Alexa Mini used sensor area with 1.85 aspect ratio



ALEXA 65

Figure 2 - Alexa 65 used sensor area with 1.85 aspect ratio

The crop factor would be calculated as follows:

$$Crop\ Factor\ = \frac{Diagonal\ A65}{Diagonal\ Mini} = \frac{53.79}{32.11} = 1.67$$

3. 4. Lenses

To match the shots between the two cameras, we needed lenses with focal lengths that would compensate for the difference in angle of view due to the different sensor sizes and that would work with both the Alexa 65 and the Alexa Mini.

To find the corresponding focal lengths for each camera, we multiplied the focal length by the crop factor. For example, the 45mm focal length on the Alexa Mini would become 75mm on the Alexa 65:

$$45 \times 1.67 = 75mm$$

However, we learned from Dominik Dusek at ARRI Rental Prague that the ARRI Rental Prime DNA lenses, which are often used with large format cameras, are not a reliable option for these tests because each lens has a unique look due to being made with vintage optics ("DNA lenses"). Therefore, we decided to use the following lenses:

- ARRI/Zeiss Master Prime 18mm T1.3
- ARRI Rental Prime 65 S 35mm T2.5
- ARRI Rental Prime 65 S 45mm T2.8
- ARRI Rental Prime 65 S 75mm T2.8

The 18mm Master Prime would be used only for wide shots on the Alexa Mini, while the remaining lenses could be mounted on both cameras.

In this case, we needed to do some cropping in post-production to match the angle of view, since the 18mm focal length on the Alexa Mini would correspond to a 30mm lens on the Alexa 65. Since we didn't have a 30mm lens, we used the closest available lens in this set (the 35mm) and digitally cropped the Alexa Mini shot slightly.

3. 5. Factors to Study and Role in Film Language

The choice of the factors to study was based, firstly, on the aforementioned qualities, such as changes in depth of field, space compression and perspective, resolution and field of view, alleged to comprise the “large format look” by cinematographers, filmmakers and camera manufacturers. These elements are also considered key components of image composition and the visual language of a scene or film (Ward 8), which makes the ability to manipulate them through the choice of format even more interesting, as it allows us to manipulate the visual information conveyed to the audience. As a result, our practical study focused on the following factors to investigate the potential effects of large format on the visual language of a film.

1) **Field of view**: Firstly, the most apparent effect a larger image plane could have on the image is a change in the field of view. Therefore, studying the field of view and consequently the crop factor would help visualize this effect of change in format size.
2) **Resolution**: Another appeal of a large format digital camera is its higher resolution, which is achieved through a larger sensor and increased pixel count. Comparing the resolutions of the two cameras allows us to demonstrate how the viewer might perceive this difference in practice. And because higher resolution usually leads to increased sharpness, better contrast, and more options for post-production treatment of the image, which can directly impact the cinematography and overall look of the film, it was important to test this factor.

3) **Perspective/Space Compression**: Perspective and space compression are fundamental components of image composition. Since the 14th century and the Renaissance, perspective has been an important focus in painting, allowing for a more accurate representation of space on a two-dimensional plane (Ward 9-10). Photography and cinematography have continued this tradition, as the way we view a space and the size ratio of elements in the frame can influence the viewer's perception of the space or characters in the shot. It is therefore important to study this factor and visually analyze whether or not the format size affects these two visual aspects of an image, as it is generally believed by filmmakers and film critics (O'Falt).
4) **Depth of Field**: Depth of field is another important technical aspect and artistic choice in a scene. It is considered a component of picture composition and an indicator of space (Ward 145) and has a direct impact on how the viewer reacts to the image. While it is well-known that depth of field is affected by changes in aperture opening, camera distance, and focal length (Ward 38), it is also frequently mentioned in discussions of the "large format look." Therefore, we tested different depths of field with different focal lengths on both the Alexa Mini and Alexa 65 to investigate the possible relationship between format size and depth of field.
5) **Noise**: Lastly, digital noise, although inherent to any digital camera, varies from one camera to the other. Its presence – or lack thereof – also alters the image, going from a more ‘polished’, soft, look to a more deteriorated or ‘rough’ one. As it is mostly observed in low-light situations, it was tested

under such conditions in order to identify the possible alleged link between the noise and the size of the digital sensor.

Moreover, distortion, also often mentioned as a part of the large format look (ARRIChannel 01:51), was excluded from this test as it is a factor that is highly dependent on the lens design itself, after a consultation with ARRI Rental's Dominik Dusek.

3. 6. Shoot

The shooting took place over two days and involved a focus puller for each camera, as well as 2nd assistant cameras who were responsible for calculating distances for camera positions. It was important to maintain precise and consistent camera positioning, including maintaining the same field of view when necessary. In addition, a gaffer and lighting assistant were responsible for setting up various lighting atmospheres, which were sometimes crucial for the scene. For example, they created low light conditions to test digital noise or achieved a specific T-stop for a desired depth of field. Lighting proved to also be an essential factor in relation to some of the elements being tested.

3. 7. Post-Production

After consulting with ARRI Rental, the footage from the Alexa 65, which was recorded in ARRIRaw, was transcoded into HDE, a lossless codec that reduces the size of ARRIRaw files by 60% (*Codex HDE*). To streamline the workflow, both the editing and grading were done in DaVinci Resolve.

Following consultations with Professor Vidu Gunaratna, it was decided to use the ACES workflow and the Rec709 color space. The clips were added to a sequence, synchronized, and any necessary post-production cropping and resizing was done to match the frames. Additionally, the use of different Neutral Density filters with slightly different spectral densities introduced some chromatic and contrast changes, and some lens-specific optical differences were also noted. Also, the small differences in camera positions meant that the light entering the lens from different angles caused some mismatched refractions and slight shifts in contrast and color. As a result, some color correction was needed to match the shots and reduce any differences that might be distracting during the visual comparison, provided they were not due to the difference in format. After color correction, the editing was done on a separate timeline, with the clips placed side by side and one after the other. Finally, the edited version was exported as a DCP, Flat 4K resolution, which was the resolution at which the screening would be shown.

3. 8. Screening, Analysis

The screening took place at the Studio Famu Reference Projection Room in 4K resolution, which allowed us to view the footage of the Alexa 65, shot in a resolution of 5736x3100px, on a large screen at a high enough quality to see the differences in definition, depth of field, and sharpness between the two cameras.

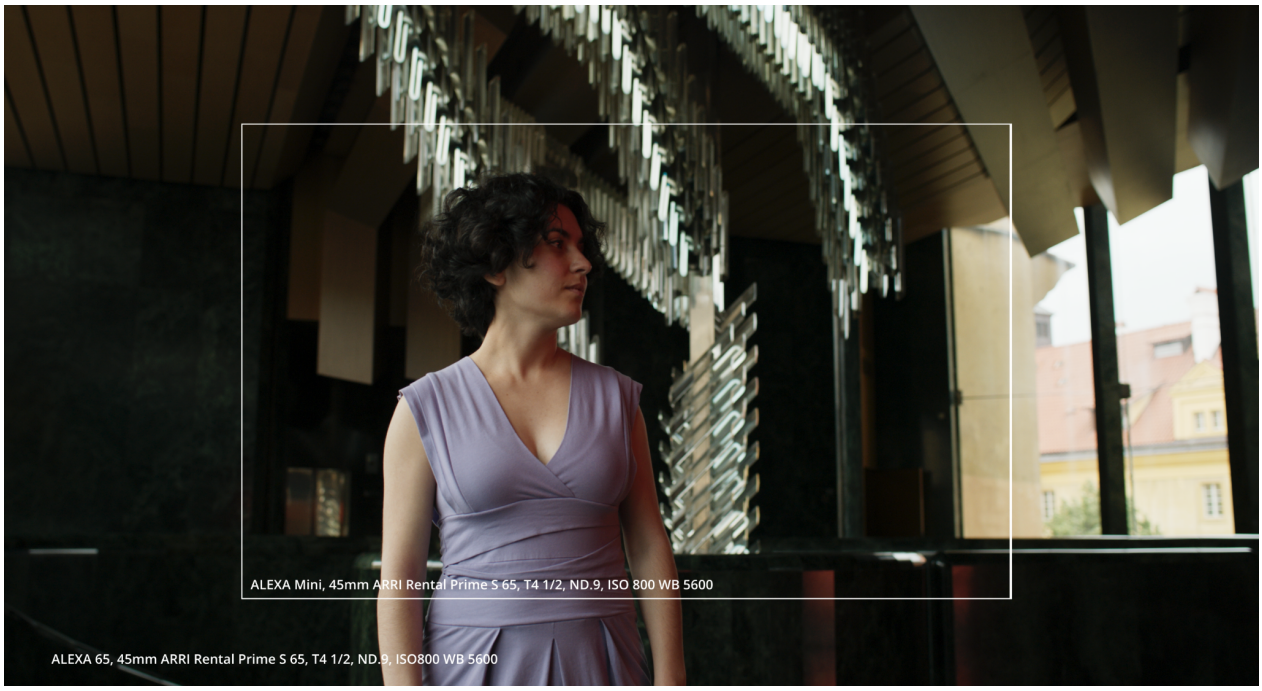
The analysis was conducted through a visual comparison of the footage, observing any noticeable differences, by the writer of this thesis, Zaher Jureidini, and Professor and Cinematographer Vladimír Smutný.

4. Results & Discussion

4.1. Angle of View/Crop Factor

To begin with, it is important to mention the difference between angle of view and field of view. As explained by Panavision in their white paper Sensor Size and Field of View, the angle of view is a “measure of the vantage point from the lens”, and is “constant for a given sensor and lens”, while the field of view is “length that the lens will cover at a certain distance” and is dependent, in addition to the sensor size and lens, to the specific distance measured of the subject from the camera.

Here, both cameras were in the same position, using the same lens (ARRI Rental Prime 65 S 45mm T2.8), with the subject at the same position.



Still 1 - Alexa Mini vs. Alexa 65 fields of view

The crop factor calculated earlier (1.67) between the two cameras is practically demonstrated in this result. The change in the size of the sensor clearly affects the angle of view, when using the same focal length, and in this case takes the shot from a Medium Shot on the Alexa 65, to something closer to a Medium Close Up on the Alexa Mini. It is also possible to calculate the angle of views (α) of the different formats using the following formula (*Sensor Size and Field of View*):

$$\alpha = 2arctan(\frac{sensor\ width}{2 \times focal\ length})$$

$$\alpha(Alexa\ 65) = 2arctan(\frac{47.12}{2 \times 45}) = 55.4°$$

$$\alpha(Alexa\ Mini) = 2arctan(\frac{28.25}{2 \times 45}) = 34.8°$$

And thus resulting in an approximate 20° angle difference, with the only variable here being the sensor width. Therefore, this change is a direct result of the sensor size change.

In order to get the same shot here, we would have had to use the crop factor to know which lens would give an equivalent angle of view at that same distance, or change the distance to achieve the same shot size with that same focal length. The equivalent lens on the Alexa 65 of a 45mm on the Alexa Mini would be:

$$45mm \times 1.67 = 75mm$$

Whereas the distance compensation to achieve the same Medium Close Up on the actress with the 45mm on the Alexa 65, would be to move the camera closer to her. However, changing focal length and camera distance would be affecting other factors, which we will explore and expand on later on.

4. 2. Resolution

To study the resolution, we shot simultaneously with both cameras, while matching the angle of view by compensating the focal length. To find the corresponding lens on the Alexa 65, we simply multiply the focal length used on the Alexa Mini with the crop factor, as mentioned earlier, resulting in the 75mm lens on the Alexa 65 and the 45mm lens on Alexa Mini.

Still 2 – Resolution demonstration of Alexa 65 and Alexa Mini at 100% digital magnification

Here, we observed the footage side by side at 100%, 200% and 400% magnification. The difference in definition is the most visible at 400% magnification, as seen in *Still 3*.

Still 3 – Resolution demonstration of Alexa 65 and Alexa Mini at 400% digital magnification

However, even at 100%, screened and observed in 4K, it is slightly visible that the definition of the Alexa 65 is better than that of the Alexa Mini, especially since the Alexa Mini's resolution is slightly less (3424 x 1850 pixels) than the screening quality, while that of the Alexa 65 is bigger. This suggests, as mentioned by cinematographer David Stump, ASC (140), that the viewing quality plays a major role in being able to view the footage at its best definition.

The higher resolution of the Alexa 65 would also allow some post-production reframing, in case it was needed. It would be possible to go up to 160% magnification without losing any quality for a 4K delivery, in case it was shot in its maximum resolution, 6.5K.

In analog photography, a larger film plane, such as 65mm, would typically have higher definition than a smaller film plane, such as 35mm, because the film grain of the

larger film plane would appear finer and the image more defined when projected. In digital cinematography, the resolution of a sensor is defined primarily by the number of pixels it contains, or more specifically the number of photosites capturing luminosity information. For example, the Red Monstro VV, a large format camera, has a sensor size that is smaller than the Alexa 65, but a maximum resolution of 8192 x 4320 pixels, which is larger than the Alexa 65's.

It's worth noting that the number of pixels or photosites is not the only factor that affects the resolution of an image. Other digital and optical elements, such as the Point Spread Function, Modulation Transfer Function, Spatial Frequency, and Resolving Power, also play a role (Goi and ASC).

4. 3. Perspective/Space Compression

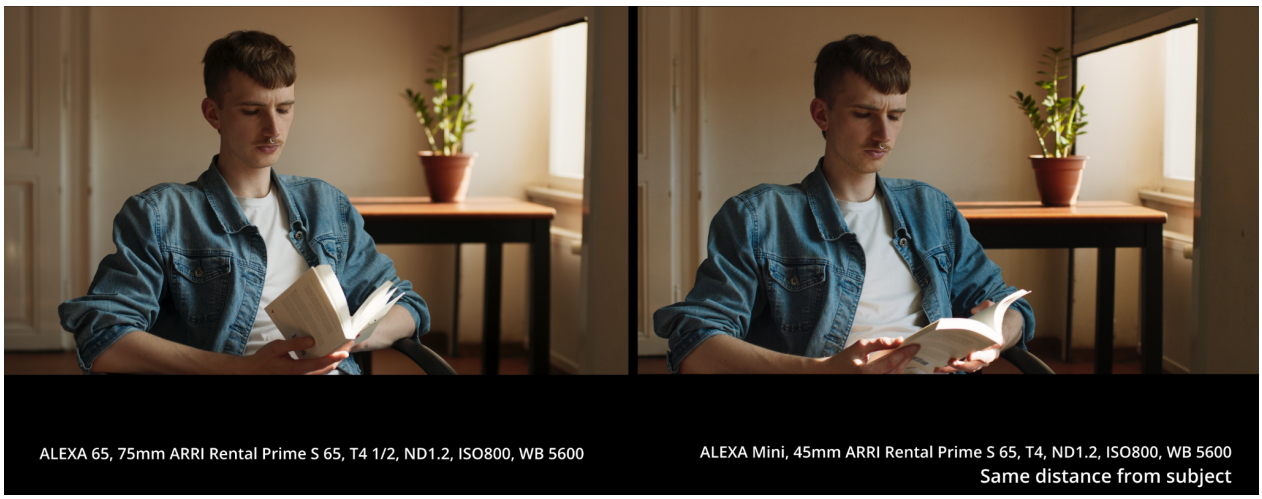
Understanding the impact of camera format on perspective and space compression is important for cinematographers and filmmakers who want to create a specific visual language for their projects. The use of large format cameras, with their larger sensors and longer lenses, is often cited as a way to alter perspective and space compression in a shot (O'Falt). It is often argued that the use of longer lenses for a given angle of view on large format cameras has a direct impact on perspective and space compression, such as compressing the space more and altering the foreground to background ratio. Given the importance of perspective and space compression in image composition and visual language, we wanted to test this idea.

To do so, we needed to determine whether the change in perspective or space compression is a direct result of the sensor size or the use of different focal lengths. To

compare, we used two different techniques to match the field of view at a given subject distance. The first technique (Still 4) involved changing the camera distance from the subject while keeping the same focal length on both cameras. We used the crop factor to find the corresponding camera distance for the same focal length on the different formats. This is because the field of view is proportional to the sensor width, which is inversely proportional to the crop factor (as demonstrated in the formula for finding the crop factor).

Still 4 - Demonstration of space compression and perspective, while changing camera position

The second technique (Still 5) involved matching the field of view by changing the focal length while keeping the same subject-camera distance. For this technique, we used the 45mm lens on the Alexa Mini and the 75mm lens on the Alexa 65.

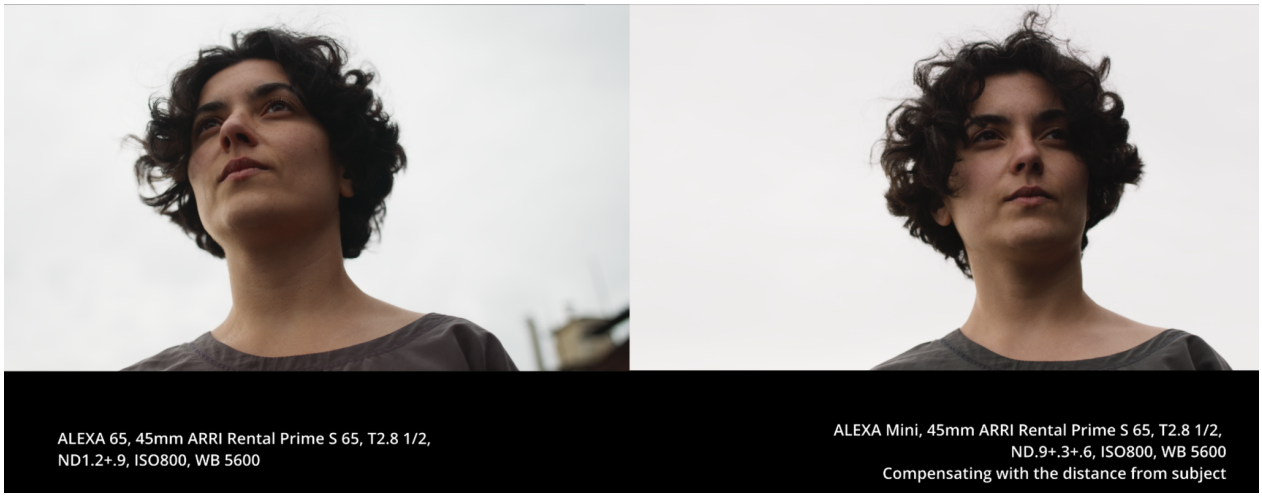


Still 5 - Demonstration of space compression and perspective, without changing camera position

In the first test, a change in image compression and perspective was visible, while no noticeable changes were observed in the second test, despite the Alexa 65 having a longer lens. This suggests that focal length or sensor size do not directly affect image compression or perspective, but that a change in perspective was only noticeable when the camera was moved closer to the subject. This suggests that the camera distance from the subject and its position in space are what affect perspective or space compression.

Perspective is the result of the camera position in space from which the cinematographer chooses to capture a scene. This is because the angle and position of the camera in space affect the angle of convergence and the position of the vanishing point in the frame, as well as the foreground to background ratio. When the camera is moved closer to the subject (as in the first example), the subject appears larger compared to the space/background and the angle of convergence is more pronounced, causing lines in the frame to become less horizontal and increasing the dynamic of the frame (Ward 48).

The subject-background ratio does not change when the camera position stays the same. This is because, like with the human eye, the perception of the size of a known object changes according to how far or close it is to us. Therefore, the size relationships in the frame are a direct result of the distance between the subject or elements in the frame and the camera, and from each other (Ward 46). In the first example, more of the wall in the background is visible, the lines are more angled, and the subject appears closer to the camera as it is larger in the frame. This creates a sense of intimacy and exposes more of the space to the viewer, as some filmmakers have noted while using this format, describing it as more "intimate" or "immersive" (Laxton). However, it should be noted that this was only the result of a combination of a particular camera positioning and the choice of focal length. In addition, proximity to the subject also affects the tilt/pan angles of the camera as well as the depth of field in the shot (which we will discuss later), as can be seen in the third example (Still 6).



Still 6 - Demonstration of space compression and perspective, while changing camera position

In this example (Still 6), matching the field of view by only moving the camera closer to the actress on the Alexa 65 and using a wider lens (left) results in a larger tilt of the camera and a lower angle view of her face, as well as viewing more of the space around her, which affects the structural skeleton of the shot and makes the image more dynamic, ultimately affecting its impact on the viewer.

It's important to remember that, although these changes are not a direct result of the sensor size, all of the factors that do affect the shot (focal length and camera position) are interconnected with the choice of sensor size as well.

4. 4. Depth of Field

To compare the differences in depth of field on the different formats, we shot the same shot, at the same camera distance from the subject, and therefore matched the angle of view by compensating with the focal length by using the crop factor, with the 75mm on the Alexa 65 and the 45mm on the Alexa Mini. In this first example below, we used the same f-stop 2.8 on both cameras.

Still 7 - Comparison of the two cameras' depth of fields at the same f-stop

We can notice that the background is more out of focus with the Alexa 65 (left) than on the Alexa Mini. This is the result of the need to use longer lenses on the large format to get the same angle of view, from the same camera position (Stump 135). As cinematographer Steve Yedlin explains in his research, it is important to distinguish the difference between depth of field, circle of confusion and blur circles. Depth of field is a mere subjective standard, that means the area between the closest distance considered in acceptable focus, and the furthest (Goi and ASC 674). The blur circle and circle of confusion are closely linked to each other, although a blur circle constitutes the size of the blur relative to the subject of the image, while the circle of confusion refers to the absolute physical diameter of the smallest blur on the image plane (Yedlin).

The blur circle size (C_B) is found with the following formula:

$$C_B = A \times \frac{(S_2 - S_1)}{S_2}$$

With A being the diameter of the aperture, S_1 the focused object plane distance, and S_2 the unfocused object distance. Yet, aperture here refers to the absolute aperture diameter, and not the f-stop which is the relative aperture, which differs by a factor of the magnification, which in its turn is proportional to the focal length (*F-number*). We can see that in the equation used to calculate the circle of confusion (C_o), which is the blur circle relative to the film area:

$$C_O = C_B \times m$$

With *m* being the magnification factor, which then suggests that **the blur circles are proportional to the magnification**. Therefore, this supports the idea that the depth of field would appear shallower when using longer lenses, which is the case when

wanting to catch the same field of view from the same position as shot on a Super 35mm camera, on a large format camera.

Consequently, if the blur circles are affected by the relative size of aperture, the f-stop, which is proportional to the factor of the magnification, then it would be possible to match the blur circle size by changing the f-stop number by the same factor used when matching the focal length: the crop factor. This series of equations therefore suggests that the blur circles are in fact proportional to the size of the sensor when shooting the same field of view, from the same distance.

We tested that in the second example below (Still 8), where the f-stop was multiplied by the crop factor to reach the same blur circle size and compensate for the exposure with Neutral Density filters. We used T4⅓ on the Alexa 65 to match the blur circles created with T2.8 on the Alexa Mini.

Still 8 - Matching depth of fields by closing the aperture on the Alexa 65

In this case, we eventually managed to match both the field of view and depth of field. However, in this particular case, the other way around wouldn't have been possible. We wouldn't have been able to match the depth of field on the Alexa Mini with

that of the Alexa 65 at f-stop 2.8, meaning to try to reach a bigger blur circle than that observed on the shots from the Alexa Mini in Still 7 and 8, because the ARRI Rental Prime S 65 lens has a maximum aperture opening of 2.8, and we would need to go to approximately f/1.6 in order to achieve the same blur circle size on the Super 35 sensor size.

Depth of field is a significant visual tool used by cinematographers and directors to control how the viewer responds to the image, as Ward argues (38). It also affects the way space is represented, as noted by cinematographer and professor Rolf Coulanges:

> [Depth of field is] an element for image composition, which supports the representation of spatiality and can also bring out details with the better resolution of the format, or which can alienate or even blow up the cinematic space. (Coulanges 3)

While it is possible to match the depth of field by adjusting the f-stop, large format cameras can still be used to achieve a shallower depth of field, particularly in situations where it is not possible to go beyond a certain aperture size on a Super 35mm sensor. A shallow depth of field can also reduce the need for VFX work in certain cases, making it a cost and time effective option. When I asked cinematographer Daria D'Antonio at the 2021 Camerimage Film Festival about the reason for using a large format camera (the Red Monstro 8K VV) to shoot *The Hand of God* (2021), she said it was simply to achieve a shallower depth of field and hide certain elements of the city background in exterior shots, as the film is set in the 1980s.

4. 5. Noise

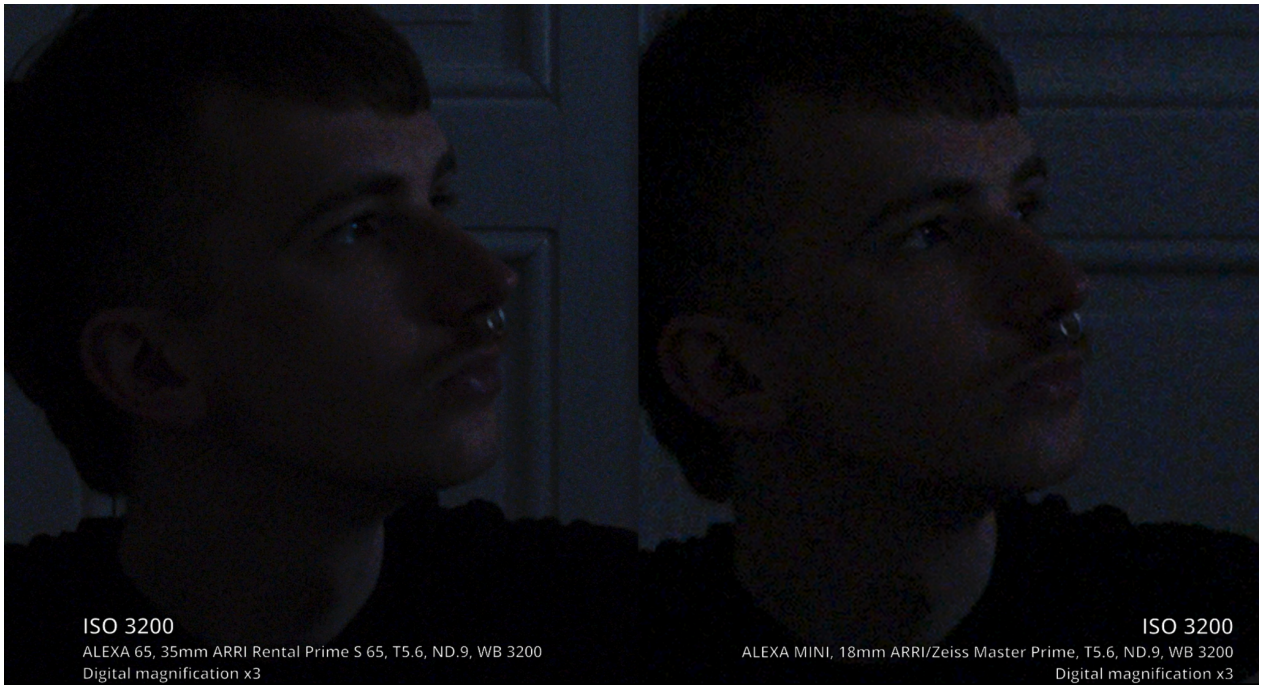
Noise is an inherent part of every digital sensor (Stump 42). It is caused by electronic error or signal interference in a camera and can represent irregular level fluctuations of a low order of magnitude (Goi and ASC 415). A lower noise visibility is also considered one of the advantages of a large format camera, as promoted by camera manufacturers and cinematographers, one of them being cinematographer Roger Deakins. (ARRIChannel 01:20).

Digital noise appears the most in low light conditions because of a low Signal-to-Noise ratio (SNR) (McHugh). Signal-to-Noise ratio is the amount of noise relative to the signal, and when the signal is strong, meaning more photons captured by the photosite, then the noise is less visible. That happens when either there is more light in the shot, or the size of the photo site is bigger, which allows it to capture more photons and makes a stronger signal (Stump 48).

So, in order to compare the noise levels in the most challenging conditions, at a low SNR, we shot a low light scene twice, once with the Alexa 65, and once with the Alexa Mini, at different ISOs. Changing ISO here means amplifying the electronic signal coming from the sensor (Stump 49) and not changing the native ISO of the camera, which in its turn amplifies the level of digital noise.

Starting our test at 400 ISO, we then increased one stop to both camera's native ISO 800, moving to 1600 and finally 3200. When screened, the difference in the noise levels is quite visible, especially at 3200 ISO, as seen in the screen grab below at 100% and then 300% digital magnification:

Still 9 - Comparing noise on both cameras at ISO 3200, at 100% digital magnification



Still 10 - Comparing noise on both cameras at ISO 3200, at 300% digital magnification

The Alexa 65 produces less noise than the Alexa Mini in low light conditions. While both cameras use the same sensor, the Alev III, the size of the photosite doesn't affect this comparison as they are the same size. However, the higher resolution of the Alexa 65 leads to lower noise visibility through its noise spatial frequency. Because the Alexa 65 has more photosites and both cameras are displayed on the same screen, the noise becomes smaller relative to the overall image, making it less noticeable. This is similar to the comparison between 65mm film and Super 35mm film when displayed on the same screen. Despite having the same absolute size of film grain, the grain appears finer in 65mm film because it is smaller relative to the overall image.

It's important to note that the visibility of noise can also be affected by other factors such as the focus of the shot, and post-production processes such as color grading and noise reduction techniques.

Based on these results, noise appears less visible on large format cameras due to their higher spatial frequency and larger number of photosites. This allows filmmakers to shoot in low light situations without worrying about excessive noise. Noise can also impact the overall feel of the image, similar to film grain on photographic film. The less visible it is, the smoother and finer the image appears, with better contrast and more preserved color information. On the other hand, more visible noise can cause the image to lose certain details such as color, contrast, and definition, and take on a rough, digital appearance.

4.6. A tool to consider

As demonstrated in this test, each of the factors examined has a significant impact on the visual language of a film. These factors, including perspective, field of view, space compression, and depth of field, are key elements in the composition of a shot and greatly influence how viewers respond to an image. They can affect the intimacy and proximity of the subject, the relationship with the surrounding space, and the overall feel of the shot, whether it is claustrophobic or spacious. However, this test also highlights that the changes in these factors are not necessarily a direct result of the size of the sensor. It demonstrates the ability to achieve the same perspective, field of view, space compression, and depth of field on both Super 35 and large format cameras.

Ultimately, these changes, even if the viewer cannot explicitly identify them, play a significant role in the visual language being communicated. As Stump suggests in his book:

> The majority of the audience may only remember the content of the shot - the house, horse or face - but they will also be affected by the series of lines, shapes, brightness points and contrasts, colour, etc., which construct the front surface plane of the image. This 'abstract' element of the shot may be crucial to the way the viewer responds to the image. (Stump 41)

Therefore, the choice of sensor size should be seen as an additional tool that can be used in conjunction with other elements such as focal length, camera distance, camera height, and depth of field to achieve the desired visual language. Overall, it offers filmmakers and cinematographers more options during both production and

post-production, including the ability to capture better quality images in low light conditions, the possibility to reframe shots, and greater visual effects work. It is important to consider the full range of tools available and how they can work together to achieve the desired visual language and impact on the viewer.

5. Conclusion

Even though the large format presents new tools in the hands of the cinematographer, the results of this research concludes that the size of the sensor alone doesn't affect much. It is merely a tool to be observed and considered and just as important as the choice of focal length, the height of the camera, its distance from the subject and the choice of f/stop to achieve the required depth of field, for instance. All of these, without forgetting the screening format, must come together in order to serve the film language of the work being created. It is important not to exalt the large format, but sensitively accept the format size as a tool to be used just like other tools, which might serve the greater conceptual purpose of the work. The viewer, whether watching in a cinema, on television, on a laptop or even on their phone, will likely not be able to perceive, from the end result, which tools were used to achieve a certain shot, such as which opening of the aperture was used, which focal length, or sensor size.

At the end of the day, the most important thing is the shot, its composition, framing and depth, which will achieve a certain impact on the viewer, and it is up to the cinematographer to choose the instruments which would achieve that impact and create the desired visual style and cinematic language. Consequently, I would suggest that the use of the digital large format sensor doesn't automatically bring any "look" on its own, and most of what cinematographers consider as an inherent quality of the large format sensor, can, in most situations, possibly be achieved on other formats as well, through different tools at their hands.

These results would suggest that the current trend previously mentioned in the use of large format cameras, might not result from the so-called large format look, but

rather as simply an attraction to new technological developments and the never-ending race towards higher K number, even if it may not be necessarily relevant to the viewer (Yedlin, “Resolution Demo” 05:10), but possibly beneficial in the post-production workflow. And even if certain elements that the large format brings to the look of a film, such as a shallower depth of field caused by the use of longer lenses, that doesn’t mean that it is objectively always serving the visual language of the project at hand.

Nonetheless, it should be noted that a film wouldn’t contain a juxtaposition of two shots taken with two different formats such as the one we did in this test. And therefore, it would be difficult to conclude if any of the tested factors would be noticeable at all if viewed individually, unlike the side-by-side comparison carried out here.

In conclusion, just like any other tool historically used by cinematographers, today, the existence of larger digital sensors should be considered as one of the tools available, which, combined with other choices made in pre-production, on set or in post-production, may ultimately serve the desired film language.

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