The Digital Cinematography Revolution & 35mm Sensors: Arri’fle Alexa, Sony PMW-F3, Panasonic AF100, Sony HDCAM HDW-750 and the Cannon 5D DSLR.

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Abstract

This paper compares several of the latest professional digital video cameras from a range of manufacturers with a sensor that is similar in size to a standard 35mm film frame. Only a handful of companies were once making ‘full sensor’ digital cameras that were solely the domain of the high-end market sector. Since the DSLR revolution of the past few years, the technology is now more readily accessible. This paper analyses the strengths and weaknesses of a range of the latest mid-priced cameras examining their native recording format, image resolution, sensitivity to light and progressive frame recording. Furthermore, it will consider the implications of the availability of such technology on the teaching of screen production in Australian Universities.

Keywords

35mm sensor, CMOS, depth of field, resolution, compression, moiré, high-definition (HD), digital single-lens reflex (DSLR), ISO, latitude and rolling shutter.

Introduction: Background and Context

This paper reports on a series of camera test conducted in April 2011 at the Griffith Film School (GFS), which is a faculty of Griffith University, located at the South Bank Parklands in Brisbane, Australia. GFS was created in 2005 as a specialist arm of Queensland College of Art (QCA), that amalgamated with Griffith University in the late 1980s as part of the Australia-wide tertiary education reforms.

When GFS was established in 2005 it continued its proud history of teaching students how to shoot film, although the writing was on the wall that it was increasingly under threat from digital advancements in video recording technology, with an increasing number of films being shot on high definition cameras such Michael Man’s Collateral (2004) Sony CineAlta HDW-F900, Thomson VIPER FilmStream and Robert Altman’s A Prairie Home Companion (2006) HDCAM SR to name but a few (Wheeler, 2009). GFS acquired a range of its own HD cameras including the Sony XDCAM PDW-F330 and F350 as well as the Sony HDCAM HDW-750 coupled with a variety of HD zoom and cine lenses to keep current with the video technology advances.

For the most part, these formats serviced the needs of the students aesthetically and from a teaching perspective endorsed them on professional cameras that were also readily used out in the industry. Once students reach their final undergraduate year and undertake their last short film, the reins are loosened and they choose their preferred format whether it be film or video.

In 2009 the first digital single-lens reflex (DSLR) project was pitched to staff. The rationale was that the script was set at night meaning a camera that was sensitive to low light conditions was required and had a ISO rating fast enough it could maximize the available light. Film wasn’t an option as the budget didn’t allow for it, the GFS HDCAM HDW-750 did not have a fast enough ISO and although it was relatively new to the marketplace, the Canon 5D Mark I DSLR met all the demands the group required. The final tipping point was that the Canon 5D had a sensor that was the same size as a Super 35mm frame which gave the image a shallow depth of field which was an aesthetic look the students found appealing. Despite concerns about native recording format, compression and the rolling shutter effect of CMOS sensors, Quiet: You’ll Wake Up The War turned out to be a very professional looking short film that screened at the 2010 Cannes Short Film Corner and Beijing Film Academy, as well as numerous other local and international film festivals.

In 2010, eight of the thirteen graduate films were shot on DSLRs, specifically Canon 5D and 7D which was a 300% increase from 2009, but this time around results were mixed. The trend toward DSLR as the preferred acquisition format was obvious, but the projects did not have the same low light demands as Quiet: You’ll Wake Up The War so there had to be another reason for the shift. Students owning the cameras appears to be a significant factor as it gave them the confidence they knew the ‘in and outs’ of
the equipment. Twenty-four hour accessibility gave them the option to test and tinker. The other significant contributor to the shift was a desire for the projects to have a 35mm ‘look.’ Even though the image was digitally acquired, the depth of field from DSLRs is similar to that of 35mm film and students obviously liked the shallow depth of field look.

Although it had never been raised in the past or even seemed like an issue, as a result of the shift towards DSLR cameras, it became apparent GFS was caught in a league of two-thirds inch or 16mm depth of field. Smaller gauges or chip sizes inherently have a greater depth of field and although students had the knowledge that it could be manipulated by light and lens choice. Now there was a readily accessible camera with 35mm depth of field, production teams immediately started gravitating towards it. They were all aware of the deficiencies when using a camera for motion picture acquisition that’s primarily designed for shooting still photographs, but the shallow depth of field look outweighed the operational and other negatives. Initially GFS looked to embrace the format and purchase equipment that would provide students with all the functionality they were accustomed to when working with professional video cameras such as provision for a director’s monitor and sync sound. However as the cost of building an infrastructure around a stills camera so it could be functional for filmmakers slowly crept higher and higher, GFS questioned the practicality and longevity of the format, particularly when several video camera manufacturers were about to release products designed to compete with the burgeoning DSLR market.

Early 2011 saw the release of the Panasonic AF100 with its micro-four-thirds inch chip and the Sony PMW-F3 with a full super 35mm sensor. These two cameras were in a price range that made them a relatively affordable purchase for GFS but before a decision could be made as to which camera, it was decided to test them against a reputable high-end camera as a benchmark. The Alexa manufactured by ArriFlex and introduced to the market in 2010 is designed for use in high budget feature film and television production. Similar high-end cameras such as the Red One and Sony F35 would have been equally appropriate, however at the time of the test, the Alexa was chosen simply because it was easily accessible and had an existing reputation for quality and film like imagery. It was also decided to include the Canon 5D Mark 2 in the mix to see how the it fared against the new cameras as well as the Sony HDCAM HDW-750 to find out if it could still hold its own in a marketplace now dominated by tapeless formats.

The tests conducted were intended to provide GFS with an informed decision about choosing the right camera and curbing the use of DSLR cameras when shooting graduate films. It wasn’t that GFS disapproved the use of DSLRs; the images they produced at times were impressive. It was simply we felt that important aspects of production such as a directors monitor, sync sound recording, proper follow focus and cine lenses were being forsaken because the cameras were not setup for motion picture acquisition as its primary function. Cinematographer Tony O’Loughlan who had recently shot the TV series K9 supervised the test and our main areas of investigation included resolution, aliasing, skin tone, exposure, motion and colour fidelity. When it allowed, the same lenses were used across all cameras to ensure equity in the comparison, while other times various lenses were attached to each model due to the limitations of available equipment and time. The main thing we wanted to investigate was the quality of the image and for this reason it would not just be a test of resolution and exposure charts, but various environments and conditions that most students would encounter.
Test 1: Latitude, Exposure and ISO
This test was conducted in the GFS sound stage under tungsten lighting conditions featuring a Caucasian face, printed 11 stop grayscale latitude test chart and printed colour test chart (Macbeth). Each camera was tested individually using the same Zeiss compact prime lenses for all cameras that could accept a PL lens mount. The cameras were all set to the same ISO rating, given a base exposure and then bracketed through a variety of exposures ranging from two stops under, correct exposure, through to two stops over. The ISO rating on each camera was then increased to examine any noise or grain in the picture, and the bracket exposure test repeated.

Test 2: Candlelight and Skin Tone
The simplest of tests, the subject held a candle in a darkened studio environment and randomly moved it closer or further away from their face at various distances to see how each format handled skin tone, highlights and shadows in high contrast conditions. Once again, each camera was given a base ISO and exposure and then slowly bracketed through different exposure and ISO ratings. Unlike test one, the same lenses could not be used across all cameras because in this instance all the cameras were pointing at the subject at the same time.
Test 3: Mixed Lighting Conditions
For this test we placed the cameras in an undercover car park that had a mix of unbalanced fluorescent light and daylight. The intention behind this test was to see how each format handled skin tones in mixed light and a location that was heavily backlit by daylight. The fluorescent lights were protected by metal surrounds and their fine lines and close proximity to the light made for perfect territory to test the cameras ability to see detail in highlights and the moiré effect.

Test 4: Daylight, Colour and Rolling Shutter
The main purpose of this test was to examine the replication and authenticity of colour and also check for any CMOS sensor artifacts, or what is commonly referred to as rolling shutter. In overcast daylight conditions several outdoor elements were recorded and then rerecorded with movement to test for any smear, skew or wobble which are common characteristics of a rolling shutter. The important thing to note is that in the rolling shutter effect is not caused by an actual physical moving shutter like in a film camera. Rather different portions of the frame are charged or exposed at different times than other portions. If the subject or the camera were to move during the exposure, the result would be reflected in the frame as a smear, skew or wobble artifacts. Most of the new cameras use CMOS sensors and the manner in which the sensor goes about capturing the shot has significant impact on the image.
Results
What’s really impressive with all of the cameras benchmarked against the Alexa is that although the Alexa is clearly the superior camera with greater latitude, zero image distortion, rolling shutter and moiré, it is also significantly more expensive. The Canon 5D is less than a tenth of the cost of an Alexa but its images are certainly not a tenth of the quality and the same can be said for the AF100 and F3 as well.

Sony PMW-F3
Out of the bunch, there is no doubt the Sony F3 performs great in low light, even when pushed to 1600 or 3200 ISO where signal noise or grain was surprisingly minimal. Unfortunately the same cannot be said for the manner in which it handles highlights and overexposure where there was some noticeable clipping and channel bleeding. We were using default, out of the box settings and apparently this issue can be remedied using cine gamma presets and as any DOP will attest, if you know the weaknesses of a format you can compensate and adjust the shot accordingly. The results from recording on the SxS cards were impressive, the only noticeable compression was during the candlelight test where at times the skin tones looked slightly blocky. That said, the expandability of the F3 to dual stream 4:4:4 and recording in Sony’s S-Log format could certainly remedy this problem. S-Log is Sony’s version of a Raw image format which protects the details in highlights and shadow areas for grading later (Zacuto: The Great Camera Shootout Episode One, 2011). Although this feature is not standard and won’t matter to a lot of users, it is very attractive for those who intend to use the camera in high-end environments. Furthermore, the dual-link HD-SDI upgrade delivers full quality 4:4:4 uncompressed video which is a feature that is usually reserved for top of the line high-end cameras such as the Sony F35 (Zacuto: The Great Camera Shootout Episode One, 2011). Sony’s decision to provide a PL lens mount as standard makes it immediately acceptable into the existing film-based world. The camera can also come with a set of entry-level prime lenses for those not wanting additional expenditure on a kit of lenses. Finally, it makes the large-sensor style camera a contender in various production environments that would never have previously considered working with such a format.

Panasonic AF100
The Panasonic AF100 is roughly a third the price of the F3 and that needs to be taken into account in this comparison. The AF100 is a good camera and is certainly adequate handling most tasks. It performed well in most of the tests, but when pushed out of its comfort zone, unlike the F3 there was a significant deterioration in the image quality. There was a considerable amount of grain, particularly sections with high detail and when the ISO was pushed. Unlike the F3 CMOS chip that was specifically designed from scratch, the AF100 utilizes a high-megapixel sensor derived from a stills camera (Zacuto: The Great Camera Shootout Episode Three, 2011). Even though the sensor has been optimised for video and delivers a much cleaner image than any of its DSLR competitors, the rolling shutter was significantly more obvious than the F3. Panasonic’s micro four-thirds sensor also limits the choice of suitable lenses because they don’t offer any cine-style lenses and neither does anyone else for the micro four-thirds mount. Instead, Panasonic are relying on third-party adapters. The utilisation of stills lenses that can be problematic for focus in a motion picture environment, and were part of the reason GFS wanted to move away from DSLRs in the first place.

An exterior image from the HDCAM HDW-750. With enough available light the camera still performs well against its modern contemporaries.
Canon 5D
Standalone, the images from the 5D look impressive, but once stacked against cameras with similar sensor sizes that are designed for video use, there are significant issues with the format. One of the most noticeable in our series of tests was the manner in which the 5D replicated colours and dealt with angles. On the whole, the images from the 5D were more saturated than those of the F3, Alexa or AF100. This is not a major issue until a scene is recorded that contains a large amount of colour and there is a risk of peaking, which in-turn causes chroma bleeding. Our main worry with the 5D was the manner in which it handled straight lines, particularly those that are on a slight angle. It was very obvious on the Macbeth colour chart that stepping had occurred in the black lines that separated the colour squares. Aliasing and moire are a symptom of shortcuts that have been taken to get video frame-rates from large sensors, as well as the fact the sensors aren’t optimised for video (Zacuto: The Great Camera Shootout Episode One, 2011). The 5D reduces its video image to 1920x1080 so while the larger sensor gives the cinematographer a shallower depth of field, the technical down res-ing produces some really unwelcome artefacts (Zacuto: The Great Camera Shootout Episode Two, 2011). So once again, go in knowing the weakness of the format and adjust your composition accordingly.

Sony HDCAM HDW-750
Like a beautiful slow reversal filmstock, the HDCAM loves light and unlike its contemporaries, performs best at its relatively slow rating of 320 ISO. However, like CPU technology, sensor technology for cameras is moving so rapidly that the newer CMOS chips simply out perform those manufactured only six years ago. The HDCAM doesn’t have the latitude of the other cameras, highlights blow-out quite easily, the 3:1:1 sub-sample rate made the colours look dull and overall, when pushed in low light with the introduction of gain, the image became extremely grainy. Like its predecessors such as Betacam SP and Betacam SX, HDCAM served the industry well for a period of time but struggles to compete with the recent advances of tapeless formats.

Conclusion
Red One set the trend with modular cameras that can be scaled according to budget and this appears to be the new direction for other manufacturers as well. DSLRs can also be included in this mix because these days they can be accessorised to operate in a similar fashion to a camera designed purely for motion picture acquisition. All of the cameras have their own strengths, while there is a significant commonality in the target market, it’s clear that Sony is aiming for slightly higher-end buyers than Panasonic or even Canon for that matter. Like when the Red One was first released, the F3 is going to be a player in the choice for independent features over the next few years. With features like Dual-Link SDI and S-Log colour, there is no doubt it has the capability. In the race between the AF100 and F3, like most things it all comes down to price. Future usage and the cameras application is an important consideration when making a decision about which to buy. For individuals, the AF100 is an affordable option that produces excellent results, however you must keep in mind the lens factor. A camera is useless without them and this may prove a difficult stumbling block for the AF100 to overcome. For
those who don’t have existing lenses, to purchase a basic kit would be a significant additional cost. Although its more expensive, the Sony F3 with its option to come bundled with a basic lens kit and its upgradeability may be a better out of the box solution. It really comes down to what was said earlier, the cameras intended application how far you want to take it.

At about an eighth of the cost of the F3, and half that of the AF100, the 5D manages to produce quality shots when you work within its limits. For a camera that’s primary function is still photography, the 5D certainly punches above its weight when recording motion pictures. However, the results from the GFS test clearly show the F3 and AF100 have considerably less rolling shutter and line skipping. The 5D has a high-resolution sensor but it reduces its video image to standard HD 1920×1080 and while the larger sensor gives the cinematographer a shallower depth of field, there are some really unwelcome artefacts that come with that. HDCAM is showing its age, it was simply outperformed by the other cameras that were more sensitive to light; have less signal noise and more colour depth. Including the HDCAM in this test was like trying to compare the latest CPU technology against a chip that was manufactured six years ago - there has simply been far too much advancement for it to compete.

At GFS, once it was announced the F3 would be added to the mix of formats for the third year production slate, ninety percent of the 5D projects switched. This to a degree confirmed that the students were chasing a camera that gave them the ‘35mm depth of field look.’ Principal photography for all third year undergrad projects was completed in July 2011 and overall; the F3 produced excellent results even when recording to the SxS cards with the XDCAM EX codec. That said, every camera has its purpose and we still had one 5D project that looks fantastic because the DOP understood the weaknesses of the format and accounted for them. The Canon 5D was the most suitable camera for this film because the script demanded something that could fit into tight places. We also still had one HDCAM project because the look appealed to the Director of Photography. Interestingly, when the budget allows, students still gravitate towards 16mm film and there’s no denying the aesthetic qualities of film will continue for many years to come.

From a teaching and education perspective, the positive aspect of these rapid leaps ahead in sensor technology and camera formats are that film schools can now access equipment that was once cost prohibitive because not only were the cameras expensive, so was the accompanying post-production equipment. The shift to tapeless formats is invariably democratising the industry and as manufacturers continue to release cameras and equipment that performs close to its high-end counterparts at a tenth of the price, it will only increase the quality of the imagery and standard of work produced. The priority now is to understand the new directions the technology is taking because things are moving so fast; equipment becomes obsolete in a much shorter timeframe. Modular cameras allow for incremental expandability and perhaps this can help the longevity of ones investment. It certainly seems to be the direction several manufactures like Red and Sony are now taking. The main principle we must always keep in mind is that the camera is only a tool in the filmmaking process, but perhaps if the stories we tell can match the quality of the imagery these new cameras deliver, we’re in for exciting times ahead.

Reference List
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