

# LET'S GET TECHNICAL

with Pawel Ahtel ACS



The Ahtel 9 x 7 Digital Cinema Camera - PHOTO Supplied by Pawel Ahtel ACS

Pawel Ahtel ACS has over thirty-five years of experience as a film maker and DOP. He specialises in natural history content creation, mainly underwater. Pawel also designs and builds cinematography equipment such as underwater housings and more recently, digital cinema cameras where image quality is paramount. As a scientist and qualified engineer, he merges visual story telling with science-based approach to technical innovations. His inventions were used in many high-end productions and features, such as *Avatar: The Way of Water*. Pawel is also an active member of Innovations Committee and member of board of directors at Giant Screen Association, Full Member of IMAGO Technical Committee and accredited ACS member.

It has been over three years since I announced availability of 9x7 digital cinema camera – a camera that was never going to replace your ARRI, Sony or RED, but an array of six to twelve of them. It is a camera that was specifically designed for shooting VFX plates, Giant Screen, IMAX, and other forms of immersive cinema requiring unprecedented levels of sharpness and image quality.

## Resolution versus Sharpness

Resolution is measured in pixels and tells us nothing about image sharpness. Sharpness is measured with MTF (Modulation Transfer Function) showing contrast (from zero to 100%) versus spatial frequency. For example, an 8K camera may or may not be able to discern 8K lines/picture width (or 4K line pairs per picture width) with contrast that we could perceive (say, greater than 20%). If contrast is zero at 8K (or 4K lp/pw), we can say that, whilst the camera has 8K photo-sites and 8K pixels in resulting images, it cannot actually resolve 8K because contrast at such spatial frequency is zero.

Whilst the 9x7 camera's sensor has almost twice the number of photo-sites as other 8K digital cinema cameras, it is not what makes it the sharpest cinema camera currently available. It is also not the fact that the camera is capable of recording up to 11GB/s of uncompressed, linear RAW. What makes it special is the design of the photo-sites that, despite being only about 3µm in size, their MTF is as good or better as some of the best photo-sites in the industry that are 10 times larger. It is this incredible amount of contrast that allows reproduction

of details up to and beyond spatial sampling resolution (Nyquist limit) and deliver up to 18.6K (9400 line pairs per picture width) with measurable contrast. The measured sharpness exceeds that of 15-perf 70mm IMAX film by factor of two (four times as much detail) and depth of field can be even shallower than that of IMAX film. It also would take no less than six RED Raptor cameras stitched seamlessly to achieve equivalent sharpness (MTF) as single 9x7 camera can achieve.

## *The measured sharpness exceeds that of 15-perf 70mm IMAX*

The maximum (actually resolved up to Nyquist limit) resolution is 18.7K x 14K (260 Megapixels) achieved through custom demosaicing and image creation process.

It is this almost limitless sharpness combined with more "squarish", 4:3 aspect ratio that make it ideal camera for immersive cinema, IMAX and for capturing 180° and even 360° VFX plates. The 9x7 was successfully used in number of feature productions, such as *Thirteen Lives* (Metro-Goldwyn-Mayer), *MEG 2* (Warner Brothers) and

Equalizer 3 (Columbia Pictures). By no means inexpensive (renting at AUD \$30K per week), it is many times more cost effective than capturing VFX plates with cumbersome multi-camera arrays and stitching them together afterwards.

The 9x7 camera is also very small and lightweight allowing it to be mounted in stabilised heads, such as Shotover, on drones, underwater housings, and hand-held gimbals – all next to impossible to accomplish with large multi-camera arrays.

Another important feature that sets the 9x7 apart from other digital cinema cameras is true Global Shutter making it very appealing for capturing fast motion. Global Shutter is incredibly important for VFX work as it allows undistorted mapping of moving objects, but also is important when filming propellers, car wheels, and monitors, TVs as well as flashes, strobes and flickering light sources. Cameras that use rolling shutter can produce significant and undesirable horizontal “striping”, distortions, and fragmentation of spinning objects – defects that look unnatural and can be very difficult and costly to fix in post-production.

Another area where the camera found applications is in high-quality 8K content delivery. As most digital cinema cameras suffer from relatively low micro contrast, cinematographers often chose to shoot 8K for 4K delivery to achieve high levels of micro-contrast. But what if your delivery is 8K? Most, if not all, 8K+ digital cinema cameras measure about 0% contrast at 4,000 line pairs per picture width (Nyquist limit of 8K), which means it would be very difficult to discern the smallest detail of such content even if the display is capable of such high resolution. Not so with content acquired with the 9x7. The actually measured contrast at 4000 line pairs per picture width exceeds 50%, meaning: it can be clearly discerned by human vision. It “pops out” off the screen. This is why companies like Samsung chose 9x7 footage in order to evaluate and show the potential of their new 8K Neo QLED 8K TVs – something they weren’t able to achieve with using footage filmed with current 8K or 12K digital cinema cameras as, despite having enough pixels, they lacked the actual sharpness and there was little difference when such footage was



PHOTOS Supplied by Pawel Achtel ACS

viewed on 4K or 8K screen.

### Uncompressed RAW and Afterburner

The 9x7 digital cinema camera records uncompressed linear RAW. The recording module can sustain up to 11 GB/s, which is an order of a magnitude more than any other digital cinema camera.

The camera comes with either 4TB or 8TB built-in specialised high-speed non-volatile memory. At 24 fps it translates to about 27 or 55 minutes of recording time. When designing the camera back some 4 years ago, the biggest risk

to the project was whether we could record this fast reliably. It turns out we “overshot” the requirement and it is actually possible to connect two camera modules to a single recorder (in stereo 3D or multi camera configuration) and still record up to 60 fps each to a single recording module – all synced and genlocked. No extra cabling required.

Working with uncompressed linear RAW footage has many benefits. It’s like having “thick negative” – images that stand up to heavy processing often needed in VFX workflows. But there are also drawbacks: disk space and speed. For this reason, we developed



Afterburner. Afterburner is an ultra-fast PCIe interface allowing data offloads, transcoding, and backup to enterprise-grade U.2 NVMEs. These are small, portable, rugged, and reliable high-capacity SSD drives that help DIT (digital imaging technician) in providing quick and reliable turnaround for dailies, backup, and delivery to editorial. The Afterburner is capable to offload the data at real-time speeds.

**What lenses can I use with the 9x7?**

We have option to use either ARRI

LF LPL mount or RED DSMC 2 – compatible lens mounts. This allows wide range of lenses to be used with either PL, LPL, PV, Nikon, Canon, Leica M, and other lens mounts.

Of course, not all the lenses are sharp enough to take advantage of the 9x7’s capabilities. In fact, only a handful of lenses offer the level of sharpness matching that of the camera. From rectilinear range, we found that ARRI Signature Primes and selected SIGMA ART lenses offer enough sharpness and contrast. When it comes to immersive

cinema, IMAX, Giant Screen and VFX plates, the most commonly used lens is the Entaniya HAL 220 LF fisheye offering near perfect f-theta mapping (equidistant projection). Such mapping is considered optimal and non-distorting when capturing extremely wide field of view. The HAL lens is also incredibly sharp showing decent contrast at 200 lp/mm and it is one of the sharpest fisheye lenses ever made.

Speaking of sharp fisheye lenses, I have recently purchased one of the kind Precision Optics C4 – a 270° 4.9mm f/3.5 hyper-fisheye lens from our friends at Lens Rentals in the US. When pointed upwards, this lens will allow me to shoot full 360° VFX plates with incredible amount of sharpness. The lens measures discernible contrast at 250 lp/mm and is one of the sharpest lenses ever made, not just the widest!

Our new firmware, 5.1 already features an overlay for the C4 lens, which has been mapped onto the sensor.

**How about colour fidelity?**

One of the strongest features of the 9x7 digital cinema camera is in its ability to reproduce colours with unmatched fidelity and colour gamut.

Until now, cameras have been pre-programmed with a default linear colour profiles (IDTs) that determine the accuracy of all colours. They also relied on Colour Temperature as sole means to characterise the whole range of different light spectra and illuminants used to light our images. How inadequate?! How can one single number characterise a tungsten light, a daylight light, as well as fluoro light and all types of LED lights? We have been doing colour science wrong all this time!

Moreover, when we try to apply “correct colour temperature” in a process called chromatic adaptation, we often end up with inaccurate skin tones and other reflective colours. Such approach also significantly limits the accuracy of super-saturated colours, which are often clipped by being mapped outside the spectral locus. The accuracy of those super-saturated colours has been impossible to achieve not just because of limitations of single number chromatic adaptation, but also through means of a linear transforms (IDTs) commonly used in colour processing pipelines. These



L-R: Aaron Cloz and Pawel Achteł ACS at Cinegear - PHOTO Supplied by Pawel Achteł ACS

limitations led to workarounds, such as gamut compression, which do not fully solve the problem of super-saturated colour reproduction in digital cameras. The 9x7 provides the option to choose non-linear processing of super-saturated colours, while still retaining the smoothness, accuracy, and tonalities of subtle colours, such as skin tones.

But the feature that I'm most proud of, is what we call DSR – Direct Scene Referred workflow. Whilst the 9x7 still allows the legacy colour temperature and chromatic adaptation, it also offers something that should have been done from day one. Instead of having fixed IDT (Input device Transform) or camera colour profile, provided by camera vendor, we give an opportunity to the DOP or Colourist to create one on set. An IDT that is specific to the lighting conditions for each specific shot, scene, or sequence. Every shot is colorimetric, meaning it doesn't require any colour correction as or chromatic adaptation. The colours are perfect "out of the gate". This custom IDT is created in camera on set and embedded in every frame of every clip as metadata. As the colour is fully managed this colorimetric image is displayed in the camera on set, and preserved in dailies and, raw files are ready to edit and colour grade

consistently as there is no need for time-consuming and often destructive colour correction process.

***“But the feature that I’m most proud of, is what we call DSR...”***

Loosely speaking, the camera stores thousands of numbers in substitution of a single number: the colour temperature. In such workflow colour temperature is completely irrelevant just as it is inadequate to properly characterise the entire light spectrum. The images, whether taken at sunrise, or under overcast, daylight, tungsten or LED illumination will be identical and ready to apply creative colour grade look consistently regardless of what lighting they were shot with.

**What about dynamic range?**

Film-Like highlight control and extended dynamic range processing allows additional 2 ~ 4 stops of dynamic range as well as soft and smooth handling of overexposed areas, just like film emulsions used to reproduce highlights. There is no “hard clipping”, or “ringing” often associated with digital images. The 9x7 Digital Cinema Camera

produces natural-looking smooth highlights gradations whilst retaining full detail and chromaticity.

And, because 9x7 camera uses 16-bit linear uncompressed RAW, highlights are much smoother and well beyond what typical log encoding is able to retain. When measured, the 9x7 has as good or better dynamic range than most high-end digital cinema cameras.

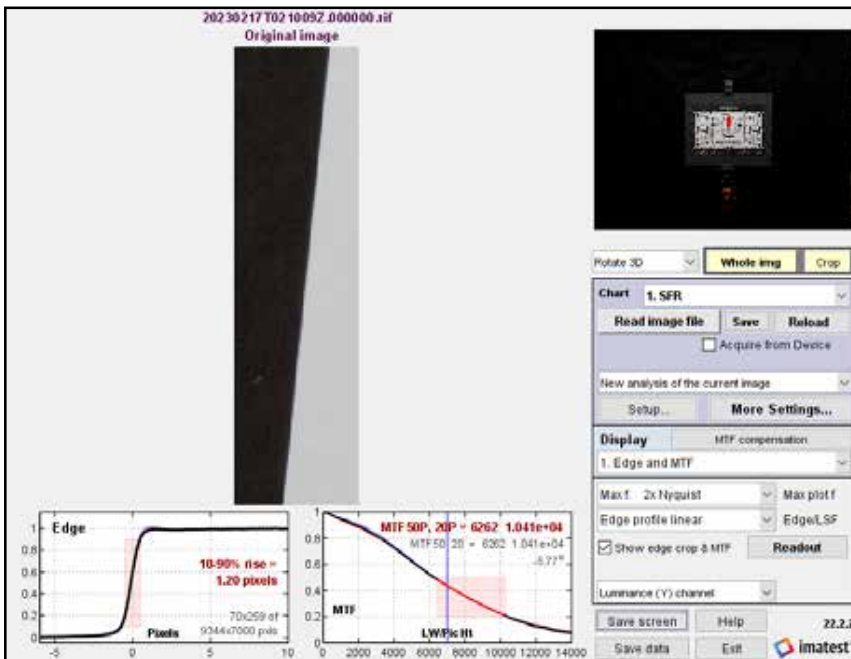
**What is low light performance?**

Most digital cinema cameras are ISO invariant (have single ISO sensitivity) or dual ISO. The 9x7 has eleven (11): eleven native and distinct ISO sensitivity settings ranging from about ISO 500 to a whopping ISO 5100 making it one of the most low-light sensitive cameras available today. Side-by-side comparisons clearly show significantly lower noise than that achieved with any other high-end digital cinema camera. It's very, very clean and some of my favourite shots are night-time city scapes, which the camera can reproduce as bright and vivid scenes.

**What makes good VFX and Giant Screen camera?**

Of course, image quality is the primary criterion.

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One such feature is resistance to flares. Whilst many cinematographers love flares, VFX supervisors and Immersive Cinema directors hate them. A single flare can ruin the shot.

Considering that most of outdoor VFX or Giant Screen shots would have the sun in the view (or a shadow of the cinematographer) it is extremely important that at least the camera should not introduce them. However, one of the most common sources of flares comes from UVIR cover glass and sensor reflections. Every single digital cinema camera has this problem. Well, almost everyone. The 9x7 is different and this extends to an innovative UVIR sensor cover glass design, which I call ClearCast. This super-expensive piece of optics doesn't simply reflect

unwanted IR and UV spectra away from the sensor. Instead, it disperses them. No other camera sensor optical stack works this way, and this is where it is pretty much impossible to cause flare when pointing the camera into the sun or other bright light source. One of our customers said that this feature alone was enough to persuade them to purchase the camera as they used to spend a lot of money to remove unwanted flares from the footage. When testing the 9x7, the customer could not cause it to flare, no matter how hard he tried.

### Cine Gear Expo, Los Angeles 2023

Cine Gear was our first public showing of the camera in US. Our friends at 8K Association supplied a colour calibrated

Samsung 8K TV, which exceeded our expectations. I'm used to working with colour-calibrated grading monitors every day but, I must say, when I played our 8K HDR sample reel containing subtle skin tone gradations of a young girl as well as super-saturated reds and greens of a Macaw parrot, I couldn't help but feel that when all technologies come together, the result can be overwhelming.

We also teamed up with Wavelet Beam GmbH from Germany offering RAW to RAW de-noising solution that is absolute revolution in noise reduction without sacrificing colour or detail in deep shadows. For anyone being obsessed with image quality as much as I am, it is quite a treat.

Another company we partnered with is our own Ignite Digi, well-known for high quality camera accessories and mounting hardware. Using their flagship "keystone" camera cage, we can essentially transform the 9x7 into ARRI-compatible camera leveraging wide range of ARRI accessories. Such configuration makes it easy on set when rigging the camera in professional production environments.

### What are we working on?

There is a range of hardware and software improvements that we are currently working on.

One significant hardware upgrade is to incorporate fibre transceivers into the camera head and recorder. This will eliminate very expensive fibre optic cables that incorporate transceivers that we use today. Instead, "off-the-shelf" fibre cables can be used, and camera footprint is going to be much smaller.

But software is where the most activity is. We are now working on our own image creation and workflow software. In addition to uncompressed RAW, we will be also providing high quality EXR export for VFX workflows, which will offer better image quality and superior colour management compared to third party software.

As we always try to under-promise and over-deliver, there are some other innovative features that we are working on, and which will be announced as soon as they are ready.