NOTES ON DIGITAL WORKFLOWS – Version 2.1
Terry Flaxton, 19th November, 2011/Revised December 2013
These notes have several functions the bulk of information presented was a consultation document for Creative England but in the form you have before you it has been reformatted to accompany a set of online evaluative exercises, preceding and then following a workshop.

These notes are not meant to be extensive. I'm setting them out for you to read *after you've filled in the evaluation* and *before you take the workshop.* The principle I'm working to is an old television principle: Tell them what you're going to tell them, tell them it, then tell them again. So in this case it's to tell you this information in this pdf, tell you again during the workshop, then have you re-read the information after the workshop. Plus – if you're serious, everything I'm about to say you should challenge with further research yourself (then let me know if I've got it wrong).

At a presentation in 2011 a Producer/Director put me on the spot with the question: 'I've asked many a cameraperson what High Definition is, and no one's been able to tell me to my satisfaction – so what is it?' At this point I immediately remembered the title of the presentation I used to give on the subject titled 'High Definition – No Mercy'. I called it that because the question, though simple, has a myriad and complex answer and if you really want to know the truth – you must engage with all of its complexity. In brief the simple answer is: *High Definition is a television delivery format where the display is of an aspect ratio of 16:9 that uses a matrix of 1920 x 1080 pixels*. Simple. The reference to 2k people make about HD is that 1920 is close to 2k as a shorthand (2000 lines). However, cinema 2k is 2048 x 1024 and has a 2:1 aspect ratio.

What follows is more concerned with Digital Cinematography than HDTV, which can use HD's aspect ratio and its matrix (16:9 can also be expressed as 1.78:1 if you divide 16 by 9 – that's the result, try it and also try dividing 1920 by 1080) – but is better understood as an area that begins at the point where HD leaves off. Cinema for instance utilises aspect ratios of 2.4:1 – this requires more pixels to do it justice because if you just used an HD capture device you'd cut off pixels top and bottom and have less resolution to play with. The Red One shoots 2:1 with 4096 x 2048 pixels (4k). But – cinema images generated on 35 film are scanned at 6k. The Red Epic has a 5k sensor a and later ones have the Dragon 6k and what's coming will be 8k, 9k and so on and so forth.

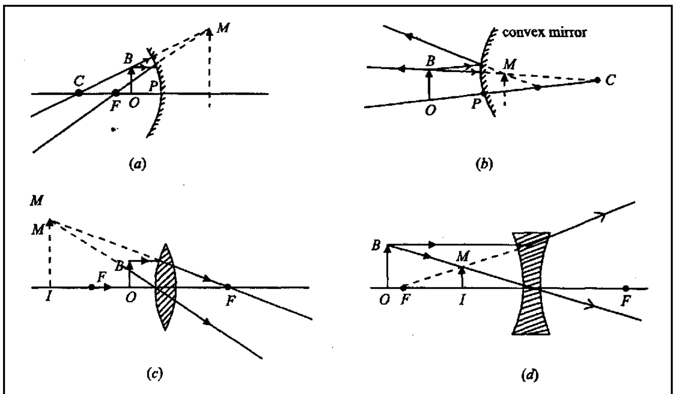


Fig. 22.6

Though the following ideas utilise the Red Camera system as its example, the principles will carry over to other data cameras such as the Alexa, Penelope, D21, Silicon Imaging, F35, F65, Genesis and so on. I use the terms 'data camera' 'data cinematography', 'digital cinematography' or 'electronic cinematography' for a camera used for the electronic form of cinematography to distinguish it from a 'digital video camera', where the the digital video camera primarily outputs an image file. A 'data camera' outputs a *data* file that can then be *interpreted as an image.* Data cameras are in a sense more similar to film cameras where a *virtual* image has to be brought out of the material into an image. Effectively digital cinema came of age when enough DP's demanded access to the raw state of the information encoded or captured within the footage prior to any of the interventions of the manufacturers – this in effect made data cinematography analogous to film cinematography as the cinematographer was demanding back one of their key roles as a DP as the 'Chief Quality Control Person' of the production process.

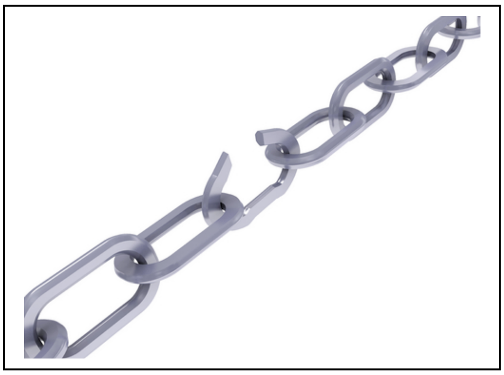
SIMILARITIES BETWEEN FILM AND DATA CINEMATOGRAPHY

In film as within photography, the latent image is encoded into the frames within the film-strip and became a real image when it is developed – this stream of still images can then be edited and later effected via a set of processes, then displayed. In data video the image has to be rendered before it turns from latent or virtual image, via a series of processes through editing and grading, before being turned into a displayed image. The film analogy can be taken too far and breaks down at certain points – however, the analogy seeks to impress on the digital cinematographer that they have to take up the resolve of the film cinematographer in quality controlling the image from capture through to display – therefore they have to know all the processes of cinematography and all of the functions that affect the final outcome. (There is an entire discussion regarding the *site* of control – early film attitudes to data/digital video produced an attitude towards electronic cinematography which fundamentally sent many image decisions to post – because the DP didn't want to limit the data that was coming from him or her and therefore be blameworthy. Others consider that a failure of imagination and courage). One other point is that, as a friend of mine says: 'There are no moving images, there are only still images played fast – it's the mind that moves'.

Needless to say, each manufacturer protects their inventions through the quirks and eccentricities of their own process and sometimes creates barriers to interchangeability between theirs and others' processes and inventions. Manufacturers also have different methods of measuring the prowess of their own devices and sometimes create the estimations of a factor, like sensitivity - how *fast* the camera is in its response to light – in a way that makes their equipment appear to be the best (Speed is normally measured in ASA or ISO). Recently Panavision and Red had a public discussion about how to measure the resolution of a camera – and disagreed. This sort of thing also sometimes puts undue emphasis in different places in the pathway between image capture and image exhibition.

THE PRODUCTION CHAIN OR PATHWAY

From now on, for me, the quality of everything that comes from an image capture device (a camera) is determined by the idea of Modular Transfer Function (MTF). To put this in layman's terms, the weakest link in the chain, characterises the strength of the chain. So within the pathway from capture to exhibition, with regard to resolution for instance: the lowest resolution component ***IS*** the resolution of the chain. For instance, the underlying architecture of Final Cut Pro is 2000 lines (2k) – so if you process a 4k image file from Red in Final Cut Pro, it will automatically have a resolution of (at best) 2000 lines (I have read but have no full proof that the architecture of Premier Pro can handle 4k – but I find this programme quite clunky to use). But MTF affects more than resolution. Anything that is a descriptor of what an image is (saturation for instance), is circumscribed by the modular transfer function. Break it down: all ideas come in packages – that's the 'modular' bit. When the contents of a package are transformed into something else other modifications occur– that's the 'transfer' bit. The notion of a 'function' is of a transition from one thing to another - that something starts, it gets moved around and changed and then pops out. The MTF describes the lowest quality or quantity limits of any of the functions of the chain or pathway.



So the traditional Cinematographer must know what's happening and why. Not so you can create the purest signal in the world – that's the DiT's role (the digital imaging technician). Your job is to know the process and then apply artistic and creative judgement to the control of the signal so that if you know the limitations of a process, you can utilise those limitations for creative effect.

In the evaluation form that you took before coming on the workshop there were a series of questions which asked you about your familiarity with some ideas like **Wavelet Transforms**, **Bayer Patterns** and the **Nyquist-Shannon Theorem**. The reason I asked these particular questions was to generate the idea that it's better for the person dealing with digital devices to have some idea of what goes on 'under-the-bonnet' in digital cinematography and to familiarise you with the idea that *nothing* is out of bounds for a bright interested person – even if your Maths is distinctly no good – as mine is – you need to feel no fear at anything in the digital domain; then you are in charge of it rather than it being in charge of you. Hearing the relevant terms more and more will make you feel familiar and at ease.

KEY POINTS:
Most systems require you to set up or configure the 'project' at some level. The 'project' is a series of baseline settings or parameters of the work you're about to do. We will be going through this on the workshop so I'm putting this information here as a reference – you don't need to memorise this.

The key Project settings in Red are **Resolution**, **Time Base** and **Quality** and these can be found in the menus when you press the '**System**' Button. Frames per second is within Time Base.

Sensitivity (ASA or ISO speed), other frame rates via **Varispeed** and the **Shutter Angle** can be found under the '**Sensor**' button on the Red One Camera. Other frame rates do not change the fundamental Time Base of the Project.

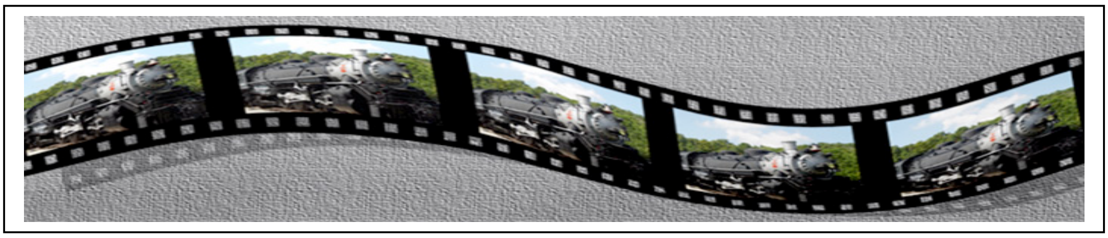
The 3rd of the fundamental Red controls to be found on the back of the Red is the '**Video**' button which controls **Audio**, **Video**, **Colour** and **Display**.

There is an 'Exit' button to get out of any of the menus. There is also 'Power up' which also 'Powers down', plus a 'Record' button.

This is Red's system and all manufacturers will do something similar – after all, it's just a set of menus and a good Camera Assistant will make it their business to know where stuff is. A DiT will know much more than this and be able to deal with the colour science that is underlying the particular manufacturers system of recording and playing back.

For more info on the red download the 'Red operations guide build 30' for all the other controls. https://www.red.com/support for Alexa - go here: http://www.arridigital.com/downloads

TIME BASE
If you're doing a cinema release you'll work to 24 frames per second – if it's the European TV system or similar you'll set the baseline to 25 fps. If you're working in America or Japan, you'll set the fps to either 23.97 or 29.98 – ask your client what they want because this one can provide big problems in transferring data from system to system. Having set your frame rate you can then work off-frame or varispeed – if you are in 25 fps, you can set 30fps for a slight slow-motion effect.



Shutter Angle is also measured as time – this is effectively one half the frames per second. In physical terms in film exposure, the device that was used to expose the film to light was via a shutter. This was simply a spinning wheel with a gap in it and the original gap was 180 degrees (sometimes 172 if you want to eliminate flicker with older HMI's), which is half a 360 circle – half the circle was open to allow light through to the film). So at 25 frames, the shutter is 180 degrees or 1/50th of a second. If the whole shutter took one 1/25th of a second to spin round and half of it was open – then the shutter was either 1/50th of a second or 180 degrees of a 360 degree circle.

In cinema therefore, 24 frames per second is has a shutter of 48th of a second – which is 180 degrees of a 360 degree circle - and so on.

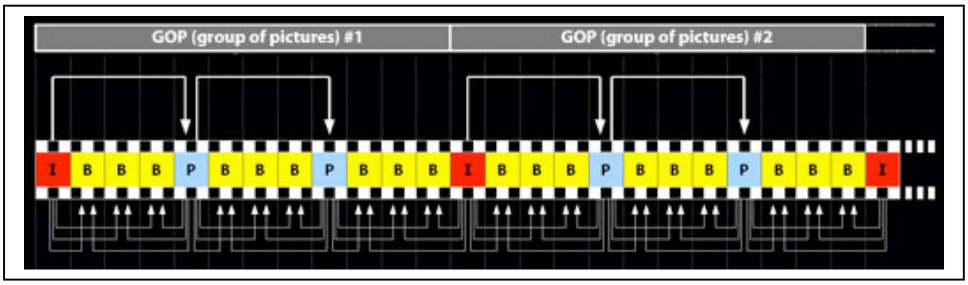
Decrease the shutter angle to achieve sharper images (as in Band of Brothers) but remember to allow more light in through the iris (Fstop) to compensate for the shutter angle change (or decrease if you open the shutter).

CRUCIAL ELEMENTS THAT AFFECT THE PATHWAY FROM CAPTURE TO POST
The lens comes first, through which light passes to an arrangement of photosites on the CCD or Chip, which are devices which respond to light by generating electricity. Obviously use well known lenses – the more expensive the lens, the better the transmission of light, colour and resolution.

In terms of the chips in various cameras, what you get given depends on the historical loyalties of the manufacturer – Sony has mostly been a half-inch chip company (with three of them to deliver colour) whereas Red Cameras started out almost double that size at 35mm. The size of chip determines the optical pathway and the small pathway of half-inch chips meant a deeper arena of focus in the optics – whereas 35mm pathways determined a shallower depth of focus in the images. The DSLR phenomenon depended on the shallower depth of focus derived from the larger optical pathway. Now however Sony is coming up to 35mm size and single chips. In terms of the kinds of sensors, these are fundamentally of two types: CCD or CMOS, where CCD refers to a charge-coupled device and CMOS refers to a Complimentary Metal-Oxide-Semiconductor. The first empties its charge line by line, the second empties the whole frame.

THROWING INFORMATION AWAY – COMPRESSION
A big question is: Does your camera/recorder record all of the lines in the image or all of the frames in a second? This is an important question. Recording systems need around 1000 megabytes per second of recording ability to obtain a 4k image. That's bloody fast. HDV outputs and records around 27 Mbs, HD Cam records 220 Mbs. So an early issue in recording data was that the systems simply weren't fast enough to record all the information, consequently different manufacturers had different ways of handling the surfeit of data. Primarily though, prior to data cinematography, they just threw data away. They did this in various different ways – Sony's HD cam system simply recorded 1440 lines of information – not the whole 1920 – plus it compressed the signal. Mathematically they made the difference up prior to display using various algorithms that then produced artifacts in the display which the experienced cinematographer could see. HDV cameras used to have chips of around 965 pixels which output a signal which was then mathematically uprezzed to 1440 (you'll see these same figures appearing again and again), then up to 1920.

HDV also did a terrible thing – it recorded images in a GoP structure. Group of Pictures. This was a scenario where frame 1 was good and frame 7 was good – but everything in between was made up of the two frames. Which is why HDV isn't very good with movement. That's a short GoP structure, which Panasonics' P2 system uses. Sony tends to go for a 15 frame Long GoP structure. Everything changes though – and it changes all the time – so check current compression rates and ideas yourself.



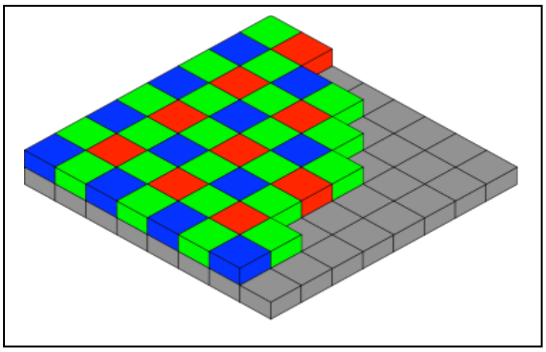
Clearly long GoP's are not good, but recent advances in the manufacture of compression and decompression algorithms have created much better replication of original data. And here we come to another key idea: Wavelet Transforms. Originally Joseph Baptiste Fourier invented DCT's (Discrete Cosine Transforms) in 1800. They're mathematical transformation formula that take a number or series of numbers and then create another group of numbers that are *analogous* to the original – but having significantly less information held, *but capable of re-constituting that information through a reverse transformation*.

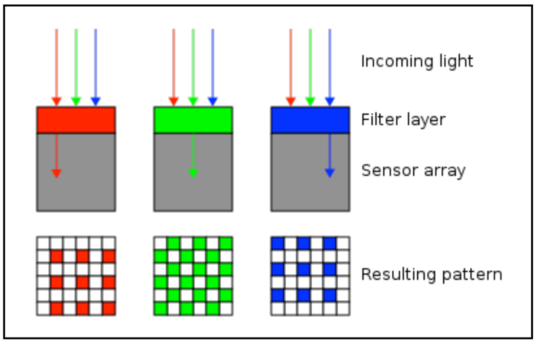
So far so good – except that so far, it's not good.

DCT's are comparable to Meat Grinders within compression of visual data. They're unsympathetic because of the way that visual data is generated. If you have both dark and light in a frame then at some edges the change between the two is huge because you are going from the highest value to the lowest value. If you're designing algorithms that essentially examine data by using a square wave technique – so that you then use many discrete samples to create a curve from what is essentially a series of bits of information *at right angles* – then something has to give. In other words you're tying to make a circle by using bits of a square. So DCT's do what they can but are lacking in finesse in the act of reducing the information to something that might have values that are better described in the millions than the tens.

In 1807 Fourier invented the Wavelet Transform – both DCT's and Wavelets were further refined by people like James Clerk Maxwell, but it wasn't until about 20 years ago that wavelet transforms became 'workable'. This is coincident with the development of modern digital invention with the internet as a specific. Wavelet Transforms are the 'under-the-bonnet technology of modern digitality. Unlike the meat-grinder approach of DCT's, they delicately examine what kind of data is coming into the equation, then intelligently bring a *relevant* piece of maths from along their 'length' to meet that data. Next up, having processed that data they then intelligently bring the next relevant piece of maths along to finally render the data as a reduced form of what it originally was, but in as sympathetic way as is possible and in a way that is *designed for recomposition*. What this all means is that the original can be reconstructed from very little data because all the algorithm has to do is reconstruct a form of arc from a series of arcs. Wavelet Transforms were derived from planatery dust particle analysis and needed to be far finer in design than DCT's. So when applied to visual data, they were naturally more appropriate.

The re-construction of colour from Bayer Pattern Filter
Here's a definition from wikipaedia: A Bayer filter mosaic is a color filter array (CFA) for arranging RGB color filters on a square grid of photosensors. Its particular arrangement of color filters is used in most single-chip digital image sensors used in digital cameras, camcorders, and scanners to create a color image. The filter pattern is 50% green, 25% red and 25% blue, hence is also called RGBG, GRGB, or RGGB. It is named after its inventor, Bryce E. Bayer of Eastman Kodak. Bayer is also known for his recursively defined matrix used in ordered dithering.



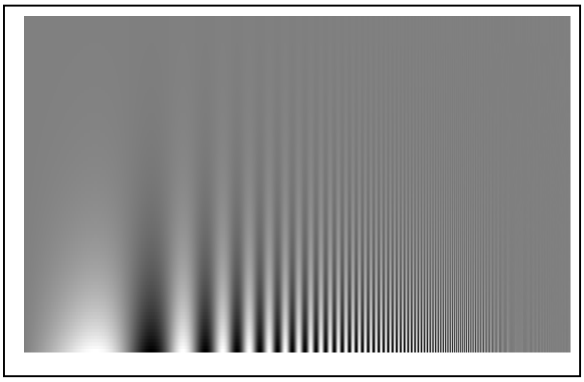


Here's a link to Silicon Imagings' explanation of Bayer Colour Filter Arrays:
http://www.siliconimaging.com/RGB Bayer.htm

Using the idea of the Modular Transfer Function – that the weakest link in the chain is the measure of the actual strength of the chain – and then extrapolate that idea into a characteristic of an asset – then resolution must relate not just to one part of the production pathway, but in the end should be measured by the lowest resolution element of that pathway. If Final Cut's architecture is limited by a 2k ceiling – then regardless of whether you've shot at 4K and post produced at 4K – if the footage has been through final cut – then the entire chains MTF is set at 2k.

Bayer patterning is also a determinant of resolution and works in association with: **The Nyquist-Shannon Sampling Theorem**. Here's a definition taken from the net: 'The Nyquist-Shannon Sampling Theorem is the basis for all digital sampling of analog signals. Its named for Harry Nyquist, whose work on telegraph technology was instrumental in the later work by Claude Shannon in 1949. It's also often referred to as just the Nyquist Sampling Theorem or simply the Sampling Theorem. **Nyquist Frequency** The importance of the sampling theorem is that following it allows analog signals, such as audio or video, to be reproduced digitally and then converted back to analog again later. One of the key requirements for accurate conversions (sampling) is the necessary Sample Frequency. The sample frequency must be **more than twice the frequency of the original signal**. In order to reproduce sounds as high as 20kHz you must take at least 40,001 samples per second (20,000 x 2 + 1). Likewise, in order to Capture a 3MHz VHS signal you must sample at no less than 6,000,001Hz (3,000,000 x 2 + 1). What this suggests is that to get a 2k resolution image – you need to start with a 4k image to derive the 2k version!

RELEVANT READING: The Colour Space Conundrum, American Society of Cinematographers, Douglas Bankston: http://www.theasc.com/magazine/jan05/conundrum/index.html. A gem from Bankston's essay: We humans value detail and sharpness more than resolution in an image. High resolution is synonymous with preservation of detail and sharpness, but high pixel count does not always translate into high resolution. "As you try to increase the amount of information on the screen," explains Cowan, "the contrast that you get from a small resolution element to the next smallest resolution element is diminished. The point where we can no longer see [contrast difference] is called the limit of visual acuity." (see top diagram on next page) It's the law of diminishing returns, and a system's ability to preserve contrast at various resolutions is described by the modulation transfer function (MTF). The eye is attuned to mid-resolution information, where it looks for sharpness and contrast. A higher MTF provides more information in the mid-resolution range. You just want to make sure that the resolution doesn't drop so low that you pixellate the display, which is like viewing the image through a screen door.



The Contrast Sensitivity Function (CSF) shows that visual sensitivity to contrast is highest at lower resolutions than the threshold of acuity (the point where we can no longer see contrast difference). This is noted by the envelope of modulation that looks like a Gaussian curve, a symmetrical bell-shaped curve of normal distribution that encompasses the more-defined blacks. If the pattern is observed up close, the Gaussian shape moves right; as you view the pattern from greater distances, it will continue to move left. The peak on this curve represents the spatial frequency where contrast discrimination is most sensitive.

… and lastly – all forms of exhibition have different parameters of representation. On a bright Sunny day your eyes can distinguish around a thousand tones from Black to White. Film is around 150 – analogue video was 35, digital 50, data round 75 – Cathode ray tubes displayed 150 tones (!!!), LCD's 40, Plasmas 50, projectors (depends on the spec, but between 30 – 75). These figures may now be out of date – do check and if you find different – let me know. The bottom line is: If you've done your best between capture and Display, the last bit is the sobering issue. Making images is about representation – that's the art of it, knowing the technology allows leaps of imagination to create the *sense that there's much more to the image.* All of the above is a series of ideas to become familiar with then keep in mind, so that bit by bit you become comfortable with the idea of Digital Cinematography.

THE PRODUCTION PATHWAY IN THE KNOWLEDGE TRANSFER WORKSHOPS
Set up the project on the camera. Shoot footage on a data card, standard hard drive or Solid State Drive. Transfer rushes to laptop in middle of day or at will and backup to second drive at the same time (Digital Imaging Technicians do this on big jobs, clapper loaders or 2nd AC's, or if one AC/Focus Puller on small jobs). Bring to Post, Transfer into two locations in Post for safety. Render footage via Computer (with or without RedRocket for speed wen using Red footage). Some systems have their own routes which you need check. Alexa can output standard quicktime files. At this stage do a 'one

light' grade into the *colour space you'll be working with (plasma or projector). Take rushes into Avid or Final Cut, Premier, a Quantel device or whatever) - Edit Project. Grade project back out in second colour pass into correct colour space for exhibition.

NOTES & DEFINITIONS
Go here for further resources: http://www.flaxton.btinternet.co.uk/KT2.htm
Download the Red operations guide build 30 from Red Cameras. https://www.red.com/support
Other notes on Digital Cinematography:
http://sites.google.com/site/cinetaur/hd24pdigitalcinematographylinks
More information on Wavelet Transforms http://www.amara.com/current/wavelet.html

Colour Space
Every technology of display, be it a printer, a projector, a computer display, a cinema projection or an cathode ray tube uses a 'colour space' which is the specifications of the parameters of what is displayed are defined by. The screen on which you are reading right now has a set of parameters – and if you're reading this on paper then your eyes also have a colour space within which they work.

Resolution Progressive and interlaced
Interlace is a hangover from the age of television when the technology needed to create a sufficient number of flashes per second to create a sense of movement through persistence of vision. The cinema frame rate of 24 fps is actually displayed either 49 or 72 times per second because a rotating shutter with two or three slits span before the film – therefore there were actually either 48 or 72 flashes per second. To emulate this, television split the number of lines into two fields and therefore in PAL 625 lines became 312.5 lines in each of two fields flashed 25 times a second – therefore there were 50 flashes a second. NTSC with 525 lines became 2 x 262.5 line fields flashed 30 times per second)

Therefore HD 1080i – is half the resolution of its progressive brother 1080p – where 'progressive' means each frame one frame at a time. Therefore 'I' stands for Interlaced and 'P' stands for Progressive. So 1080i is actually 540 lines of resolution whereas 1080p is 1080 lines of resolution.

Log and Linear recording.
Linear recording is designed to obtain and keep the data that best refers to a standard colour space like 'Rec 709'. This is great if you just want to show your work on TV. Log recording creates files that takes ALL the available colour and tonal information that the sensor can gather – even if a device like a plasma display cannot display it. Why? Because that same data may be used for a digital to film transfer for cinema display where more colour and tone variations can be seen. The drawback to Log recording is that it generates massive amounts of data.

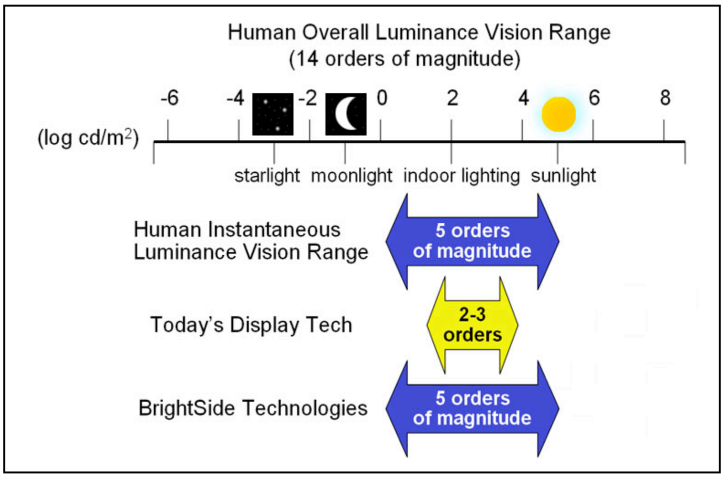
RAW Recording
From the web: A raw file is essentially the data that the camera's chip recorded along with some additional information tagged on. A JPG file is one that has had the camera apply linear conversion, matrix conversion, white balance, contrast, and saturation, and then has had some level of potentially destructive compression applied. With Red, because it uses Wavelet Transform as opposed to DCT you always get a kind of Raw file – this is compressed of course, but to a degree, sympathetically so.

Look Up tables or LUT's
The output of a data camera is generally visually flat. Cinema data files are recorded Log as opposed to Linear. Most clients can't visualize what an image *should* look like and need to see it. 'Enter the Viewing LUT'. This is from Steve Shaw's Light Illusion website: "The first thing to realise about LUTs is that they have different applications that require a different level of understanding, and a different type of LUT! LUTs being used to make an image visually 'pretty', often called Viewing LUTs, are very different to LUTs used to show an image accurately calibrated to another display format, referred to as Calibration LUTs". Fundamentally a viewing LUT is applied to a monitor so that the visually flat images are massaged to look like they would after grading without changing the recorded data. Go to this link for further information: http://www.lightillusion.com/usingluts-info.htm

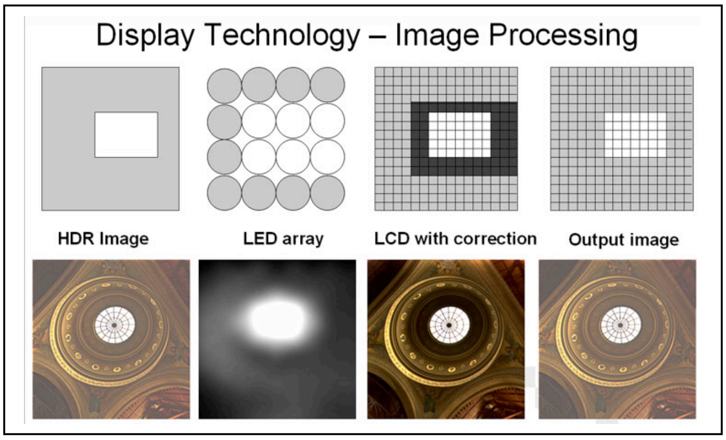
Photosites
When you look up photosite in wikipedia, you get redirected to 'pixel' (which in fact is slightly different). However, read the article and you'll get a definition of both:
http://en.wikipedia.org/wiki/Photosite

Higher Dynamic Range
As with all things video/digital – there is always a superlative involved. In this case 'higher' refers to a better technical response from new technologies when compared to older technologies – in this case with reference to the issue of Dynamic Range. An HDR Display is 10 times darker and 30 times brighter than any existing display and uses images with 32 its per channel as opposed to the current 8 bits per channel (1024 bits of information about colour and tone rather than 256). Previously Film could capture about 12 -14 stops of information from the exposed scene. Video can now cover about 12 stops – the eye however can cover about 20 stops. Not all at the same time though, think of your urge to put on sunglasses on a very bright day, so it's instantaneous response is about 5 orders of Magnitude (see diagram - this is a different scale, but it describes the same issue). In other words the eye/brain can adjust in any given situation and display about 5 orders of magnitude similar to our capture technologies – but, given the whole range from a dark night to a bright day, our eye/brain can usefully employ the whole scale by intelligently moving its receptivity to light up and down the 14 magnitude total range. In the diagram below you can see the relationship between eye/brain and display technologies. The 'Brightside' reference is to a technology now owned by Dolby which uses LED's and LCD's in combination to increase the display technologies dynamic range.

Dynamic range capture has a series of issues within it – for a start there are several ways of obtaining a high dynamic range but one of the most easily understood ways is via capturing two perfectly registered frames – one exposed in the higher luminance area, one exposed in the lower luminance area – then combining the two. It was less possible to make HDR moving picture images with film because of the instability of the film moving through the camera – with the advent of Digital Cinematography registration is inherent in the capture and all you have to do is expose the frame twice before exposing the next frame. Red Epic Cameras will capture HDR images. The first results are described as looking 'plastic' – this is mainly because they infer a computer graphics look because too much range is displayed in a device not suited to the display of that range. If you look at the output of an HDR image on your computer screen (diagram 2 bottom right image of dome) you'll see the dome looks like a simulation rather than a real image.



Here, you can see how the HDR Display technology works. In an HDR Display, two screens are overlaid on one-another. The top screen closest to the viewer is an LCD screen and basically a colour filtration screen – all of the LCD's are generating the relatively correct colour for that pixel. Usually LCD's are backlit from the side and hence quite dull (i.e. 2 – 3 orders of magnitude). But in HDR Display technology a brighter backlight made up of LED lights shines through the LCD's and illuminates them to 5 orders of magnitude, which is the level of the Human Instantaneous Luminance Vision Range. The LED needs only be



much lower resolution than the LCD screen as it simply concentrates high luminance *diffused* back-lighting behind the much higher resolution colour filtration which then seems to us to more closely resemble both the resolution and the actual luminance of the world we see through eye and brain. The only problem with current technologies is that it's really quite expensive – the Dolby HDR Display is about £40,000.

Finally, here are what I consider to be the governing principles for Digital or Data Cinematography:

> a) the optical pathway is 35mm or above (derived from technical and industrial limitations possible at the time of origination for manufacturing photo-chemical negative).
>
> b) it generates a progressively based lossless data/image flow, at 10 bit depth or above, which relates to a specific time-base as opposed to an interlaced image flow (one full frame of information at a time rather than a field-based workflow)
>
> c) like one of its predecessors, film, it holds the image in a latent state until an act of development (or rendering) is applied - but unlike film is non-destructive of its prior material state
>
> d) it's capture mechanism though generating a nondestructive, non-compressed data pathway from which an image can be reconstructed, is not its sole intent as a medium or method of capture (but is distinguished from digital video, the sole intent of which is to generate images in a compressed manner from less than 35mm optical pathways)

These latter three qualities are also base characteristics of many developing digital technologies: with the use of two triangulated camera's photo-site grids, we can map 3D space in real Time Recently we've seen the development of the Kinect but the singular vantage point is problematic in terms of accuracy. Mapping space will allow us to create defined regions of space with greater and greater resolutions. This idea requires extremely fine tuning of the above triangulation, with high degrees of resolution, plus an auto correction of each partition in computer space to correlate with its position in actual space. However, it seems to me, the conception and manufacture of such a thing is within our grasp. If we can accurately map 3D space then we can create events in a location with gesticulation or voice and therefore trigger events. But not only this, that location could then be mapped over a distant and enabled space, so that events could be created there.

Furthering the above ideas with 'White Light Interferometric Scanning' we should be able to capture spatial images for 3D printing - White light interferometry is an extension of triangulation to create extremely accurate measurements of X, Y and Z co-ordinates. Further: at a lab at ETH in Zurich in 2010 I was shown lenticular holographic images of a cup and then asked to reach out and 'touch' the cup which I did. The explanation of my sense of 'touching' was that a puff of compressed air had met my finger at the perimeter of the image. The research team had worked on the hypothesis that if a *sufficient* percentage of the brain was involved in one sense, then 10 % of engagement of another sense could convince the brain that the object was 'real' as two senses had confirmed its existence.

Using the camera more traditionally, we should be able to create images with enough resolution for very large displays. *If* large surfaces can be enabled to carry images then using a suitable material, a building could be covered with an image. Building textures could be changed as clothes are changed. Using this kind of criteria, digital cinematography is about more than just capturing images - it's a portal onto the digital landscape so far unexplored due to its apparent function as an image capture medium.