

RED 101

Mark Lloyd, root6

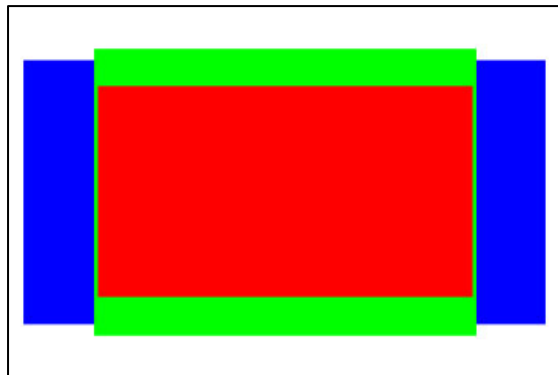
So, the “vaporware” is real. When the RED One was first announced it was dismissed by many as “smoke and mirrors”, a billionaire’s fantasy project. But a few years on and not only is the camera a reality it is fast making inroads into the industry. It may be too early to call the RED One revolutionary, but an amazing variety of productions are using this camera – everything from music videos and wildlife documentaries to TV dramas and big budget features. And the take-up just seems to be snowballing.

If you haven’t worked with RED originated footage yet, it probably won’t be long before you are. Which is the reason for this white paper – a quick primer to get you up to speed with everything RED - the camera itself (and some of the issues to consider when using it) and some of the common post production workflows that you may come up against.

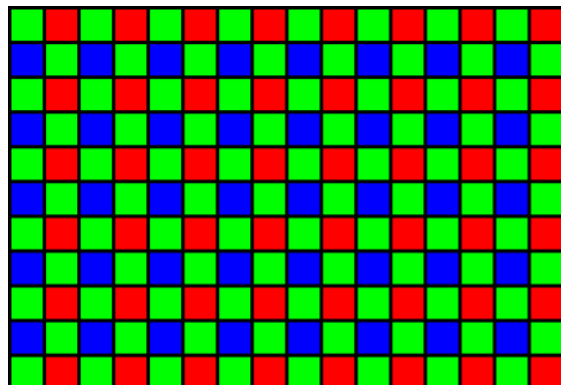
The Camera

RED are working on a number of cameras (*Scarlet and Epic coming soon*) but their first, and currently the only one shipping, is the RED ONE. The features are constantly changing, as RED frequently release firmware updates and offer hardware upgrades, but today the specs of the camera are:

- 4K, Super 35mm equivalent, single CMOS sensor
- Shoots at up to 120 fps (2K)
- Data saved as proprietary, compressed RAW “REDcode/r3d “ files
- Records to CF cards, RED Drive (and soon RED Flash)



RED/Panavision Genesis, ARRI D21, Dalsa Origin



Mysterium sensor

Being roughly the same size of a 3-perf Super 35mm film frame, the Mysterium sensor can produce images with “cinematic” shallow depth of field (*soon to offer 4.5K, 2.40:1 ratio with firmware update*).

It is also about the same physical size as the Panavision Genesis. The Arri D21 is the same width but has a 4:3 aspect ratio of 4-perf super 35mm and the Dalsa Origin is closer in size to a full frame DSLR or Vistavision camera.

The pixels are arranged in a red-green, blue-green Bayer pattern so whilst it has a luminance resolution of 4k, it could be argued to that its real chrominance resolution is 2K for the Green channel and 1K for Red and Blue. The sensor outputs a grayscale RAW image that has to be converted to full RGB when debayered in Post Production, although the camera can play out a colour monitoring feed, with LUT support, at up to 1080p.

As mentioned, there is ongoing debate over the true resolution of the camera and its bayer pattern sensor, but I suspect for the majority of users the most important thing is not technical stats and numbers but the quality of the resulting images.

There is an abundance of RED originated footage online so decide for yourself. Some of my favourite (albeit scaled and compressed) clips are:

<http://www.kennanward.com/alaska/kwpalaska.mov>

<http://www.apple.com/trailers/independent/knowning/>

Whatever the sensor's "true resolution", to my eyes at least, the camera is capable of producing astonishingly pristine images – almost too "clean" for some tastes. However, to get those results the camera needs to be treated as it should be – as a professional digital camera. Despite its relatively low price, it is not a point and shoot ENG-style camera and you need to know how it works to get the most out of it and avoid problems.

Like in the majority of digital cameras, the sensor is naturally most sensitive to red light and least sensitive to blue. That and the fact that there are twice as many green pixels than blue means that for VFX use you are more likely to get a cleaner key from a green screen than a blue one– although users have successfully keyed from both.

The colour temperature of the lighting is also important as the sensor is balanced close to daylight, with a rating of 5000 Kelvin, so shooting with red biased Tungsten lights will rob the already weaker blue channel. Correcting the white balance in post is achieved by boosting the gain in the blue channel, increasing the noise. So for cleanest images, and especially when shooting blue screen, try to light with daylight balanced lighting.



http://ftp.datausa.com/imageshoppe/outgoing/RED_232/blue_channel_compare.png

You may have come across, or heard about, some compression-like artifacts in the blacks of the blue channel, especially under tungsten lighting. As I understand it, this issue has now been fixed as of firmware build 16.

Another thing to be aware of with the sensor is the "rolling shutter". Unlike a CCD chip, which captures from the whole sensor in one hit, CMOS sensors capture progressively by scanning vertically downwards. This means that, under some circumstances - usually when panning or moving the camera very quickly, the image can be skewed as the top of the image is captured before the image at the bottom.

See http://ftp.datausa.com/imageshoppe/outgoing/SHUTTER_STUDIES/RED_rolling_shutter_test.mov

I thought that increasing the shutter speed might help, but apparently they're separate issues and increasing the shutter speed may actually make the skew more obvious as there's less motion blur.

This skew can cause problems for motion tracking software. Other CMOS cameras, like the Arri D21 and Dalsa Origin, get around this problem by using a physical, mechanical shutter but RED say they are

reducing the read-reset of the CMOS sensor and even now, many people have successfully motion-tracked RED footage. Just do some tests before hand to see if the movement you are planning is likely to cause problems.

On a similar note, try to avoid any flashes or strobe lighting as the rolling shutter can cause a “tear” across the image as one half exposes the flash and the other doesn’t.

For an example see:

http://ftp.datausa.com/imageshoppe/outgoing/SHUTTER_STUDIES/STROBE&ROLLING_SHUTTER.mov

If you do have to have strobe effects of muzzle flashes, you may find it safer to add them in post.

Frame rates / Resolutions

The RED One can shoot at various frame rates and resolutions up to 120fps at 2k. The maximum frame rate you can achieve depends not only on the resolution you’re shooting at but also the recording quality and the device you are recording to:

REDCODE 28	RED 8GB	CF RED-DRIVE & RED 16GB CF
2K 2:1	113 fps	120 fps
2K 16:9	100 fps	100 fps
3K 2:1	50 fps	60 fps
3K 16:9	36 fps	50 fps
4K 2:1	25 fps	30 fps
4K 16:9	25 fps	30 fps
REDCODE 36		
2K 2:1	89 fps	120 fps
2K 16:9	79fps	100 fps
3K 2:1	36 fps	50 fps
3K 16:9	30 fps	36 fps
4K 2:1	25 fps	25 fps
4K 16:9	n/a	25 fps

For the highest frame rates, you will need to shoot at 2k with either the RED Drive or 16GB CF card. The 2K and 3K resolutions are windowed, not down converted, meaning that the images are only captured from part of the sensor. There is no in-camera scaling.

This is a good point to stress that shooting at 4K does not mean you have to finish at 4K, you can always down convert from 4K in post. But for maximum quality and cinematic depth of field it’s best to shoot at 4K unless you need the high frame rates.

RAW

The camera records to a proprietary, compressed format called REDCODE, which uses wavelet based compression to compress the RAW data coming of the sensor. That means that very little is baked-in off the camera and settings such as color space, white balance and ISO ratings can all be altered later.

There are two quality settings for REDCODE, 28 and 36, which roughly represent the compressed data rates (*which vary as a function of the image complexity and detail*) of 28MB/sec and 36 MB/sec respectively.

Note Mega Bytes, compared to 25 Mega bits/sec of HDV - almost ten times the size but still a lot less than the 334MB/sec data rate that would be needed for uncompressed 4K at 24fps.

There's very little documentation on the two quality settings and I couldn't find any comparison tests so unless you need the higher frame rates it's probably best to stick with REDCODE 36.

Exposure

This isn't the place for an in-depth course in cinematography, however - a brief note on exposure. Like all digital cameras (*and reversal/transparency film*) it's best to "expose to the right" - getting the histogram as close to the right as possible without clipping the highlights.

The monitor image will appear brighter and the histogram will clip earlier if the colour space is set to rec709 or REDspace, but one of the camera's user buttons can be set to toggle the colour space to CameraRAW and the exposure reading in this mode is the one that matters. In this colour space, if you're clipping one of the channels you might be able to recover the highlights in that channel in post, but two or more clipped channels will probably be permanently blown. As long as only one channel is slightly clipped, it doesn't matter if it appears blown out when the viewing space is set to one of the other modes. However, if the footage is later converted to rec709, for example, the technician processing the footage in post may have to adjust the exposure down during conversion to compensate.



Recording Media

Finally, before moving on to workflows, a quick look at the pros and cons of the recording device options. The Flash drive hasn't been released yet so I'll just focus on the CF cards and REDDRIVE.

Compact Flash:

Pros: Compact, robust

Cons: short recording time (4 to 5 mins per 8GB) – however that may be a good thing



REDDRIVE:

Pros: long recording time (320GB roughly 3hrs at 4k) – however that may not be a good thing

Cons: Heavier, hard drives striped in RAID 0 so no redundancy

These devices are your digital negative. The danger with the REDDRIVE is that the longer you record with it the more material you have to lose if the hardware fails – and with striped hard drives that risk is a lot higher than with solid state memory.

Whatever device you shoot to, swap cards/drives and back-up as frequently as you can!

Also it may be safer to playback takes after backing up, rather than from camera, or use a separate playback recording solution. Would you play back you negative/master HDCAM SR tape?

Other Digital cameras record to RAID arrays with build in redundancy so with them the same advice may not apply, but just be aware that with the RED, until you back up your source media that is your only copy. Whatever device you record to, you will probably need to make at least the following three backups, verifying the data after copying:

- Local storage device with some form of redundancy (raid 5 or mirrored etc) that stays in production office at location or studio.
- Transport drive for post house (e.g. GRAID or GSAFE)
- LTO tape for archive

Only then can the recording device be erased and sent back to production for re-use.

Post Production

If anything has stood in the way of the rise of the RED One it's the often far from smooth file and software juggling that may be needed in Post Production. Every workflow is different. Some, such as a Final Cut Pro based one with ProRes 422 as the final output format, are pretty straightforward but throw Avid, DPX or conforming into the mix and suddenly it becomes a whole lot more complicated.

The source of the trouble is RED's .r3d output. It's a new, proprietary, non-industry standard file format and until now very few software programs natively supported it. However, that is now changing. At IBC this year, a range of manufacturers announced that they had signed RED's SDK agreement so expect to see much greater REDCODE support appear over the next few months.

That increase in SDK take-up may soon make some of the following section out-dated, but for now, here are some of the most common workflows that you might come across:

Dailies and Editorial

On receiving the footage from the day's shoot the highest priority is usually to generate dailies and provide the editorial department with material in a format they are able into to ingest. ContentAgent, from ROOT6 Technology (www.root6technology.com), provides a powerful, simple solution for both tasks – offering a fully automated RED Dailies workflow that can take the .r3d files and generate:

1. Watermarked MPEG2 versions of the footage, authored to DVD, complete with menu and slates, if desired. If a Rimage publisher is connected then multiple, colour-printed DVDs can be produced, with individual barcodes if required.
2. Avid DNxHD 36 MXF files, copying them to the SAN where they can be accessed immediately by editorial.
3. Generates any other version required, such as high definition h.264 versions that are uploaded over ftp, high definition AVI versions for output to tape or rights managed WMV files that are emailed to a saved recipient list.

Apple

For a long time Apple users have been able to play back RED footage by downloading a free plug-in for QuickTime (from www.red.com/support) that enables support for REDCODE and making use of a workaround by RED that wraps the r3d files as QuickTimes.

The RED One, in addition to r3d files, also saves four QT reference files (*full, half-res, quarter-res & eighth-res*) and by using one of these it is possible to playback RED footage on OSX. Likewise by importing one of the reference files into Final Cut Pro it is possible to edit the footage without any transcoding. However, the r3d files must be kept alongside the QuickTimes – without them there would be no footage to reference!

Until now, that has been the only Apple solution, but in the last week RED and Apple have provided additional r3d support for Final Cut Pro and Color (up to 2k) in the form of the Log and Transfer tool and Redcode plugin for Color (from www.red.com/support).

The Log and Transfer tool enables import of REDCODE RAW clips into FCP, either as QT wrapped files or transcoded to Apple's ProRes codec. By default the color settings at the time of the shoot (stored in the r3d's metadata) will be used but these can be changed during this stage (albeit via a roundtrip to RED Alert) or, if the footage has been imported as QT wrapped files, the settings can now be changed during grading in Color.

Avid

Until Avid supports r3d files natively, and other than using ContentAgent, footage can also be imported into avid by:

- Using Mac OSX and RED RUSHES (*part of the free RED ALERT from www.red.com*) to generate an ALE file and QuickTime references, stored in a single folder.

- Using Mac OSX or Windows and RED CINE (free from www.red.com) to generate an XML file and QuickTime wrapped Avid DNxHD files (currently DNxHD 175x only). The XML then needs to be converted to an ALE using some translation software and Avid XSLT (Extensible Stylesheet Language Translations) file – see www.avid.com/red for more details.

DPX

Compositing software such as Eyeon Fusion and Grading systems such as Digital Vision's Film Master and Film Light's Baselight now natively support r3d files, however, many users still need or want to work with a more established format and naturally gravitate to the one that is pretty much industry standard for film projects – dpx.

On the plus side, dpx is established. Nearly every post-production software or DI hardware supports it and project-proven workflows built around it. It's also uncompressed so no processor-intensive debayering is required to work with it.

However, the dpx files will take up more storage than the r3d files they originated from and whilst the 10bit Log space is theoretically capable of storing the full dynamic range from the 12bit linear r3d, care needs to be taken during the transcoding process to make sure that no colour information is inadvertently lost.

RED ALERT, RED RUSHES and REDCINE are all capable of converting r3d to dpx, as is Assimilate Scratch and products from DVS and Digital Vision. There is no one-for-all setting that will give you the best results for your project so testing and experimentation with custom LUTs really is advised.

Conforming

The non-RED products mentioned above will also be able to handle conforming (not just to dpx) but the free RED offerings will need the assistance of some third party intermediaries to work with that EDL or XML from editorial as they do not natively read EDLs.

Monkey Extract (<http://www.rubbermonkeysoftware.com/>) is a relatively inexpensive solution that automates the rendering process – only rendering the footage dictated by the EDL. Another option (currently only for FCP users) is Crimson Workflow (<http://www.crimsonworkflow.com/home.htm>).

Contact Us

This has only been a very brief overview to some topics that could easily have many hundreds of pages dedicated to them in their own right; however, hopefully it has served as a useful primer. If you have any questions or want to discuss any of the issues covered further then please do contact root6:

info@root6.com or 020 7437 6052

Resources

This guide couldn't have been put together without some great online resources and real mine of information:

www.red.com

www.reduser.net

www.fxguide.com and podcast <http://www.fxguide.com/redcentre>

<http://www.scottsimmons.tv/blog/>

<http://prolost.blogspot.com>