

RED - Camera

Moving from film to a completely digital workflow

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DAP04S

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1 A Short history of Film production formats

1.1 Film gauges

Most motion pictures shot within the last 100 years have been shot on some variant of the 35mm film format. The gauge was introduced for the first time in 1892 and standardized in 1909. Still today, over 100 years later, most films in cinemas are projected using 35mm film.

16mm film was introduced by Eastman-Kodak in 1923, and has since become the industry standard for documentary and high-end television work.

There are several other filmgauges in use: 8mm is for purely consumer use, while 65mm and 70mm filmgauges are mainly used in IMAX-theaters and other “speciality” venues. Bulk of all motionpicture work is done in the two aforementioned formats.

1.1.1 35mm versions and aspect-ratios

There are several 35mm film versions on the market. At first, the film was shot using the aperture provided by the lens on the negative, 1:1,33 (the same as SD-television, 4:3). After television got popular in American homes, the movie studios needed to do something to lure the audience into the theaters. Two of the biggest things the cinema could provide over television were colour and a wider, bigger screen.

After several colour versions where several strips of film were run simultaneously through the same projector, thus creating a colour image, the real colour negative was introduced in 1950, starting the boom with colour motionpictures.

The bigger screen was also developed, at the same time. The first option was to do a “hard-matte”, and cover either the top or the bottom of the image, thus ending up with an image that is wider than it is tall. This process however compromises picture quality, as the full frame is not utilized. Cropping was used to achieve an aspect ratio between 1,75 and 2:1.

Several techniques (such as Cinemascope) utilize anamorphic squeezing. The film is shot using a specialized lens, which squeezes a widescreen image onto a normal-

aspectratio frame [1, 167]. The image is then projected using a similar lens, thus reversing the effect and creating a widescreen image of greater quality than cropping.

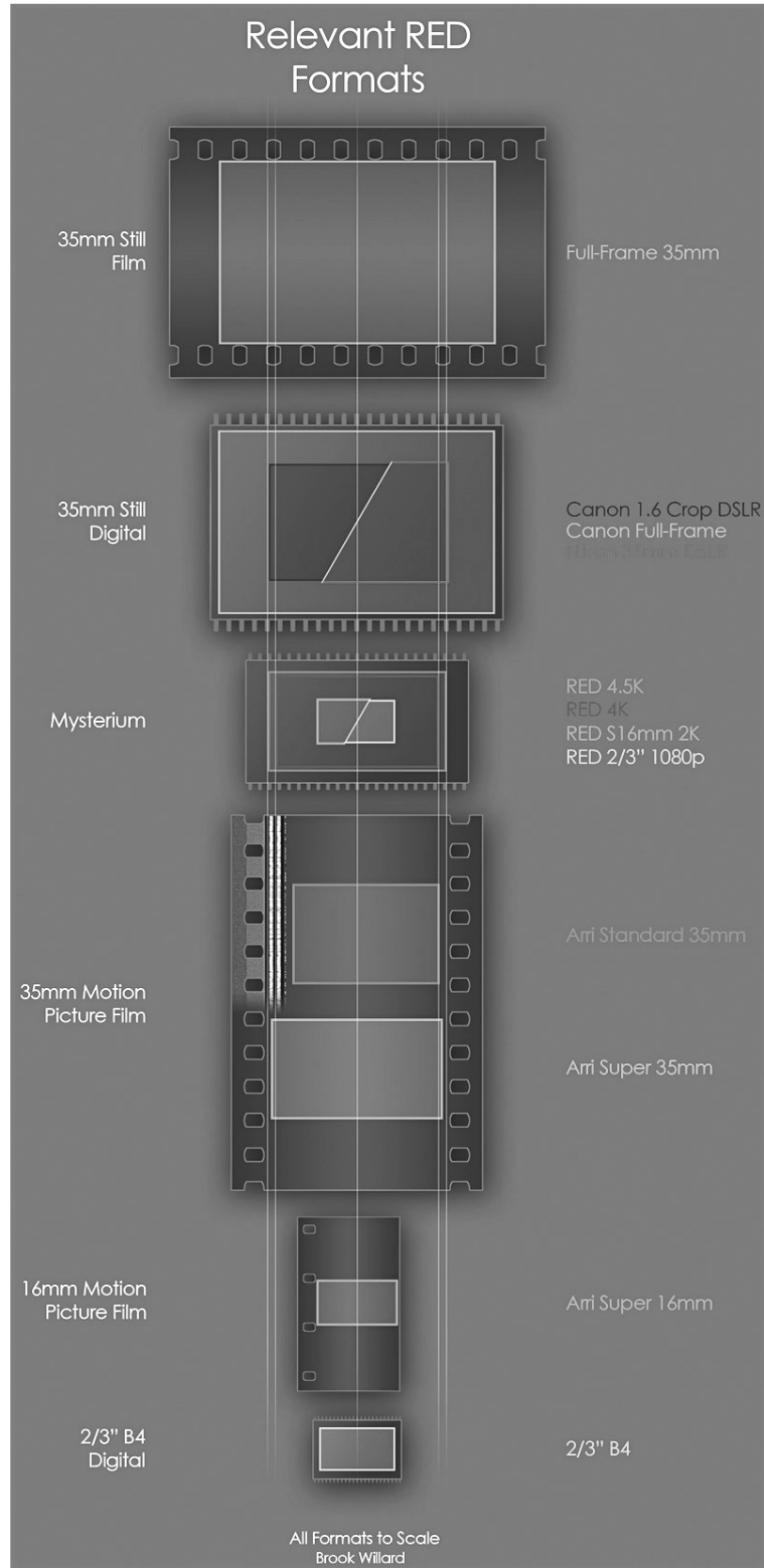


Fig 1. Framesizes of different cameras

1.2 Film postproduction

Before digital postproduction became the norm in the 21st century, film postproduction was a very manual process. Effects and colourcorrection were done by optical and chemical processes.

Digital processes became the norm in the late 1990's, when processing power and storagesystems caught up with the requirements of the motionpicture industry.

2 Digital Production

2.1 Digital Postproduction

Motionpicture postproduction has evolved in leaps and bounds since the second half of the 1990's. Several filesizes and formats have been tried and discarded, with the whole industry slowly adopting the same standard formats. Uncompressed 2K post production is usually performed using DPX-files. DPX is a SMPTE standardized file, which is based on the Kodak-developed Cineon-format. The files can be in either linear or logarithmic colourspace and make extensive use of look up tables (LUTs).

2.1.1 Frame Sizes

2.1.1.1 HD

HD comes in two flavours: 1920x1080 (1080 from now on) and 1280x720 (720 from now on). HD is the standard for high resolution digital broadcasting, and has been widely adopted by NLE and camera manufacturers in professional, prosumer and consumer markets.

2.1.1.2 2K & 4K

2K and 4K are formats used in the motionpicture postproduction industry. The moniker 2K means the image is 2048 pixels wide [1,317] and 4K means that the image is 4096 pixels wide. There are several conventions used when scanning and processing frames that are cropped or anamorphic, but these are the more known and used frame sizes:

Scanning Resolution	Full Frame	CinemaScope
4K	4,096 x 3,112	3,656 x 3,112
2K	2,048 x 1,556	1,828 x 1,556
HD	1920 x 1080	N/A
Aspect Ratio	1,316	1,175

Table 1 Framsizes for Digital formats

2.1.1.3 Filesizes

Here are some examples of the sizes of files that post production works with:

Scanning Resolution	16Bit / frame	16Bit / min	10Bit / frame	10Bit / min
4K	55,27 MB	77,73 GB	36,85 MB	51,82 GB
2K	12,66 MB	17,80 GB	8,44 MB	11,87 GB
HD	11,87 MB	16,69 GB	7,91 MB	11,12 GB

Table 2 Filesizes for Digital formats

2.1.2 Digital workflow

The workflow of working with film is pretty standard. The film is scanned into DPX files using a filmscanner. The files are then processed to create low-resolution, lowbandwidth files for offline editing.

After the offline edit is done, the necessary fullquality frames are chosen for offline editing, visual effects and colour grading. After the grade is complete, the frames are printed back to film using a film printer.

2.1.3 DCI

The digital cinema initiative is an organization formed by the manufacturers and motion picture studios. They have created the group to advance the digitalization of the actual cinemas around the world.

The advantages of digital cinema are many:

- no more film distribution costs. These days, the distribution of one motion picture to 4000 screens world-wide costs to the tune of \$5 million for the printing alone. With digital projection, the whole film can fit on a \$50, 300GB hard drive, that weights a fraction of a film reel.
- No more wear on the film. The customer gets the same pristine quality regardless of how long the film has been running in the cinema.
- Easier maintenance on the projectors → less wages
- International copies can be transferred over the web, instead of freight.

The main issue has been money. Cinema owners have been reluctant to upgrade theaters with their money, when the bulk of the actual short-term savings (distribution costs) would go to the studios. But now the companies are working together, and digital screens are coming up everywhere. In Finland alone it is expected that the amount of digital screens will double during 2009 from 10 to 20 screens.

2.1.3.1 DCI specs

The Dci specification is based on the JPEG2000 format:

- Image:
 - 2048x1080 (2K) at 24 fps or 48 fps, or 4096x2160 (4K) at 24 fps; 3×12 bits per pixel, XYZ color space
 - JPEG 2000 compression
 - from 0 to 5 or from 1 to 6 wavelet decomposition levels for 2K or 4K resolutions, respectively

- Compression rate of 4.71 bits/pixel (2K @ 24 fps), 2.35 bits/pixel (2K @ 48 fps), 1.17 bits/pixel (4K @ 24 fps)
- 250 Mbit/s maximum image bit rate
- Audio:
 - 24 bits per sample, 48 kHz or 96 kHz uncompressed PCM
 - Up to 16 channel

3 RED One

RED has been making a lot of waves in the motionpicture industry. They have brought a camera to the marketplace that completely rewrote the pricing for professional equipment and took some of the established names by surprise.

3.1 The Company

Red was founded in 2005 by Jim Jannard , an entrepreneur who had a little earlier sold Oakley, a company manufacturing sunglasses, recreational wear and other similar things for several billion dollars. A long time camera geek, he wanted to set off creating the ultimate digital motionpicture camera.

RED One was first announced in 2006 at the NAB tradeshow in Las Vegas. It was met with a lot of doubting and labeling as vapourware, since the claims by the company were quite unheard of in the marketplace.

At NAB 2007 the company had three working prototypes available. The cameras had been tested by Peter Jackson, who had shot a short movie using the cameras. The company starting taking deposits from prospective owners, and promised to start shipping cameras before the end of the year. In a short time, the company had received more than 500 deposits of 1000 USD.

3.2 The Camera



Fig 2. The RED ONE camera

RED One camera has 12 Megapixel CMOS Mysterium sensor, designed and built in-house. The sensor is physically 24.4mm x 13.7mm in size, and has 4900 x 2580 pixels. The biggest actual framesize shot is 4096 x 2304. The camera is equipped with a standard Panavision Lens-mount, with interchangeable mounts for Nikon and Canon cameras optional. The camera supports shooting at variable framerates, upto 113 frames per second.

The pricepoint of the camera is unique: \$17500 for the camera body is about 1/10th of the price of the competition (Sony F23 is priced at around \$150 000), which makes is extremely affordable. Many film makers can afford to buy their own cameras instead of renting.

Red does not have a resales organization, instead all cameras need to purchased directly from the company. Support is heavily P2P driven, with several active forums giving support to users in all aspects of the workflow, from shooting to postproduction.

3.2.1 Redcode

The secret of the camera is in the proprietary recording format. An uncompressed 4K datastream (around 77 GB/min) could not be really recorded onto any conventional medium, so compression is used to record the data onto normal harddrives and flashdrives. This compression is called Redcode, and deoted by a r3d extension in the file. Redcode records the 4K image at only 2,2 GB/min, a whopping 97% decrease in filesize. It comes in two different versions, Redcode28 (28MB/s) and Redcode36 (36MB/s). Redcode is based on wavelet compression.

RED likes to refer to Redcode as a RAW format, but this is somewhat misleading. In the still-camera world, a raw-file means that all the information from the sensor is put in the file. Red has somehow turned that around, and here “raw” means that they have discarded most of the data available.

Proprietary Redcode recording format means trouble in the post-production pipeline: The format is not supported by most NLEs, as native redcode support is only in the pipeline for most companies (API was released fall 2008). Decoding into other formats takes quite a long time (8-Core 3,2 GHz Mac Pro takes 2-10:1 realtime in decoding, all cores running, depending on end resolution).

3.2.2 Workflow

Working with the Redcode files is a different workflow when compared to normal film or video based workflows. This is the basic workflow:

- Decode Redcode Raw-files into intermediate format for offline editing. Usually ProRes422 is used, as it is a good compromise between image quality and filesize.
- Bring back finished edit, conform raw-files into DPX-images for online editing using XML
- Do online editing and grading, print to film or compress for distribution

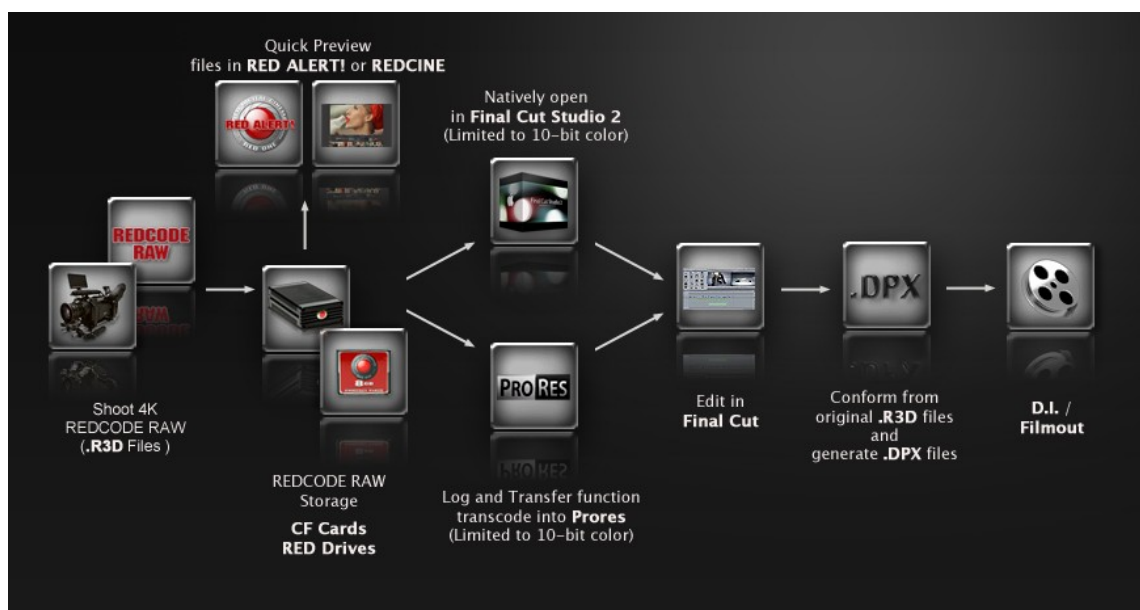


Fig 3. The Redcode workflow

Online-editing is done using DPX files. In the process visual effects-shots are added, and the image is flattened for colour grading. The image is then rendered from the grading unit to the film printer or DCI system.

3.2.3 Issues

Several issues have come up with the camera: low-light photography is not quite up to the level or traditional film, and highlights are sometimes clipped. There is also significant “rolling shutter” effect due to CMOS-technology: the camera does not

expose the whole frame at once to the the sensor, instead it exposes a pixel line at a time. This means that during pans vertical lines can become disrtoted and slanted. Depth of Field becomes and issue when shooting something else than 4K.

One of the bigger problems is storage. Companies are used to having the original negatives and film prints in storage, incase something needed to be re-cut etc. Now everything resides only in computer data, and most companies do not have a data storage and archival system in place in order to store the huge amounts of data generated during the photography and postproduction stages of a Red project. This is something many companies are figuring out at the moment.

3.3 New cameras

RED annaounced new cameras on the 13th of November 2008. The announcement consisted of 8 different cameras ("brains") and a whole slew of attachments, accessories and modules. The brains come in two different flavors, Scarlet is the smaller, "lowend" (called professional) unit, Epic is the "master professional", high end unit. Both come with several models, with different lens mounts and sensor sizes.

The new Red cameras vary in resolution from 3K to 28K. Yes, 28K. Everybody can probably guess that the 28K camera is meant for very specialist uses. It creates a image with 261 Megapixels (28000*9334). But even the normal Epic cameras have a resolution between 5K (5120×2700) and 9K(9334×7000).

New Redcode formats were also announced, Redcode42, Redcode225 and Redcode500 (for the 28K camera) [3;4].

4 Appendix

1. Brinkmann, R. The Art And Science of Digital Compositing. 1st edition. Morgan Kaufmann; 1999.
2. Red Digital Cinema Camera Company
URL: http://en.wikipedia.org/wiki/RED_Digital_Cinema. Accessed 12th november 2008.
3. Red company website. URL: <http://www.red.com/>
4. Red user forums. URL: <http://reduser.net/forum/index.php>