Technical Background of the flashscan*HD* Film Scanner

Fig. 1: The flashscanHD

The new flashscan*HD* film scanner is not just a further development of the succesful flashscan8 model. With respect to all the input from our customers, their requirements and ideas, MWA decided to create a completely new scanning system. The film transport has been radically simplified, all electronic parts are redesigned from scratch and the operational concept has moved onto a software platform.

But we also preserved the good parts of the previous machine: its lightsource technology, its precision optics, its heavy construction and particularly the flashing light principle.

The flash principle has proven its outstanding picture quality with over 160 machines of the flashscan8 and flashtransfer series. The principle is as simple as it can be: The film runs smoothly through the gate and whenever a new frame is right in front of the camera the lightsource triggers a flash impulse. The impulse is so short - just some microseconds - that there is no chance for the picture to blur. Geometrical deformations from moving mirrors in the optical path or the "watering" effect known from line scanners will not appear.

The All New Filmdeck

The basis for a stable and precise film transport is the filmdeck. MWA has gained years of experience with both capstan driven decks (products: MB51, flashtransfer) and sprocket driven decks (LLK, flashrecord, flashscan8). All the knowledge from both systems put together now results in our brandnew 8mm filmdeck:

- Basic design objective has been the easy threading of film and quick handling of reels.

- An exchangeable rubber coated capstan wheel driven by a high-resolution microstepping motor transports the film.
- A laser perforation detector scans the holes for frame synchronisation.
- Camera and filmdeck can run at progressive 50 fps in HD (25 fps in SD).
- The film can be threaded using two film paths: The scanning path allows a maximum shuttle speed of 100 fps with stable picture whereas the fast winding path is meant to rewind the reel quickly with up to 1000 fps (depending on the reel diameter). Winding directions can be switched at the machine and at the fsHD control software. The software graphically demonstrates the user how to correctly thread.
- Tension sensors keep the film tension constant over the entire length of a reel. Large reels (max. 320mm) can be mounted as well as camera reels without readjustment of the tension.
- Robust metal adapters fit into Super8 reels whereas Standard 8 reels directly fit onto the motor hubs.
- Particle Transfer Rollers (PTR) pick up loose dust before the film passes the gate.
- The two-track sound head can be plunged in the filmdeck plate if not in use.
- The new lightsource delivers five times more light than its predecessor. This became necessary because the HD camera is less sensitive. (It has much more pixels waiting to be fed with photons!)
- Zoom and focus motors allow quick setup of the image size within the fsHD control software.
- A red tally light, the filmdeck illumination and acoustic alarms can programmed to signalize system events (e.g. tape end).

Sprocketless, Laser-Registered Film Transport

Traditional capstan-driven film transports require a sprocket wheel for the frame synchronisation - the machine must somehow know where the images are. But sprocket wheels have some disadvanta-ges: They must be changed for different film formats, shrunk film runs badly or is even damaged and splices tend to throw the film off the wheel.

For this reason MWA has developed the patent pending laser registered transport system. A laser beam scans the perforation holes before the filmgate and detects their exact positions. The position information is put into a memory and when the image runs into the gate, the machine already knows where to trigger the flash.

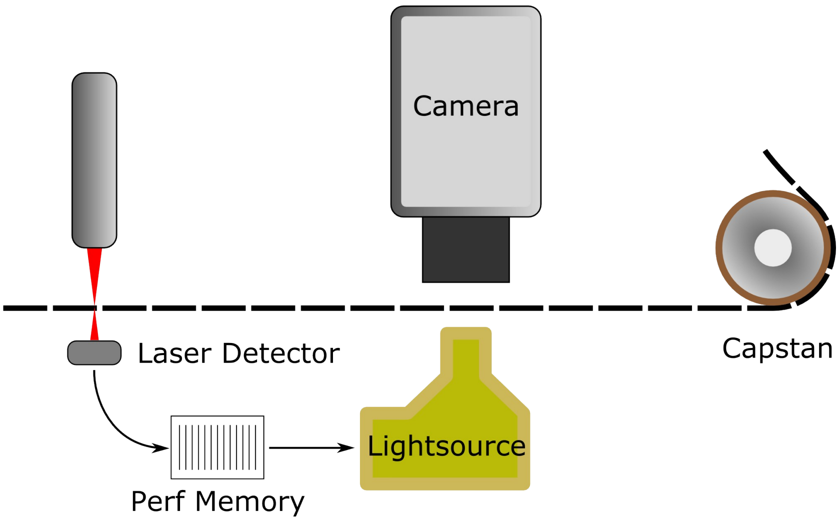

Fig. 2: Laser registration principle

Since the laser detects every single frame position for its own it does not matter how shrunk or badly spliced the film is. In case of damaged perforations sophisticated software algorithms sort out the useless perfs and calculate their position from their neighbours. Timecode and frame position remain consistent up to 15 unreadable perforations. The laser scanner is sensitive enough to detect the holes in clear film as good as in black film. Changing the film format between Standard 8 and Super8 is just one click in the control software and one push onto the laser assembly, you don't need to unthread the film.

The Lightsource

The perfect picture starts with the construction of an adequate lightsource. The flashscan*HD* lightsource is built from a set of red, green and blue high power LEDs. These are not only capable of generating the extremely short flash impulses that we need but also can be controlled individually. This allows us to precisely adjust the colour of the emitted light within a colour space that exceeds the gamut specification of any TV standard. The light can be set from the darkest blue to the hottest red as well as to the brightest green. Any kind of white point error of the film – even the orange mask of negative film – can be compensated without loosing signal quality.

Optical Scratch Concealment

A substantial advantage of the flashscan*HD* lightsource over a common film projector illumination is its scratch healing behaviour. Directed light as typically used in a projector is being refracted at the scratches and runs astray behind the film (red rays, Fig. 3). The camera lens does not capture this part of light and the scratch appears as a dark stripe.

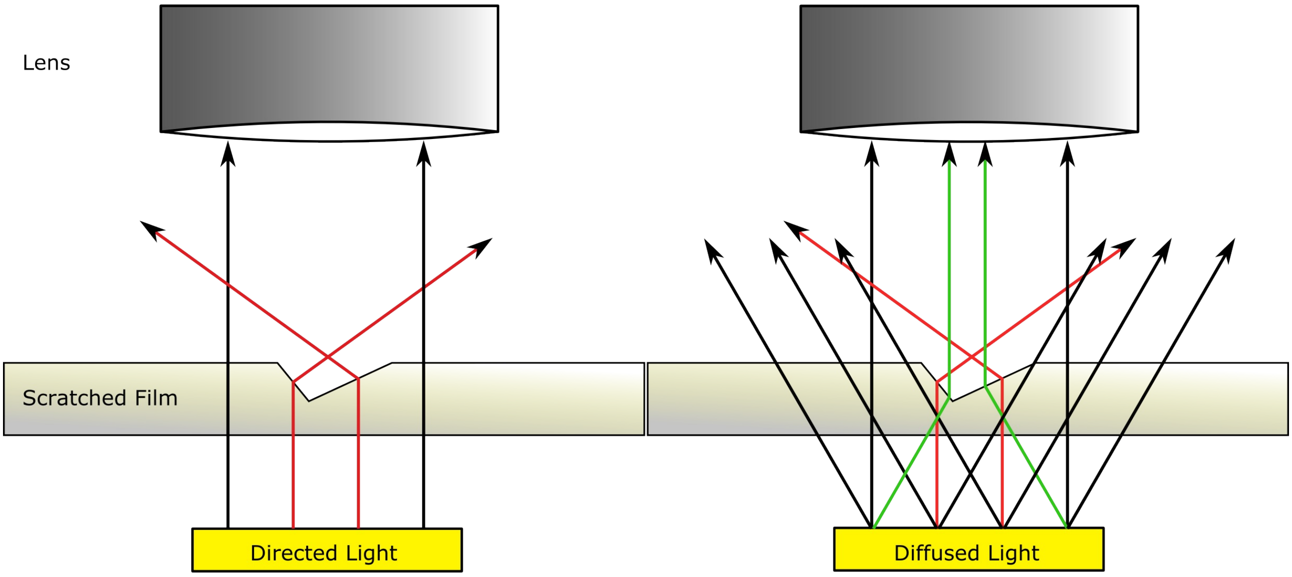

Fig. 3: Scratch concealment through diffused light

The lightsource of the flashscan*HD* provides totally diffused light which means the rays are hitting the film under a wide range of angles. The scratch then refracts some of the rays away from the camera but others into its direction as well (green rays, Fig. 3). In total the camera does not see a difference in brightness between the damaged and intact areas of the film surface. Scratches become literally invisible.

Matched Light Spectrum

Film transfer solutions using a halogen lamp or a "white LED" illumination often lack colour saturation and output video images look old and bleached out. What a pity! The typical rich colours of film and its large contrast ratio is gone or can only be restored with electronical manipulation afterwards. The reason for this is to be found in the spectrum of the light. Incandescent light sources like halogen lamps as well as white LEDs have a broad spectrum covering the whole range of visible wavelengths. This is normally a good choice for general lighting applications but not within a film scanner. Here we have to take into account that the film dye density curves overlap, and the transmissive spectra of the camera's colour separation filters overlap, too. This so called colour crosstalk reduces the saturation.

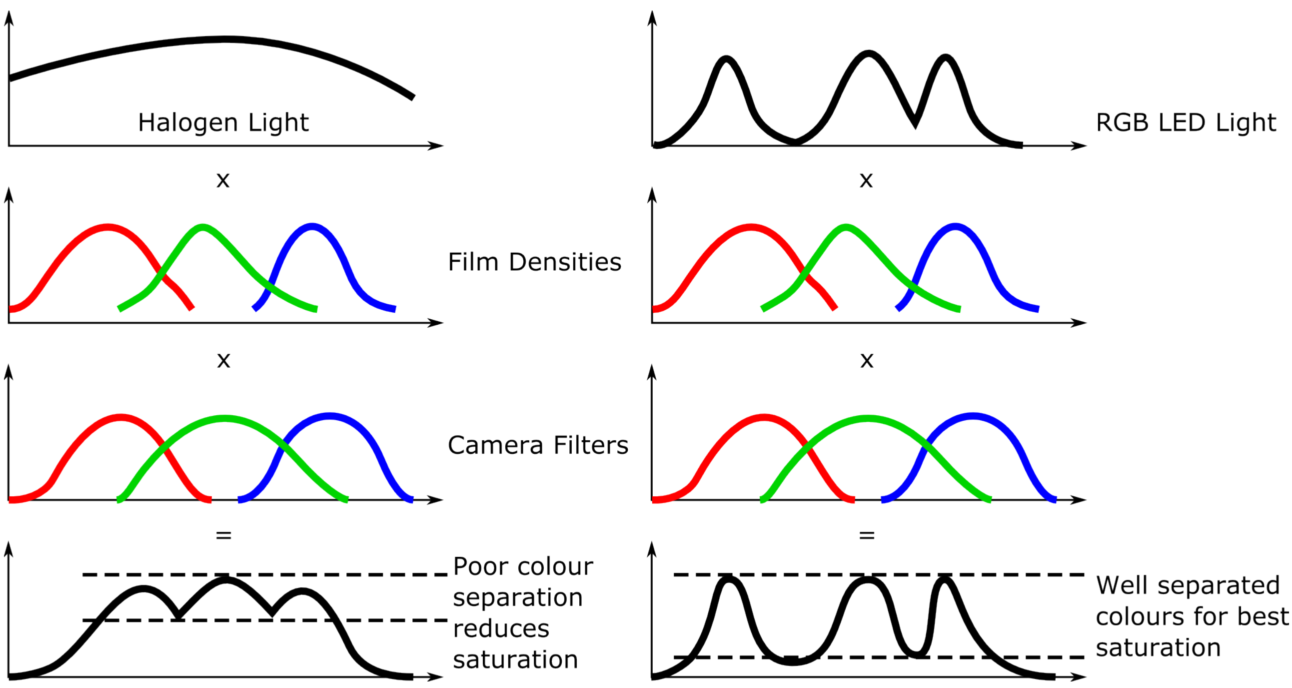

Fig. 4: Influence of the light spectrum on the colour reproduction

Due to the narrow bandwidth nature of the flashscan*HD*'s RGB LED light, the camera will fully reproduce the colour saturation. This kind of light spectrum simply does not include those wavelengths where the film and camera curves overlap. The result is less crosstalk and the camera brings the three colour channels to the digital domain with high selectivity.

Motorized Zoom and Focus, Stable Frameline

The fact that HD video always has an aspect ratio of 16 by 9 while the film image is still roughly 4 by 3, demands for a large zoom range. Nevertheless the flashscan*HD* uses a valuable 40mm fixed focus lens ("Apo-Componon" from Schneider Kreuznach), because prime lenses have less colour aberration and higher light throughput than zoom lenses. Lens and camera are mounted on motor driven linear shift tables. The lens shift motor sets the image size while the camera shift motor sets the focus point. The wide magnification range allows the user to fill the full video width from a Standard 8 picture (biggest magnification) or to fit the height of a Super8 picture into the video height (least magnification). The latter case shows the entire film width including perforation hole and sound tracks. For this reason the output video can be masked with black at the sides.

Zoom and focus position are controlled from the fsHD control software. The software also controls the frameline position (vertical image shift). Due to the laser registration principle the frameline position stays stable at all times during playback. During standstill the filmdeck parks the image at its correct framing position. Frameline adjustment is only necessary if the image position on the film varies relative to the perforation.

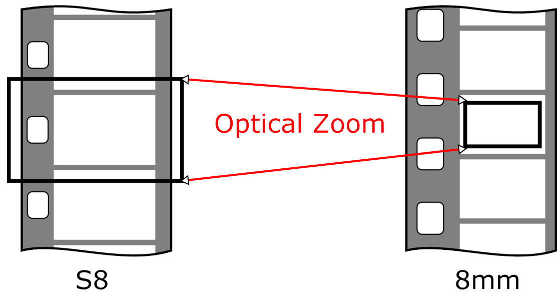

Fig. 5: Zoom range

HD Camera Resolution

An issue that often leads to misunderstandings is the camera resolution. Camera manufacturers often try to show off with large numbers of pixels and terms like "full HD" or "2k". But the number of output pixels does not tell us anything, because it is always possible to blow up a small image to whatever pixel count - and many cameras do so.

If you want an honest comparison of the expectable image sharpness you must take a closer look at the camera chips. There are three main categories: The size of the chips (1/3 inch or 2/3 inch), the number of chips (1 or 3) and the physical resolution of the chips.

Large chips make a better image. That's why broadcast cameras have larger chips (1/2" or 2/3") and consumer cameras have smaller ones (1/3" or less). We will focus on small chips because silicon area is expensive.

The number of chips stands for two different camera technologies: In a 3-chip camera (3CCD or 3CMOS) a beam splitter separates the image into a red, green and blue excerpt and there is one dedicated chip for each colour. One pixel on the chip corresponds to one pixel at the output.

In a 1-chip camera things are less straight forward. Here we must get the three colours from only one chip. Therefore the pixels are coated with red, green and blue filters (the "Bayer pattern") and the electronics must calculate the colour for each output pixel from this pattern. The fact that one pixel on the chip delivers only the information for one colour channel results in reduced sharpness. A 1-chip camera must have roundabout twice the pixel count on the chip to deliver the same sharp picture like a 3-chip camera.

To find out the actual resolution of the chips you must read the camera datasheets carefully. Very often they specify the "output pixels" instead of the real on-chip pixels or they count all inactive pixels around the image area as well. In general HD camera chips can be classified in such with 1280x720 active pixels and such with 1080 lines. The latter ones often have only 1440 or even 960 pixels per line, and rarely 1920 in expensive cameras.

Something completely different is the output video resolution. The HD-SDI standard basically provides two alternatives: "720p50" with 1280x720 pixels at 50 frames per second and "1080i50" with 1920x1080 pixels at 25 frames per second. Most cameras can be switched to both standards no matter what the actual chip resolution is!

The following table compares possible camera alternatives for scanning 8mm:

	720 lines	1080 lines
1 chip	- bad resolution	+ enough resolution - more expensive - only 25 fps
3 chips	+ enough resolution + affordable + progressive 50 fps	+ by far enough resolution - most expensive - only 25 fps

The flashscan*HD* embodies a professional 720p camera. It has 3 chips with native 1280x720 pixels. It runs at 50 fps and thus perfectly suits into our high-speed workflow, whilst it is still an affordable choice. Furthermore it offers comprehensive remote control capabilities, which we utilise in the flashscan*HD* control software.

Conclusion: If you buy a telecine or a camera, please don't ask for buzzwords. Ask for:

- The chip size
- The number of chips
- Their physical resolution

Entirely Digital Signal Processing

There are no analog signal paths inside the machine. This makes it immune against distortions like hum or noise. From an electronical point of view the machine basically consists of five parts:

- The camera with a 10 Bit HDSDI output (720p50)
- The sound head with integrated digitization at 48kHz / 20 Bits
- The output processor provides three SDI outputs with embedded audio and one separate AES/EBU audio output. The SDI signals can be freely configured as 1080i or 720p HD outputs or as a downconverted SD out.
- The filmdeck controller which contains all the motor drivers and the lightsource supply.
- The power supply can automatically shut down the scanner together with the control computer. When you are starting the control computer the scanner will also power up.

Camera, filmdeck controller and output processor communicate with the fsHD control software through a USB interface. The software runs on a user-supplied PC, an older model is sufficient because the software itself does not do any image processing. It is possible to control more than one scanner from one central computer, in this case multiple instances of the software have to be opened. Alternatively the software can run on the same computer which is used for editing the video.

In a typical scenario one of the SDI outputs feeds an editing computer or a VTR and another output is connected to a monitor. The AES/EBU audio signal is useful if the video recording device does not make use of the SDI-embedded audio. It can also supply a loudspeaker or may be used to loop in an equalizer or mixer.

The status of the GPIO pins (4 outputs, 2 inputs) is accessible at the fsHD control software. It can be mapped to system events. For example you could connect an alarm bell and make it ring at the tape end. The pins can also function as biphase IO.

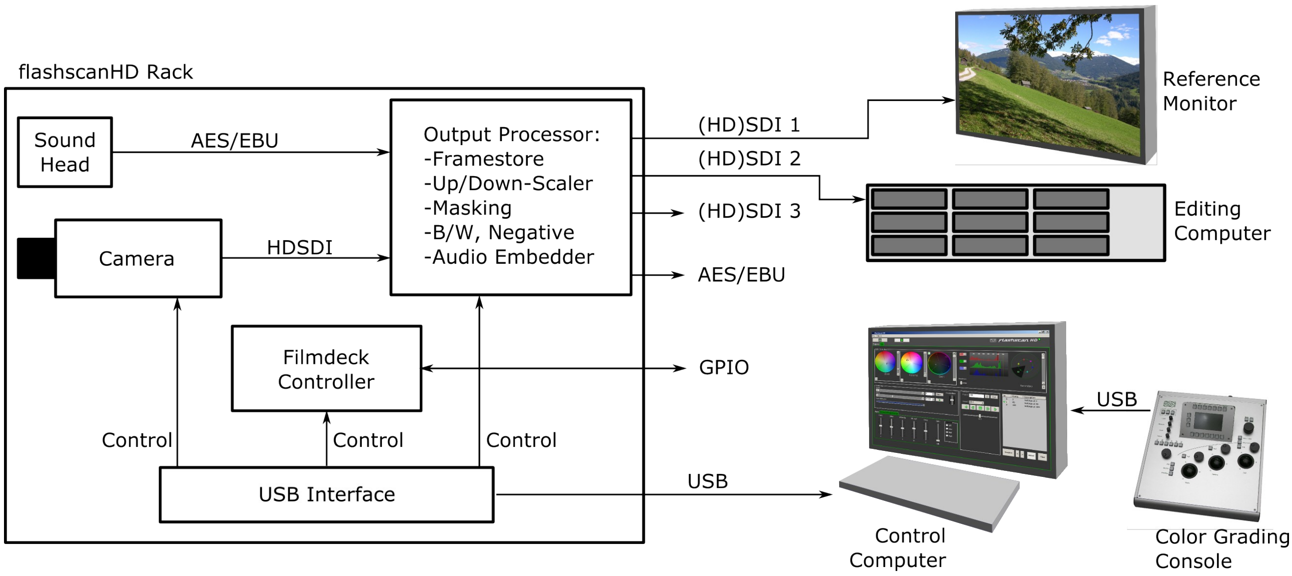

Fig. 6: Signal flow

SD and HD Workflow Alternatives

There are several ways to process the pictures after scanning. In most cases it becomes necessary to convert the speed of a captured film clip to its original speed of 16 or 18 fps. In all professional editing programs this is done with a mouseclick and it takes only little extra rendering time during finalisation of the output media. The bigger challenge you have to deal with is the amount of data if you capture the uncompressed HD video. You can easily fill up a terabyte harddisk with one day's work. For HD production the editing computers...

- should have a RAID with at least four disks.
- should have at least four cores. Take care that the editing software really uses all cores when rendering the output media (eg. blu-ray disk). Alternatively hardware encoder boards are available to speed up the video compression.
- You may use more than one computer, eg. one for capturing while another one renders.
- You should think up a defragmentation strategy for the harddisks. Capturing onto fragmented disks will lead to lost video frames. For example split the disk into several partitions, so you can empty a whole partition after a project is finished.
- Use intermediate codecs during capture. They save a lot of disk space with negligible loss of quality.

For SD production an ordinary (not too old) PC with SDI capture card is sufficient.

One Unified User Interface – the fsHD Control Software

The machine is completely operated from the fsHD control software. It runs under Windows and Linux as well as on the Mac.

The software explains itself, operators with a little experience in video editing will quickly get useful results. It is not possible to screw up the machine with bad settings. Users also do not have to understand the machine in depth just to do a transfer.

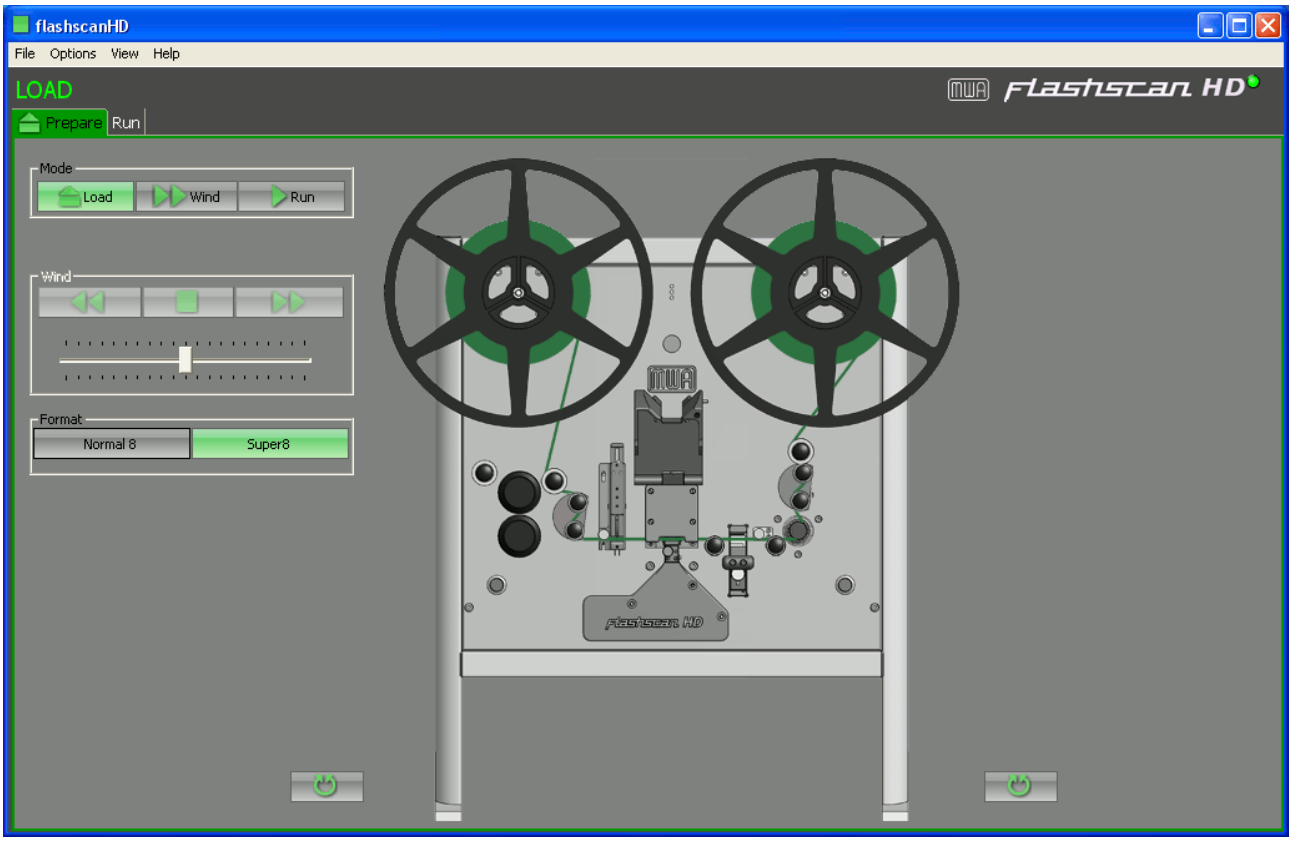

Fig. 7: fsHD control software - film preparation page

Since software development is an always ongoing process, the following list of features might not be complete:

- The film preparation page interactively shows the correct film path for wind and playback mode. Winding direction and PTR usage are displayed.
- The primary colour correction adjusts the black, gamma and gain values. Black and gamma are a function of the camera whereas the gain adjustment affects the lightsource colour.
- The histogram shows the distribution of the pixels over the signal range for each colour. Here you can check that the video is correctly levelled.
- The automatic colour correction derives the lightsource setting directly from the histogram. There you find sliders that define the upper limit for the video level of each colour channel. The headroom slider sets the number of pixels to be allowed above these limits. With a larger headroom the machine ignores small bright parts of the image (e.g. candles or lamps), which normally is the best setting. With zero headroom the machine would keep the video level strictly below the limits.

  The automatic colour correction is a powerful tool if you don't want to spend the time for grading scene by scene, for example if you plan a mass production workflow. Most films will produce nice results without prechecking if auto colour is on. It can be switched to either correct the complete whitepoint or only the light level while the whitepoint is to be set manually.
- The secondary colour correction manipulates the colour saturation of six colour sectors independently (Fig. 9).

Fig. 8: fshd control software - main operation page

- The geometry area provides controls for optical zoom and focus and the frameline position. Settings can be stored and recalled which allows quick setup of different film formats. The focus finder bar helps finding the exact focus point, thereto the machine continuously analyses the picture content.
- The transport control area has the usual buttons of a tape machine for playing and shuttling. The frame counter always shows the momentary film position. It can be set to any value or a cue frame number can be typed in where the transport will stop.
- The machine can switch all possible settings automatically through the event cue list. If playback passes at a given frame number in the list, the machine for example switches the colour or readjusts the focus. In a scene by scene workflow users can set up the list with all colour settings for each scene in a first run and then do the final transfer at high speed.
- The advanced image settings tab contains several controls for camera adjustments like detail enhancer, knee limiter or the gamma LUT.

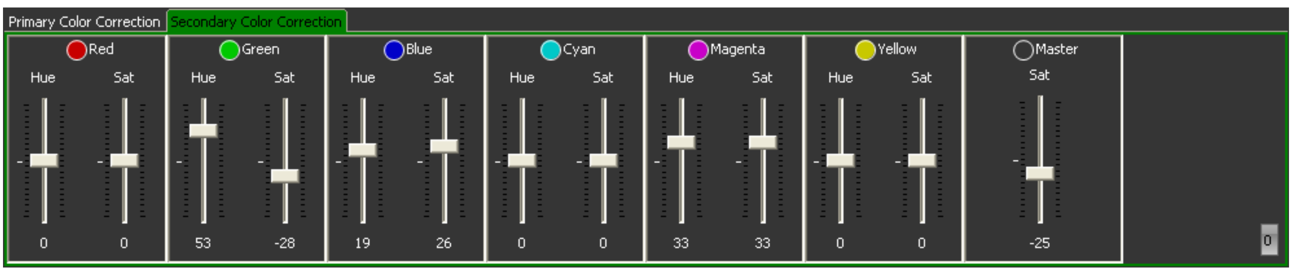

Fig. 9: Secondary color correction

- The audio settings tab defines the audio routing: The two sound tracks can be put out as a stereo signal or only one of the tracks feeds both stereo channels. Audio levels are adjustable.

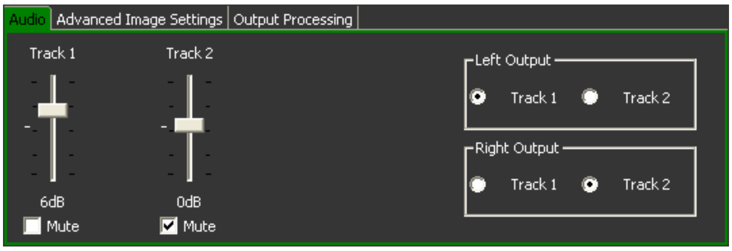

Fig. 10: Audio settings tab

- The output processing tab configures the signals on the SDI outputs. They can be switched between SD and HD formats. SD aspect ratio conversion to 4:3 is possible as well as anamorphic correction.

  The masking area allows to put a black mask over the image at the left and right side which is useful to cover the perforation hole or unwanted edges of the film frame.

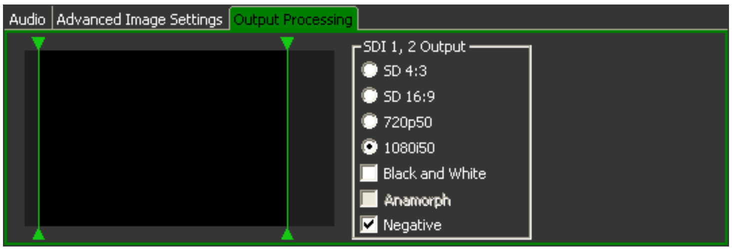

Fig. 11: Output processing tab

Boost Your Productivity: The Remote Control Panel

Professionals who wish to make more of their flash-scan*HD* now get the new remote control panel at hand. It features three trackballs for black, gamma and light adjustment and eight high resolution encoders. The color TFT display grants quick overview of all settings.

The remote panel connects to the control computer via USB. It can control almost every function of the software including color, transport, audio and optical settings. Local scene files can be stored and quickly recalled.

The remote panel also allows operation of the machine while the fsHD control software is minimized or in background.

Centre Direct du Multimédia
BP 32, 5 rue du 8 mai 1945
91470 LIMOURS - FRANCE
Tél. : 33 (0)1 64 91 46 24
Fax : 33 (0)1 64 91 46 87
Email : cdm@cdmultimedia.fr
http://www.cdmultimedia.fr