

The Quality of Film Images in Digital Transfer  
Experiences with ACES' New Scanning Technology  
APD in the Film Restoration of Sacy Perere,  
a Black and White Film About Music from Brazil  
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Abstract:

Nowadays, our films are presented digitally in the cinema, and this also applies to the many productions that we originally shot on film stock. They have to be digitized for projection, and special care is needed to transfer and preserve the specific qualities of the film image in digital transfer. For the film material, especially the negatives, which have been further developed over the last 20 years, embodies the experience of more than 50 years in the design of colours and the differentiated reproduction of light gradations; they were abandoned by the film industry without necessity and are often still superior to digital cinematography, especially in borderline areas. In addition to the colour design that film emulsions allow, I count their special behavior in the uppermost lights and, often less noticed, in the deepest shadows. The "sag" in the lowest part of the gamma curve of film stocks offered cameramen important possibilities for shaping the moods of the night and the visual impression of the limits of seeing in the dark.

On the occasion of the digitization of a documentary film made 25 years ago for new cinema screenings, certain limits of digitization became apparent, primarily because of the black-and-white photography of the film, its specific reversal technique and its specific shooting locations. I would like to present the details of these limits in the following essay. This work became particularly interesting for me because I was provided with a method for the qualitative expansion of the scanning process, which was newly developed by the Academy of Motion Pictures and Science within the framework of the ACES project, and I was therefore able to have the experiences described here.

In letterpress printing, certain fine differences in the screenshots shown may not be fully visible; I have therefore added the corresponding oscillograms of the waveform monitor to the individual images, which visibly document the differences.

Keywords:

Digital Transfer, Film Scanning, Academy Printing Density, ACES

Introduction: Starting with Film

For the archive of the German Cinematheque I recently worked out a restoration of an early music film, shot in Paris in 1984 and first performed at the Festival Internacional del Nuevo Cine Latinoamericano Havana 1985. Sacy Perere is the name of a group of Brazilian musicians who met up in Paris some years after immigrating from Brazil. Over the course of a few days, the camera follows the rehearsals of the five musicians – four instrumentalists and one singer. Their work centres around the traditions of Brazilian music, the Samba and its African roots, and the multi-faceted forms which reflect the history of black music in Brazil. The film shows the process through which music is created and which is able to connect the musicians through their experiences and their feelings for a new artistic expression.

The film Sacy Perere was designed from the beginning to be shot in black and white, for cinema projection and for a true sound in the theatre. I expected an extended shooting with the musicians of the group during many days of rehearsals and consequently expected a lot of needed film stock. Therefore, I decided to work in 16mm, using the Academy 1.37:1 format for later screening in cinema (when the film was made, the full format on the screen was still the Academy size). The film had to be shot with 16mm black and white Kodak Plus-X Negative, blown up to a 35mm Intermediate Positive, and then printed by a 35mm Duplicate Negative sent to a release print for the screening in 1.37:1. To ensure the best possible image quality, I used my set of Zeiss HS lenses for S16mm with fixed focal length.

But my tests for this negative-positive process which shows a picture of the 4th generation on the screen were not satisfying, mainly because of a lack of resolution, caused by the emulsion of the black and white negative. Looking for a solution, I remembered earlier successful experiences with black-and-white reversal film, tested it, and together with the technicians of the black-and-white-experienced Neyrac laboratory in Paris, I worked out a special fine-grain developing process for Kodak Plus-X Reversal film 7265 (80/100 ASA) and also Tri-X Reversal film

7266 (160/200 ASA) for night sequences, both modes with reduced contrast and sensitivity. The tests showed that using the 16mm reversal film together with a 35mm release print by proceeding through a 35mm Blow-Up Intermediate gave a much better result in definition and resolution than using a 16mm Negative film for recording and was absolutely comparable with an original shot on 35mm black-and-white negative film. The film was finally done in this way and was shown in cinema by 35mm prints.

Over the years, all my prints have been consumed from many screenings, whereas the black-and-white reversal original and the intermediate negative of the film survived over 36 years without any losses in quality, mechanically nor optically.

#### 1. Exploring the Scanner

After checking both materials on the Arri Scanner – the reversal positive and the intermediate negative – it became very obvious that the intermediate negative naturally had the better performance for scanning, compared to the reversal film stock of the original. The scanner is designed to capture negative film stock, which has a density of ca. 0-1.9 above black, whereas my reversal positive needed up to four densities to be scanned. The scanner is able to scan film stock providing the data standards Cineon 10-bit log, DPX 10-bit log / 16-bit log / 16-bit lin. For the 16-bit formats, the ArriScan works with a double exposure system integrating the extended ranges of light and shadows to a 16-bit scaled image.

But because of a slightly visible loss of resolution in the intermediate negative (caused by the preceding printing process in the optical printer), it seemed to me still preferable to scan the original 16mm positive whenever it could be technically made possible, and to do that with an optimal contrast range.

To get a precise adjustment of the scanner's double exposure 16-bit system to the density range of my positive, we first had to calibrate the internal digital ND (Neutral Density) filters of the scanner for best light intensity. Even after calibrating, it still remained an ambitious task to scan the whole density range of a black-and-white reversal film, but the laboratory's special fine grain development with a lowered Gamma made the conditions significantly better.

The decisive problem which had to be solved for scanning the reversal positive was the material-dependent increased density of the film stock's base, and especially the high density in the shadows, even more so because five of my six musicians were black people. We shot their music sessions in their little restaurant in Paris, which made their living; this place had a white flagged floor and white painted walls – a nightmare location for the cinematographer. Under these conditions, it was elementary for the cinematography to ensure a maximum of different greys for the skin tones: by a specific lighting of this difficult place, by optimizing the contrast range of the film stock through the revelation process, and by finding an appropriate scanning process to transfer the quality of the film stock into the media of digital cinematography.

#### 2. Experiencing Two Scans

The first scan we made was a 10-bit scan from the original positive image, slightly overexposed in the scanner through a specific ND filter setup and converted by using Arri's LUT for Print or Reversal film scanning (abbreviated: PrintLUT), which converts the 16-bit RAW scanner records into 10-bit logarithmic DPX files (one LUT for Prints and another LUT for the transfer norm to log). These LUTs were calculated from test patches of modern Kodak print stock; Lothar Binder (Arri Munich) designed them for the ArriScan and kindly sent them to us. Overall, they gave an excellent result, except for the decisive fact of missing details in the intense densities of the reversal film in its quite dark areas, which are important for the dark skin tones of the protagonists. An attempt to visualize them using the existent workflow would lead to increased noise, or even rough structures in the dark parts of the image.

The second scan we wanted to test needed to combine the best available conditions for both the reproduction of the film's greyscales and the very dense areas of the blacks (with a maximum of code values in digitizing). For recording we decided to use the Academy's new APD (Academy Printing Density) with encoding in 16-bit ADX (Academy Density Exchange) standard, and to consequently use ACES for the colour-grading process. Even though the film SACY PERERE is black-and-white, it soon became very obvious that the best result would be achieved only by using a complete RGB workflow up to the completed image.

The best option for my Academy-sized 16mm film format turned out to be the ArriScan 16mm full frame gate, which had to be processed as 2K with the size 2048 x 1536 px as our custom format. The scanner generated it by down-sampling the native 4K scan, realised with double exposure

because of the necessary contrast range for the reversal film stock.

### 3. Calibrating the ArriScan for APD

With the help of Lothar Binder (Arri Munich) and Dave Stump (ASC), we used matrices sent from the Arri company to convert the ArriScan density to the Academy Printing Density (APD) values and then to encode them in the ADX16 (Academy Density Exchange Encoding) format for export.

The APD converter and the ADX encoder are part of the new Academy Color Encoding System (ACES), introduced from the Academy of Motion Picture Arts and Sciences (Los Angeles) to scan film prints preserving the full range of highlights, shadows, and colours of the original film stock and preparing the print film images for colour grading with ACES.

For this processing, the APD values have to be encoded into the ADX (Academy Density Exchange Encoding) format. Therefore, the Arri Scanner has to be set to the High-Resolution Data Format 16-bit (logarithmic) and then calibrated with unique encoding gain values for Red, Green, Blue, and Base to generate the 16-bit log DPX format. The outputs are ADX 16-bit log encoded files: a sequence of DPX files as a digital negative from the reversal film stock with a wide gamut and a resolution of > 8;000 code values for each colour.

This negative gave optimal conditions to judge the proper scanning of the densities of the original reversal positive. You can compare and evaluate the results of these two different scanning processes in the three horizontal rows of DPX-Images below. The ACES ADX 16-bit negative (third row) completely shows what the scanner was actually able to record from the original material and what can therefore be shown in the positive in a good grading. The OpenEXR 16-bit image (not shown) from the APD scan as a desirable Master format for further processing of the movie is also a very good possibility to see the details in the shadows.

The images on the second row are the result of our early scan version with the 10-bit setting processed with Arri's LUT for Print or Reversal film scanning (see above). Even when this image shows a very good quality, it cannot develop any further separations or details in the blacks, not even at the best grading procedure.

I graded the images scanned with the Print+LUT-process provided from Arri for the ArriScan FilmScanner (see second horizontal row) as near as possible to the images produced by the ADX process (first row). So you can compare both systems in their ability to reproduce deep shadows and blacks in the WFM-oscillograms next to the respective images. According to the reproduction of these images by a standard monitor or video projector, the black level reference is set to legal range (64 cv).

Watching the original ADX16 digital negative (third row) enables you to receive precise information about all details of the scanned image. You know then what you can achieve in the differentiation of the blacks.

ADX 16-bit log (ACES)

PrintLUT 10-bit log

ADX16 digital negative

ADX 16-bit log (ACES)

PrintLUT 10-bit log

16 digital negative

ADX 16-bit log (ACES)

PrintLUT 10-bit log

ADX 16-bit log (ACES)

PrintLUT 10-bit log

ADX16 digital negative

Please note that all the pictures you see here had to be transferred from 16- or 10-bit to 8-bit images for reproduction in this text file or in video projection. Therefore, some differences between 10- and 16-bit images might be not visible in this reproduction.

### 4. Configuring the DaVinci Resolve

I did the restoring work of Sacy Perere with Blackmagic's DaVinci Resolve (V.16.2.). It took some extensive tests to find the best Resolve configuration for the optimal grading of the 16-bit negative image. Our workflow provided to use the Resolve for the image conversion of the ADX images from digital negatives to print film; we choose the Rec 2020 colour space for the monitor or video projector and provided DNxHR 444 as the export format for the Master file (for subtitling with Avid Media Composer). The completely uncompressed export was too large.

The original recording format of the image is the Academy format: 2048 x 1492 px (1.373:1). This is exactly the film gate of the 16mm camera when using the N16 format (which was used for shooting). The ArriScan uses a 16mm full frame gate 1.33:1, so we decided to use this as the custom format for the postproduction workflow, inserting a small matte at the top and bottom into the final image to stay with the movie in its Academy size.

The ACES ADX16 – configuration for Sacy Perere:

Colour Science: ACEScc

ACES Version: 1.1

Image Processing: 32-bit floating point

Resolution: 2048 x 1536 px (1.33:1)

ACES Input Device Transform IDT: ADX16

ACES Output Device Transform ODT: Rec.2020

Export: DNxHR 444 HDR 12-bit

Essentially relevant for the whole processing is the use of the ADX16 IDT to transform the ADX scanner data to the colour grading engine. Without the use of this IDT, the grading process would be more or less inoperable; at least the proceeding is difficult and very elaborate. The same applies to the ODT and to the monitor's colour space.

#### 5. Operating the Colour Grading

Whereas the grading of the 10-bit scan with Print LUTs proved to be quite sensitive and critical in reproducing the upper lights, partly limiting or even clipping the signal, the scan with APD and grading with ACES 1.1 was very open to create clear highlights and bright whites. Not to forget, these areas are those of low signal levels in the digital negative from the scanner and certainly more sensitive to noise than the medium or high lights (see the images above). However, the whites, as I explained further up, continued a critical point of our location (the restaurant with white walls and a white flagged floor). But because of the extensive options of ADX16 to control these upper lights precisely, we were able – except for a few situations, when the footage itself was too high exposed – to bring a distinctive and adequate texture into the high key effect of the location for the whole movie.

Even much more important for the image was the reproduction of the various shades of skin tones of the mainly black musicians, reflected as shades of grey in the black-and-white cinematography of Sacy Perere. We could perform this structure in the shades and black areas in general with the 10-bit Print LUT scan, quite similar to the 16-bit ADX scan, but with two important differences:

1. With the 16-bit digital negative we received significantly more structures in the deep shadows, which created a richer texture in the faces of the protagonists and the numerous dawn light and night shots.

2. With the 16-bit scanning creating the digital negative, there was also an enhanced resolution for details noticeable, mainly in the blacks. Not very strong, but this improvement of visual details in the shadows finally supported the texture of the image and the avoidance of artificial video structures in the shadows.

Undoubtedly, the use of the Academy Printing Density with the Academy Density Exchange encoding was decisive for this important improvement, realized with the ACES colour grading.

#### 6. Résumé

ACES provided us with more freedom in outlining the highlights and the shadows of the Kodak Plus-X Reversal 7264 and 7266 black-and-white film. The comparison of the digital image with the film original demonstrates that all gradations of densities in the film material are captured by the scan to digital information. They were available in the grading to create a digital design of the very specific black-and-white texture of this film. Without using ACES, there would have been technical limitations in creating sufficient structures in the highlights and a lack of details in the shadows; these limitations had partly shown up in the handling of the 10-bit Print LUT data. The ADP scan enabled us to create the adequate texture in the (for this movie) crucial shady and black elements of the imaging.

Very important for an effective workflow is the choice of the adequate IDT. In our case, the choice of ADX16 IDT was essential for the whole workflow. A grading without using this IDT for the ArriScan in our 16-bit calibration would have meant the impossibility of colour grading.

Very important when working with ACEScc is the precise control of Gamma values, which can structure the distribution of white, grey, and black parts in the black-and-white image. In the movie Sacy Perere, this Gamma calibration in ACES was very helpful in structuring the many different

whites in our unique location.

The use of ACES and the ADX encoding resulted in an increase in the impression of sharpness, probably caused by the extensive 16-bit-information, which caused – despite the persistent image resolution – an improved detail contrast as an important precondition for the sensation of a certain texture.

Finally, with the output of the images as openEXR we received a professional base for the further workflow to work out a DCP for cinema screening and to provide archival material for the German Cinematheque.

For cinematographers like me, who were used to working with film material, the lowest shadow areas are an important design element of the film image, which absolutely had to be preserved in our film prints, and of course, the same was true for the digital transfer of the films.

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Sacy Perere received the award “Outstanding Film of the Year” of the British Film Institute at London Film Festival 1985.

Followed by

Part 2 - The quality of Film Images in Digital Transfer

Comparison of 2 alternative scans, demonstrated on four scenes of the movie Sacy Perere

Part 2 – Movie file on Vimeo/

<https://vimeo.com/527815842>

CV

Rolf Coulanges first studied philosophy with Georg Picht, then went on to study at the Film and Television Academy in Berlin Film, and since 1979 has worked as a freelance Director of Photography for documentaries and feature films. As a director and cameraman, he has made several documentary films, mostly in Latin America, including the film Sacy Perere, which was awarded “Outstanding Film of the Year” by the British Society of Cinematographers at the London Film Festival in 1985.

From 1988 to 1998, he taught for the Goethe-Institut at film institutes in various African countries as well as in Brazil and Mexico. In Germany, he taught camera for several years at the German Film and Television Academy Berlin (dffb) and the Film Academy Ludwigsburg, and he has been a regular guest professor at the International Film Academy in San Antonio (EICTV), Cuba, since 1992. He teaches there at the Catedra Fotografía, which he also directed from 1999 to 2005.

In 2001, he was appointed tenured Professor for Image Design and Lighting in Film at the Stuttgart Media University, where he was responsible for Film and Digital Cinematography until his retirement in 2010. The HdM also marks the beginning of his research into the development of digital film cameras and, in conjunction with Arnold & Richter (ARRI, Munich), the use of the first digital cameras (Arriflex D20 and D21) in the university’s scenic productions.

Since returning to Berlin in 2011, Rolf Coulanges has been working as a freelance Director of Cinematography and teaching in the fields of classical and digital film photography, for example as professor for cinematography at EICTV, at the Hamburg Media School for postgraduate professionals, and at film institutes in Kyrgyzstan and Myanmar. He is the author of publications on light design in Murnau’s SUNRISE, on the photography of the cinematographers Michael Ballhaus, Renato Berta, Raoul Coutard, and Robby Müller, and on fundamental questions of image design in digital cinematography. In addition to working on a documentary film, he is currently working on a research project for the development of creative tools in digital image development within the international framework of IMAGO.

As a filmmaker, he is particularly interested in documentaries which focus on the politics and culture of Latin America, Africa, and Asia, as well as in experimental films about music and dance and its history.

Rolf Coulanges has been a member of the Executive Board of the German Society of Cinematographers since 1996 and from 2015 to 2020 a member of the Executive Board of IMAGO, the international umbrella association of camera associations.

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