

Digital Video Origination Vs. Film Origination: A Comparative Test

By René Villeneuve

With the emergence of new digital video recording formats and the growing quality of video origination equipment, it has become attractive for many producers to consider these technologies in the production of features for television while addressing the possibility of a theatrical film release. This study attempts to compare, through the subjective evaluation of selected video and film-originated scenes, the various options that are available to low-budget filmmakers. A range of digital video cameras and digital video recording formats was tested and compared with film origination, which has been a reliable benchmark for quality theatrical viewing. This paper describes the production of the test materials and the nature of the comparative evaluation, which should help viewers come to their own conclusions.

A great number of productions today are being created initially for television release and do not necessarily rely on film as the originating medium, thereby limiting such projects from being exploited in more traditional (film-based) markets. Although video-to-film technologies have come a long way since the days of black-and-white kinescope recording, the high cost of these commercially available services have precluded most producers from taking advantage of them. On the other hand, the relatively high cost of producing and finishing on film is often a limiting factor in completing a project, and unless a film release (theatrical) is assured or required, there is no marked advantage in shooting on film considering the high quality and cost benefit of digital video technologies. The evaluation described in this paper attempts to provide some direct comparison of film and video processes as they apply to independent filmmakers and the smaller production organizations which rely mostly on television as their primary market, but would still consider attrac-

tive the potential of theatrical markets for some productions.

The National Film Board of Canada is a Canadian government cultural agency that produces and distributes films and videos addressing a wide variety of subjects, mainly in the documentary and educational field. As such, most of its audiences are reached through the television medium, but, nonetheless, some of its productions have benefited from theatrical release. For the last 58 years, film has been its main originating medium, but going into the next millennium, there is a definite shift toward electronic origination because it better corresponds to the need to reduce costs while maintaining a constant volume of high-quality work aimed at the widest possible audiences.

With the help of veteran cinematographers Michel Brault and Sylvain Brault of Nanouk Films (a Montreal-based independent film production company) and professional videographer Luc Dussault from Les Productions Luc Dussault (a Montreal video rental house), a number of selected scenes were shot with a variety of video and film cameras and recorded on some of the more widely used digital recording formats as well as on Super 16mm and 35mm film. Post-production was supervised by Daniel Arié of Télépoint (a Montréal

video post-production facility) and René Villeneuve of the National Film Board of Canada. The entire project was produced by Anouk Brault of Nanouk Films with the added financial support of the Société de Développement des Entreprises Culturelles (SODEC; a Quebec government cultural development agency).

The Tools

Three digital video cameras were used, ranging from a consumer digital video camcorder to a high-end digital broadcast camcorder; one high-end component-analog camcorder was also used, and a Super-16mm and a 35mm camera provided the film origination.

The three distinct digital video recording formats tested were DV,* DVCPRO,† and Digital Betacam. As a benchmark, an analog Betacam SP camcorder was used for the video sequences, and on the film side, an Aaton XTRProd Super 16mm camera and an Arriflex BL4 35mm camera (using the same film stock in both film formats 72/5279).

Table 1 identifies the characteristics of these cameras.

The Nature of the Test

The technical specifications of the equipment used could have been sufficient to determine objectively which might produce the best possible

*DV uses DCT (discrete cosine transform) to store digital information on a 6mm metal tape format. It provides 5:1 compression, quantizing at 4:1:1 (4:2:0 in PAL). A stepped process drops the data rate by 2/3, reducing the video data to a 25 Mbit/sec constant rate.

†DVCPRO is a professional variant of the DV format by Panasonic. The major difference is a doubled tape speed, required for a better dropout tolerance and frame accuracy in linear editing. It is also capable of 4X normal speed playback when using the SDTI protocol (formerly CSDI).

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Table 1 — Characteristics of Aaton XTRProd Super 16mm and Arriflex BL4 35mm Cameras

Cameras		Specifications		
Type	Camcorder/Camera	CCD Format	Lens	Format
Video (1)	Panasonic AJ-D700P Ser. G6TKA0032	1/2 in. FIT 410,000 pixels	Canon J14a x 8.5B4 IRS (w/mech. adapt) 1/2 in.	DVCPRO 4:1:1 (component digital) 5:1 compression
Video (2)	Sony Betacam SP BVW D600 Ser. 10048	2/3 in. FIT 520,000 pixels	Canon J14a x 8.5B4 IRS, 2/3 in.	Betacam SP Component analog
Video (3)	Sony Digital Betacam DVW700WS Ser. 10003	2/3 in. FIT 520,000 pixels	Canon J14a x 8.5B4 IRS, 2/3 in.	Digital Betacam 4:2:2 (component digital) 2:1 compression
Video (4)	Sony DCR-VX1000	1/3 in. 410,000 pixels	5.9-59mm F1.6 1/3 in.	DV 4:1:1 (component digital) 5:1 compression
Film (5)	Aaton XTRProd	n/a	Zeiss Hi-speed lenses	Super 16mm
Film (6)	ARRI 35 BL4	n/a	Zeiss Hi-speed lenses	35mm

results. Instead, it was decided to compare the output of the tests in a more subjective fashion by letting the viewers determine, based on their own criteria and biases, each medium's potential for use.

The notion and perception of quality is affected by a number of variables. The technical characteristics of each component tested (the cameras and recorders) are obviously the most significant elements in the overall quality assessment and the ones to be most objective about. However, for many producers and filmmakers,

other factors such as cost efficiency, reliability, flexibility, and ease of use are likely to affect their ultimate choices.

Furthermore, the nature of the scenes that were shot was more typical of the documentary style of filmmaking than the traditional feature film or TV movie. There was little control over the lighting of the scenes, and whenever possible, mixed lighting was used to increase the level of difficulty. This provided a set of situations that are marginal at best and that might help in highlighting the limita-

tions of each medium and the potential (or lack thereof) of each component tested.

The Scenes

The Tables 2 through 7 list the characteristics of each of the scenes that were shot, trying to repeat as accurately as possible each of the actions with all six cameras. Ideally, all cameras should have "filmed" the same scene simultaneously, but this was not possible because of time and physical limitations. As well, because of the many different formats and

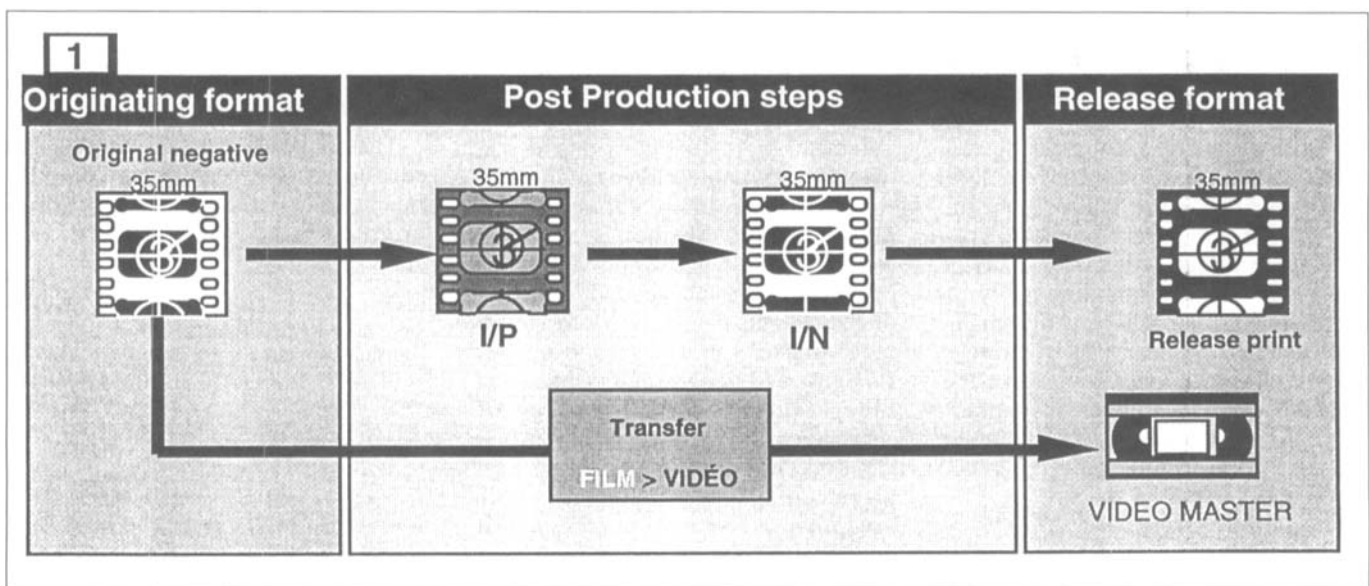


Figure 1. Original 35mm film.

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Table 2 — Scene 1: Gray Scale and Resolution Chart

Camera	Lens/focal length/F-stop	Filter	18% (IRE)	Distance	Remarks
Panasonic AJ-D700P	Zoom/14mm/f2.8	#1-3200K	40	8 ft.	No shutter, master gain 0 db, white 80 IRE
Sony Betacam SP BVW D600	Zoom/19mm/f2.8	B1 3200K	40	8 ft.	Black 10 IRE
Sony Digital Betacam DVW700WS	Zoom/14mm/f2.8	B1 3200K	35	8 ft.	Black 10 IRE
Sony DCR-VX1000	Zoom/?/f2.8	Tungsten	35	8 ft. 2 in.	*45 f/c Gain 0 db
Aaton XTRProd	Zeiss/25mm/T2.8	nil	n/a	6 ft. 11in.	7279 500 ISO
ARRI 35 BL4	Zeiss/50mm/T2.8	nil	n/a	8 ft. 9 in.	5279 500 ISO

*30 f/c (3200K)

Table 3 — Scene 2: Tunnel

Camera	Lens/Focal Length/F-stop	Filter	18% (IRE)	Remarks
Panasonic AJ-D700P	Zoom/?/f4	#1-3200K	70	No shutter, master gain 0 db, Auto-Knee ON
Sony Betacam SP BVW D600	Zoom/?/f4	B1 3200K	40	Black at 10 IRE
Sony Digital Betacam DVW700WS	Zoom/14mm/f4	B1 3200K	35	Black at 10 IRE
Sony DCR-VX1000	Zoom/?/f2.8	Tungsten	35	Gain at 0 db
Aaton XTRProd	Zeiss/16mm/T2.5	81 EF N3	n/a	7279 500 ISO PUSH ONE STOP
ARRI 35 BL4	Zeiss/35mm/T2.5	81 EF N3	n/a	5279 500 ISO PUSH ONE STOP

64 f/c-4 f/c Fluorescent (4100K)

Table 4 — Scene 3: Jacques-Cartier Bridge

Camera	Lens/Focal Length/F-stop	Filter	18% (IRE)	Remarks
Panasonic AJ-D700P	Zoom/35mm/f4.5	#4-ND6	n/a	Auto-Knee ON
Sony Betacam SP BVW D600	Zoom/48mm/f4	D2-ND6	n/a	DCC-ON; No pan
Sony Digital Betacam DVW700WS	Zoom/40mm/f4.5-5.6	D2-ND3	n/a	DCC-ON
Sony DCR-VX1000	Zoom/?/f4	Daylight	n/a	
Aaton XTRProd	Zeiss/50mm/T2.8 ^{1/3}	85 N9	n/a	7279 500ISO
ARRI 35 BL4	Zeiss/85mm/T2.8 ^{1/3}	85 N9	n/a	5279 500ISO

Exterior day—cloudy (6000K); 480 f/c

aspect ratios involved, the equipment operators tried their best to be consistent in the framing and the camera movements, but at times a compromise was necessary.

Obviously, this affected the objectivity of the test, and, conscious of

this, no claims are made that this is a thoroughly scientific and exhaustive study. However, every effort was made to document the conditions under which the scenes were shot in order to analyze the results and put them in perspective.

Post-Production

Film Finish

Once the film was processed normally (the tunnel scene was push-processed one stop), both negatives were transferred to Digital Betacam

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Table 5 — Scene 4: Girl 1

Camera	Lens/Focal Length/F-stop	Filter	18% (IRE)	Remarks
Panasonic AJ-D700P	Zoom/16mm/f2.8	#1	n/a	WB:B; Gamma:M Auto-Knee: ON
Sony Betacam SP BVW D600	Zoom/18mm/f2.8	B1	n/a	-3 db, DCC-ON Gamma: B Matrix: R-G 33/R-B -44/B-G 76/B-R 2
Sony Digital Betacam DVW700WS	Zoom/13mm/f2.8	C1	n/a	-3 db, DCC-ON Gamma: B Matrix: R-G 33/R-B -44/B-G 76/B-R 2
Sony DCR-VX1000	Zoom/?/f1.7	Tungsten	n/a	+3 db
Aaton XTRProd	Zeiss/25mm/T2.8	nil	n/a	7279 500 ISO
ARRI 35 BL4	Zeiss/35mm/T2.8	nil	n/a	5279 500 ISO

Interior (6000K-HMI/2800K-25W bulb on dimmer); 16 f/c.—key (incandescent + candles); 6 f/c.—HMI fill, no candles; 2 f/c.—room (HMI backlight)

Table 6 — Scene 5: Girl 2 Close-up

Camera	Lens/Focal Length/F-stop	Filter	18% (IRE)	Remarks
Panasonic AJ-D700P	Zoom/50mm/f2.8	#1	n/a	WB:B; Gamma:M Auto-Knee: ON
Sony Betacam SP BVW D600	Zoom/55mm/f2.8	B1	n/a	-3 db, DCC-ON Gamma: B Matrix: R-G 33/R-B -44/B-G 76/B-R 2
Sony Digital Betacam DVW700WS	Zoom/40mm/f4	C1	n/a	-3 db, DCC-ON Gamma: B Matrix: R-G 33/R-B -44/B-G 76/B-R 2
Sony DCR-VX1000	Zoom/?/f1.7	Tungsten	n/a	+3 db
Aaton XTRProd	Zeiss/50mm/T2.8	nil	n/a	7279 500 ISO
ARRI 35 BL4	Zeiss/85mm/T2.8	nil	n/a	5279 500 ISO

Interior (6000K-HMI/2800K-60W bulb on dimmer); 16 f/c.—key (incandescent + candles); 6 f/c.—HMI fill, no candles; 2 f/c.—room (HMI backlight)

Table 7 — Scene 6: City Street at Night

Camera	Lens/Focal Length/F-stop	Filter	18% (IRE)	Remarks
Panasonic AJ-D700P	Zoom/?/f2	#1	n/a	Auto-Knee: ON ; 0 db
Sony Betacam SP BVW D600	Zoom/?/f2	B1	n/a	DCC: ON - Gamma:B Matrix: ON 0 db
Sony Digital Betacam DVW700WS	Zoom/?/f2	B1	n/a	DCC: ON - Gamma:B Matrix: ON 0 db
Sony DCR-VX1000	Zoom/?/f1.7	Daylight	n/a	0 db
Aaton XTRProd	Zeiss/25mm/T2	nil	n/a	7279 500 ISO
ARRI 35 BL4	Zeiss/50mm/T2	nil	n/a	5279 500 ISO

Exterior (sodium vapor street lighting)

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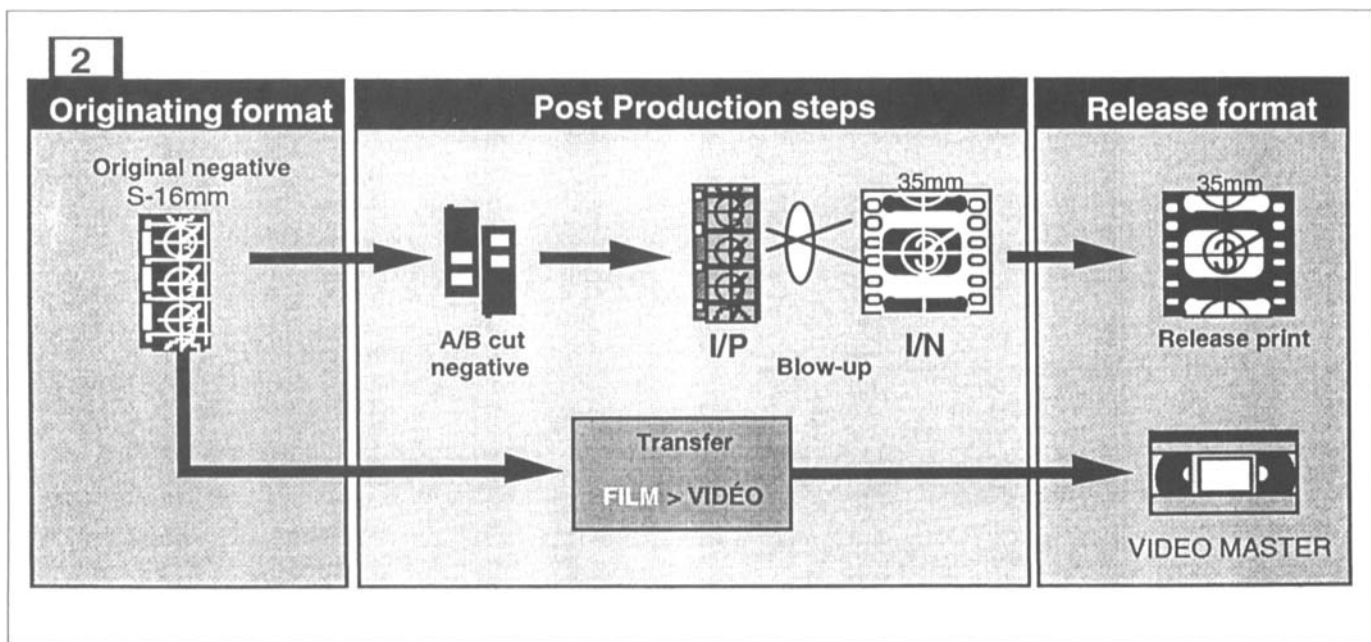


Figure 2. Original Super 16mm film.

videotape on a Rank Cintel URSA Gold telecine equipped with an Accom noise reduction unit. Exposure and color balance were adjusted according to the director's requirements.¹ As the film images were framed with a 1:66 aspect ratio, the resulting image was reformatted to fit the 1:33 aspect ratio of the TV format, producing a slight magnification compared with the video-originated materials. However, a similar effect was introduced when transferring the video-originated materials to 35mm film.

After this, the 35mm original was contact printed to produce a 5244 interpositive, and a 35mm internegative was struck from it (Fig. 1). For the Super 16mm original material, a contact-printed Super 16mm interpositive (7244) was made from the Super 16mm original, and a blow-up 35mm internegative (5244) was struck using a high-speed step optical printer (Debrie) (Fig. 2).

As for the video-to-film process, a dub² was made of the color-corrected master videotape (as described in the following paragraphs) and was sent to a video-to-film transfer facility in Los Angeles. With the use of a proprietary process, a 35mm negative was produced and a reference 35mm print made.

After negative-cutting the 35mm film elements generated above (respecting the same sequence as the

video finish), a color-corrected 35mm check print was produced and a 35mm release print was made from this assembled dupe negative (Fig. 3).

The flow charts in Figs. 1 through 3 outline the post-production paths used for the film elements.

Video Finish

The multicamera shoot produced four distinct original videotapes (one DV, one DVCPRO, one Digital Betacam, and one Betacam SP), one Super 16mm color negative, and one 35mm color negative. All four original videotapes were dubbed to a Digital Betacam master. This dubbing process consisted of playing back the original Digital Betacam and Betacam SP tapes through a Digital Betacam player. The 4:2:2 CCIR 601 output signal was routed through the SDI (serial digital interface) output of the player to a digital character generator (Collage) to insert the camera ID number³ in all four corners of the image, and the resulting signal was recorded onto another Digital Betacam tape.

The same process was used for the DVCPRO and DV original tapes using a Panasonic studio player with a 4:1:1 to 4:2:2 interface. All video material was thereafter mastered onto a single Digital Betacam tape ready for editing.

The tapes of the film transfers

(described earlier) were then assembled onto a single edited master⁴ with the video elements. From this assembly, another dub was made where primary color correction was applied through a digital DVE (Abekas 8150). This process ensured that a relatively uniform color reproduction for all scenes. All dubs were made in the digital format using Digital Betacam players and recorders (through the serial digital interface).

Although other post-production options could have been considered, the path shown in Fig. 4 was chosen to try to replicate the number of generations and signal processing steps encountered in average productions. From the finished master, a Digital Betacam submaster was then produced and identified as the finished product (comparable with the on-air master delivered to most broadcasters).

The Results

The video master that resulted from these processes was viewed (in component digital format) on high-quality digital video monitors. The assembled film sequences were screened on a 30-ft wide screen at the recommended brightness levels. The following assessment is in fact a mixture of personal opinions and perceptions as to how well each originating medium fared when viewed in a large-screen environment. Because these results

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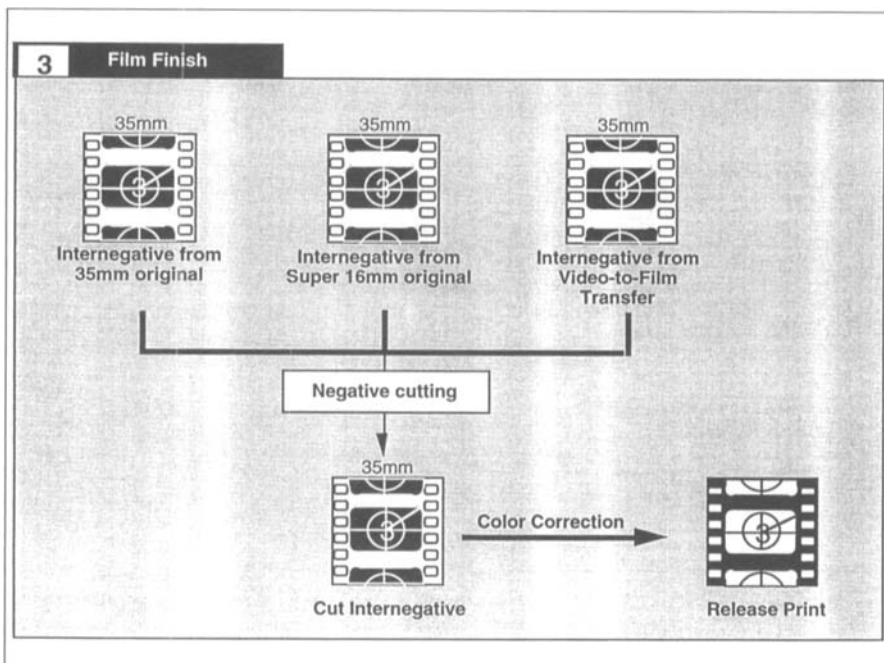


Figure 3. Film post-production.

are not based on an objective and scientific appraisal, they should not be used to make any qualitative evaluation as to the general performance or overall potential of the equipment or the technologies (or processes) described herein.

On the Video Side

The Digital Betacam originated scenes appeared to give slightly better results than the other video originating formats, but not always by a great margin. In the gray chart and the resolution chart, all three digital video sources were equivalent in terms of resolution (measured in excess of 6 MHz). It was in the gamma and the latitude that the differences were greatest. The analog component (Betacam SP) fared well, but fell behind in resolution (possibly attributable to the analog recording format more than the capacity of the camera itself).

Obviously, the high-end equipment provided more flexibility in the marginal scenes (bridge scene, tunnel, street at night), but the differences were not necessarily as noticeable in the less difficult situations. The film sequences that were transferred to video suffered from the obvious 3:2 pull-down artifacts and, combined with the use of high-speed emulsions,

made the overall picture appear fuzzy and grainy when compared with the video material. This was unusually disappointing because, generally, it was expected that there would be much better results with film; in this instance, it may have been the marginal nature of the scene content that contributed to this result.

On the Film Side

The large-screen projection of video-originated scenes transferred to film was quite acceptable when viewed by itself, but in direct comparison with film-originated material, it was easy to see marked differences in color reproduction and sharpness. Although film origination remains the prime choice for eventual film release, based on what was obtained in these tests, it is felt that when no other solutions are available, video origination may be viable for well-planned and technically flawless productions (proper lighting and exposure). The scenes that presented some of the more marginal image content (candles burning, night scene, etc.) suffered greatly and did not reproduce very well.

An Alternative to Film Projection

Because the evaluation of the video

assembly was made using a video monitor and the film evaluation required large-screen projection, a decision was made to screen the video-originated material on a large screen (same size as film projection) as well, to see how video projection compares with film projection. Using a cathode ray tube-based projector with line doubling, the difference between the film-originated elements (projected on film) and video elements (projected on video) was less marked than in the previous test where video was transferred to film. In fact, video projection may be a more desirable and effective solution (if conditions allow it) when considering large-screen viewing of video productions. However, the high cost of good quality video projection and its limited availability in traditional venues do not make it a realistic alternative to film release at present.

Conclusion

The tests produced have provided the following insight into the issues outlined originally:

- The sequential reproduction of the scenes shot with various media and equipment was helpful in evaluating perceived differences between video and film sources. Digital video origination and post-production of various grades of camcorders seemed to demonstrate that the perceived differences among them seemed less significant than anticipated.

- It also provides direct comparison between the video-to-film transfer results and original video material. Although this comparison is greatly dependent on the quality of the viewing facilities, the fact that the material was identical and the viewing environments were controlled helped establish a more direct relationship between the two distribution media (video and film).

- The added comparison of the video-to-film transfer and the video projection of the same material was also enlightening and demonstrated the considerable potential of large-screen video display for commercial or theatrical venues.

When factors other than those strictly relating to image quality were considered, the opinions tended to

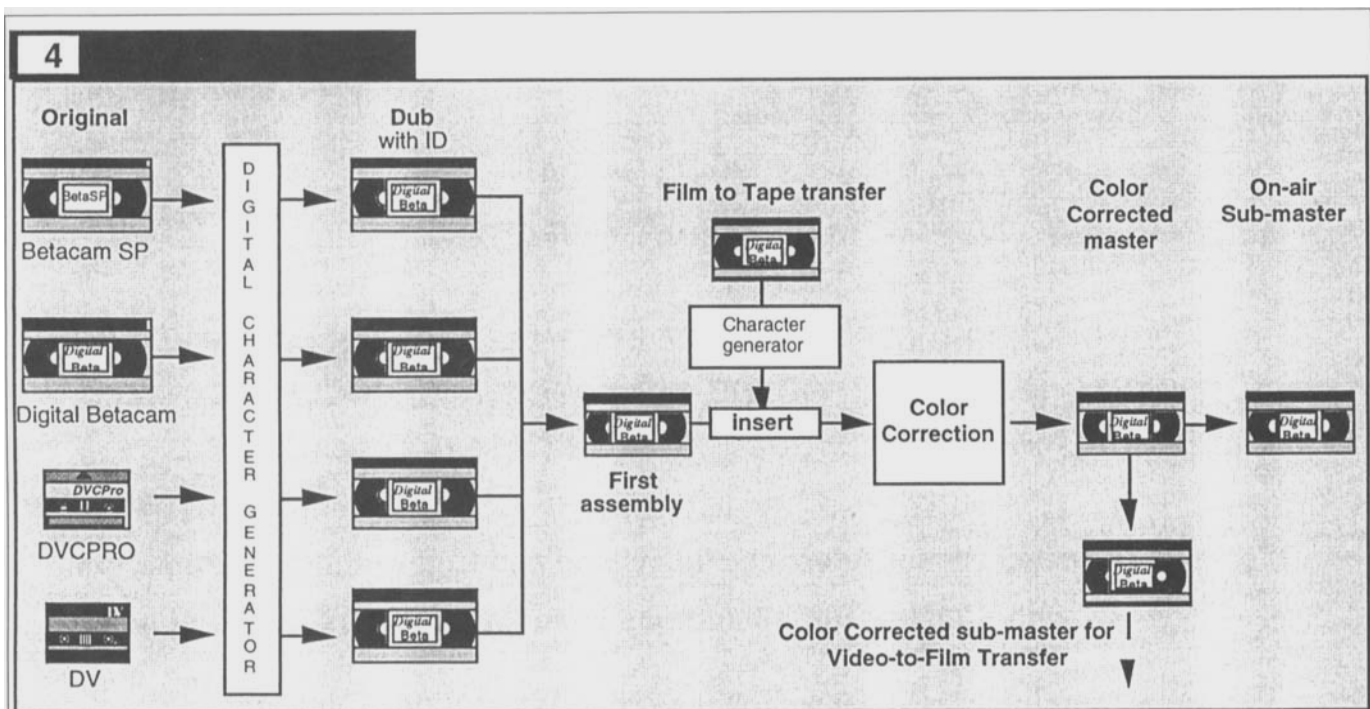


Figure 4. Video post-production.

vary somewhat among those who have seen these tests. For some, the advantages of having the flexibility and cost effectiveness of the electronic medium for origination and post-production were sufficient justification for considering video-to-film transfer, even if the quality was less than what film origination can provide. For others, the decision to transfer video to film is mostly determined by the nature and size of the markets to be potentially reached by a given production: if film distribution is a financially viable proposition for a given project (i.e., distribution revenues cover the cost of shooting on film), then it should be shot on film without hesitation because image quality may be a critical factor in reaching those markets.

This paper describes the methodology used in producing the tests and does not attempt to judge any of the media or equipment employed. It attempts to provide some means of assessing and comparing the many technologies available to the industry in times of considerable change. It also addresses other subjective and related issues that influence the decision-making process when considering a particular path for exploiting audiovisual productions.

Endnotes

1. During processing, the lab inadvertently push-processed the 35mm bridge sequence that had to be adjusted in the film-to-tape transfer.
2. Naturally, a similar adjustment had to be made for film post-production.
3. The objective of this test is to view similar scenes shot on various types of media and

use a diversity of hardware. To avoid preconceptions or prejudices toward one or another, it was decided to identify the source with a number inserted into the image area. The viewers are only informed of the "key" to these ID numbers after having seen the material at least once in its entirety.

4. At which time ID numbers were added for the film sequences.

THE AUTHOR

René Villeneuve has been the Director of Technical Services and Informatics at the National Film Board of Canada since April 1997. He heads the integrated technical motion picture and television production facilities of this Canadian government cultural agency and is also responsible for its Informatics division.

Villeneuve was trained as a still photographer but quickly shifted to audiovisual production. As a freelance technician, he went from multimedia work to television production before joining Kodak Canada in 1978. In 1981, as film laboratory manager at Sonolab, he introduced a new video duplication facility. Leaving Sonolab for the National

Film Board of Canada in 1986, he was initially chief of the Visual Effects Department, and in 1988, he became the assistant director of technical and production services.

A member of the SMPTE since 1978, Villeneuve has held a variety of positions at the Section level (including secretary-treasurer and chairman) and was Canadian Governor from 1994-95. He also participated in organizing the 1984 SMPTE Television Conference held in Montreal and was involved in the Mini-Conferences organized by the Toronto-Montreal/ Quebec-Ottawa and Rochester Sections from 1978 to 1992. He is also a member of the BKSTS.

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