T A P E   H O U S E
D   I   G   I   T   A   L   F   I   L   M

DV To 35mm
Technology Guide

TABLE OF CONTENTS

GENERAL OVERVIEW
TRANSFERRING *VIDEO ORIGINATED* PROGRAMS TO 35MM

There are three methods of transferring video to film. Of the three the Kinescope transfer (a camera shoots off of a video monitor) is the oldest. The Honeymooners non-film episodes are an example. An EBR (electron beam recorder) uses an electron tube and records directly onto B&W film as red, green and blue frames. This is then step printed through filters to color film. While much better than a kinescope, EBR's are old technology. Both of these transfer methods have been characterized as soft, smeary, ghosting, strobing, or low contrast. The best choice is the Digital Film transfer (more later). Regardless of the method you choose the two most important issues with making a 35mm motion picture from video originated materials are: Interlaced Video and Frame Rate.

Interlaced Video
Problem: The broadcast NTSC and PAL standards interlace video frames. Each second of video contains 60 NTSC fields or 50 PAL fields. If the capture media is video, each field is recorded at a different point on the timeline. One second of NTSC video is actually 60 distinct images (fields) not 30 whole frames. For this reason, when you de-interlace the video (view field 1 and field 2 together as one frame) the frames will flicker. The video camera, the subject matter or both have moved between fields. Field based video cannot be viewed or transferred as frames without huge losses in quality.
Solution: Shoot in frame mode, also called progressive scan. In a progressive scan system the camera captures images as frames not fields. Instead of 60 NTSC or 50 PAL images (fields) per second, progressive scan records 30 NTSC or 25 PAL video *frames* per second.
Look For Yourself: There is an excellent site on the Internet where you can view the difference between interlaced and progressive scan frames: http://home.earthlink.net/~demografx/intrlce.html

Frame Rate
Problem: 35mm motion picture runs at 24 frames per second. NTSC video runs at 30 frames per second. Shooting in progressive scan NTSC (frame mode) solves only half the problem. There is still a 6 frame per second difference between film and video. Removing these 6 frames will make video look like Max Headroom. For those of you who missed the TV series, one of the trademark visual effects was the stuttering motion whenever Max spoke or moved. Unless you desire this effect, do not shoot in NTSC.
Solution: Shoot in progressive frame mode in 25 fps PAL. One camera we've tested is the Canon DM- XL1 (http://www.canon.co.uk/). When transferring PAL video to 24 fps film, every video frame becomes a film frame. The extra frame per second makes one minute of video run 62 ½ seconds in theaters. The slowdown is generally imperceptible. Your camera audio is then stretched 4.1666% to match the new film length and processed to adjust for pitch. As a bonus, PAL captures more information than NTSC. The PAL standard is 625 lines versus NTSC 525. Those extra 100 scan lines increases resolution by about 20%. This method of shooting in PAL is not new. Advertising campaigns are frequently shot on film at 25fps and posted in PAL so they can broadcast worldwide while leaving an option open for cinema advertising. A PAL video master can be standards converted to NTSC without loss of quality and transferred to film.
Shooting
Aspect Ratios: Compose with the middle 72% of your viewfinder. So long as cables, dolly tracks, boom mikes and etc. are not in your viewfinder, your video can be dual purposed. The middle of your frame is the 1.85:1 aspect for cinema and the whole frame is for broadcast.
Lighting: Video does not have the same range as film. Film sees into shadows and holds detail in over-exposed areas. Video goes black or blows out. To avoid the video/electronic look you have to approach lighting differently. Example: Instead of shooting a character in direct sunlight at noon, try shooting when
the sun is lower in the sky. A carefully planned back-lit shot hides the limitations of video while exploiting its strong points. Even in harsh sunlight, a back lit face with a background that is in open shade will look better than direct light on subject and background. When shooting indoors light low key and use dimmers on light fixtures. Also avoid direct light on white walls. Remember that video has less range than film.

Digital Film
What you need: Theaters need a composite print in order to show your film. The lab makes sound prints from two separate film elements. They need a picture negative and an optical track negative.

Picture Negative: Much of what is done in a Digital Film transfer is via software. YUV video frames are converted to an RGB color space. Each of these RGB frames is then made into a digital computer file. Each file is then interpolated from the incoming file size (video resolution) to a higher resolution. Unlike Kinescopes and EBR, the Digital Film transfer shoots frames at film resolution. When projected on a big screen, unprocessed video looks very grainy. By increasing the resolution, video takes on the correct look by mimicking film grain. Once the frames have been interpolated to film resolution, the computer files are output via a film recorder. This film becomes your OCN (original camera negative.)

Audio: 90 PAL minutes will run 93 ¾ minutes at 24fps. In order to sync the audio you need to stretch the track 4.1666%. Try to limit the audio stretch to the original DV audio. Music and effects should be mixed after the film transfer. The actual process of stretching audio is time consuming. You should not be stretching a full mix. If you do, the mix has to be broken out so that each element can be processed and checked individually. Your final mix should be made with either a work print or video off the OCN. Either way the mix has to be done for theater sound (Dolby SR, SDDS, Dolby SR-D and etc.)

Reels: For features, film must be broken down into reels for the lab, post production and theatre release. A feature in big release gets spliced into one big platter for continuous projection, but up until that point it must be in manageable reel sizes. 2000' should be the absolute maximum size for one reel. 90' at 24fps is one minute of program. This gives you about 22 minutes per reel. Since film needs an academy count as well as head and tail leader, the program length of each reel must stay under 20 film minutes (19:12 in PAL). When editing a feature for theatrical release, you must close each reel with a straight cut and audio out before last picture frame. This allows the projectionist to change reels without an audio pop or jump cut in the middle of a scene. It is also a good idea for your out going scene to be either in a different environment or at least a different camera angle (same setting) as the income scene. This will avoid a noticeable shift in color. Laboratories do not print reels in order. They print a whole bunch of reel ones, then a whole bunch of reel twos and so on. Don't take the chance of having the end of one reel match the beginning of another. Film developing is a chemical process that is constantly changing. Changing scenes between reels hides potential differences in color and density.

Editing: If you are going to edit on an off line system, do not use the editing computer output as your master. Digital video already has compression. Compressing video further on an editing system will decrease image quality. Clone your camera DV tapes to another digital component format (D-1, D-Beta, DCT and etc.) and auto conform based on your off line. An exception to this rule would be to FireWire directly to a desktop computer (the MAC G-3/G-4 with "Edit DV" or "Final Cut Pro" software is worth looking into) and FireWire your finished cut onto a new DV tape. There is no further compression and/or generation loss. Go to Apple.com or Digitalorigin.com for computer and software specifications.

<div align="center">

Free Advice

</div>

If you had a huge budget, you would probably shoot on film in the first place. With this in mind we offer the following suggestion. The potential for a finished feature on videotape being picked up for theater release is not the same as one in the can. Distributors like to see those metal ICC cases and hear film reels rattling inside. It's conditioning. You could whack out a quick Kinescope for screenings, but why spend all your money to create a negative that no distributor would ever use. There is an excellent alternative to laying out the big bucks (yours I might add) for a feature transfer. Make a trailer. From your finished video master cut a trailer, transfer it to film and shop that around. They may not even know it was from a tape source. Once they're interested, have them view the feature on tape. The trailer is proof that your video will look good on film. Plenty of low budget independents have shot on 16mm only to have the distributor pay for the optical blowup. If your feature is commercially viable then the Digital Film transfer can be negotiated into your deal.

Conclusion: If you want to shoot and post on video then transfer to film, do so in the PAL standard with a digital camera that has a progressive scan option.

<div align="center">

EQUIPMENT SPECIFICATIONS & RECOMMENDATIONS

</div>

THDF assumes you'll be buying most of your DV specific equipment for a long form or feature length project since more often than not the purchase price is less than cost of rental.

<div align="center">

Camera

</div>

THDF has purchased and tested the PAL Canon XL-1 camera. It is the only DV camera we know of that has the progressive scan feature for 25fps, interchangeable lenses and the ability to use professional microphones. Canon

makes a full manual focus/zoom (no servos) lens that can pull focus. Canon also makes a high resolution b/w eyepiece. The standard LCD is not good to evaluate critical exposure or focus. It is to your advantage to use a 12v field monitor for both exposure and focus. You can't miss with a 5" Sony PVM-5041Q.

Remember that video does not have the same gamma (exposure range) as film. It can't see into shadows the same or hold detail in the highlights. We find that when whites are blown out they look artificial. Use the Zebra Pattern option to determine what is 90 IRE and above. Everything in frame that goes over 90 IRE will go screen white or blow out when projected. If this is not desirable, control your contrast with the lighting. Run some tests. This is not as important in the shadows since they go ink black on film. Shoot in full manual exposure. If you are getting too much noise take the gain off Auto and set it on 0. If you want motion picture directional blur (similar to a 180 degree shutter angle) use 1/50 of a second. Faster speeds may strobe when projected. The stabilization is mechanical and shouldn't cause problems. The built in ND is fine to use. The Canon lens supplied with the camera goes soft when you stop down too far. Again, run tests. Wide open and a few clicks down will look sharp.

For sound, set the camera for 16 bit 48khz stereo. Get the Canon MA-100 XLR adapter or a BeachTek DXA-4C box so you can use balanced microphones. The on camera stereo mic is for home movies, public access and running down the dark street documentaries. Don't use it. If you want to put a mixer in line, the Samson Mixpad 4 is compatible or if you can budget for it, a Shure FP-33 will meet and exceed all your requirements.

Editing Computer

Forget offline editing. DV only needs about 18GB for 90 minutes, so why bother. You can FireWire DV lossless in and out of a computer. Any of the blue and white 300mhz or faster G-3's or new G-4's are fine. They have built in FireWire. You'll need a second hard drive for video only. The G-3/4 factory disk is an ATA66 and you can install a second 7200rpm ATA66 drive internally. SCSI is fine but expensive. The bigger your video hard disk the better. Most software needs a minimum of 128MB's of RAM. If you can, go with 256MB, more is better.

Editing Software

Digital Origin makes a DV only platform, Edit DV. We have a copy and have found it has pros and cons, but it works. A stripped version is $150 or download a trial for 30 days and play with it. The other choice is Apple's Final Cut Pro. The 1.2 version is certified with PAL and the G-4's. If you have an older version, a free upgrade is available online. People we've talked to who have used Adobe Premier says its slow and clunky.

Venders

Supplier	www Address	Product(s)
Canon UK	http://www.canon.co.uk/products/pfinder.html	PAL XL-1
Canon USA	http://www.canondv.com/	NTSC XL-1 XL-(PAL XL-1 coming soon)
Apple	www.apple.com	G-3, G-4 & Final Cut Pro
Digital Origin	www.digitalorigin.com	Edit DV Unplugged, Edit DV
Sony	http://bpgprod.sel.sony.com/matrix.bpg	Model PVM-5041Q 5" Monitor
Samson	www.samsontech.com/audio/mixpad4.html	Mixpad 4 Portable Mixer
Shure	http://www.shure.com/fp33.html	Model FP33 Portable Mixer
BeachTek	http://www.beachtek.com/products/dxa4c.html	Model DXA-4C Dual XLR Adaptor
IBM	http://www.storage.ibm.com/hardsoft/diskdrdl/hddprod.htm	Deskstar & Ultrastar hard drives

Canon PAL XL-1
Optimum Settings For DV To 35mm Transfer

Action Safety

The viewfinder and/or the field monitor will show a 1.33:1 broadcast aspect ratio. You need to know how much of the active video image will be masked out in projection. With a grease pencil or a Sharpie, draw two lines depicting the cinema action safety on the monitor tube or if you can figure out how, on the eyepiece on the camera. If you do not want to write directly onto your equipment, place a clear sheet of acetate over the tube first.

One way to approximate the 1.85:1 or 1.66:1 format is to draw them on a piece of paper, put it on a wall and zoom in with your camera until the left and right sides touch the edge of your active video. Remember that we will be using all of the active video to make film, so the monitor should be set up to see all the active video. Check your over/under scan setting.

THDF has two masks that you can print out for this purpose. Please use them as a rough guide only. They began life as a MS Word file, then saved as an Acrobat pdf file for download. They are not an exact 1.85:1 or 1.66:1 shape. They should however be close enough for you to trace some lines onto your equipment. For the most accurate dimensions, get some graph paper and make your own targets.

Camera Power Source

If you want to avoid all possibility of getting AC noise, spikes or whatever else can happen with 110v AC current, shoot off battery power only.

Progressive Scan

With the camera's power dial set to Manual, access the on screen menu. Scroll to MOVIE MODE and change the setting to Frame. If you leave it on Normal the camera uses the broadcast interlaced standard which ruins image quality.

Zebra Pattern

With the camera's power dial set to Manual, access the on screen menu. Scroll to Zebra and turn it ON. The diagonal stripes are very helpful to evaluate what is going to clip. Remember that anything over 90 IRE goes screen white in theaters.

Audio

With the camera's power dial set to Manual, access the on screen menu. Scroll to Audio Mode and set it 16 bit. Scroll to the Audio 1 In and select MIC. Your XLR adapter's two RCA cables should plug into the Stereo 1 RCA jacks on the at the back of the camera.
Open up the little door to reveal the audio panel to access the AUDIO 1 MIC controls. Set the REC LEVEL switch to M for manual and the INPUT SELECT to AUDIO 1 to make RCA jacks active. The balance and level knobs can be set using the level meters on the camera.

Recording Mode

With the camera's power dial set to Manual, access the on screen menu. Scroll to REC MODE and select SP. If you select LP you'll get more record time, but the image quality will suffer.

Zooming

Use the optical zoom only. If you use the digital zoom feature, the camera is going to take half of the frame you are shooting and digitally blow it up. You will loose image quality with this feature.

Image Stabilization

According to Canon, this feature is mechanical. It really helps with hand held shots. For most tripod work leave it set to off. For hand held or any type of Steady Cam style rig, you may want it off. Run tests to see which you prefer.

ND Filter

The neutral density filter is built into the lens and swings in and out of the optical path. It is OK to use and is very helpful if you want a short depth of field when out doors. Check your white balance after you turn the ND on or off as it may shift the overall color balance ever so slightly.

Shutter Speeds

Video camera manufacturers mistakenly call the duration of exposure per frame a shutter speed. Video cameras do not actually have a shutter. The speed indicated will none the less effect the same results in most instances. If you want to mimic the shutter speed most commonly used on a motion picture camera (and by extension create video frames that approximate film frames) shoot at $1/50^{th}$ of a second. Most cameraman use a shutter angle of 180 degrees which results in $1/48^{th}$ of a second shutter speed. If you use a shutter speed faster than $1/50^{th}$, you may see some strobing or a flicker when your video goes back to film. The reason is that faster shutter speeds reduce the amount of directional blur that is necessary to smooth out fast pans or fast moving subject matter.
The XL-1 also has a feature that allows you to shoot at speeds less than the frame rate. For instance, if you shoot at 1/12 of a second, the camera somehow replicates that exposure enough times to make 25fps. Understand that when you shoot in this mode that all bets are off concerning image integrity, but for an in camera effect, it works.

16:9

The XL-1 has an anamorphic setting that actually does a horizontal compression. In order to see your video uncompressed, you need to use your field monitor and set it on the 16:9 scan. The screen will uncompress and shrink the image to fit left/right and increase the blanking top bottom. This is the only way to see an undistorted image while shooting. The problem with shooting this way is that the camera only uses a 1.77:1 portion of the chip to record video. You loose about 25% of your resolution. You should run some tests before committing to using the on camera 16:9. Another option is to use an optical 16:9 anamorphic adapter that fits on the front of the lens. Again, run some tests first.

Exposure

Shoot in manual. It is the only way you are sure that exposure will not ride or fluctuate as the action in frame moves. As you pan by a light source, in an auto setting, the camera will decrease exposure to compensate for the extra light. This will look like a home video. If you leave the Gain setting on auto, you will experience the same effect. Concerning the gain, if you leave it on automatic or on any other setting other than 0, you may experience an increase in video noise. Video noise will look terrible on film.
Not also that the zoom lens supplied with the camera gets a little soft if you stop down to far. Run some tests varying the f stops and see at what point image sharpness is compromised.

White Balance

Set your white balance for every scene or change in lighting. If you leave it set on automatic you will experience the same effect as auto exposure or auto gain. The overall color will shift if the camera senses that the average of all colors has changed.

Conclusion

All of the settings that THDF has suggested are for the best image quality you can squeak out of a consumer Mini-DV tape using a PAL Canon XL-1. You should use them for all normal shooting situations. In the event that you want to depart from these optimum settings for a desired effect or look, please note that your image quality may suffer.

GLOSSARY OF TERMS

DV: Generic name for any of the 6.35mm digital videotape formats (DV, Mini-DV, DVCAM & DVCPRO). So long as a tape can play down in the THDF PAL DV deck, the trade names are immaterial. We can play the mini size with an adapter (just like VHS-C in a VHS deck) or the full size DV tapes. "**DV**" can be used to describe any of these formats since they all spawned from the same technology. Filmmakers submitting tape from cameras other than an XL-1 or from a VTR should test for compatibility. Some cameras are not compatible in some decks. We'll make a list as we go along.

Progressive Scan: Non-interlaced video frame recording. In order to make 35mm from DV filmmakers must shoot in progressive scan at either PAL 25fps or High Definition 24fps. Every manufacturer describes progressive scan differently. Some call it frame mode, others movie mode or frame movie mode. Even more confusing is that sales literature labels the feature one way and the operators menu on the camera itself labels it another way. Generically, a camera feature that can capture video in non-interlaced whole frames should be referred to as **progressive scan**. The onus is not on THDF to find out if cameras can shoot progressive. Some cameras shoot in a still camera progressive mode. While it is true that this feature captures an image progressively, it is specifically for shooting one frame and holding it on tape for a few seconds. This is great for Digital C-Prints but wholly inappropriate for movies. A few cameras can shoot all three ways; interlaced, progressive and still. If a filmmaker is not sure, they should submit a tape for evaluation. Make sure to have some horizontal motion in their footage so we can see interlacing. A point of interest (according to Panasonic) related to 625 PAL DV is that the "4:2:0 raster scheme has merits for progressively scanned images". This can only work in our favor in the DV to film transfer.

FireWire: Developed by Apple, a high-speed serial digital data bus, also known as IEEE 1394. For filmmaker's purposes, FireWire allows DV cameras and editing computers a loss-less in/out. Except for testing, THDF has no practical use for FireWire in the transfer of DV to film. Filmmakers should only be submitting their conformed tape. Accepting only tapes eliminates the potential for problems in the camera to computer to tape link. It is the filmmaker's responsibility to present a properly prepared tape for transfer.

Audio Stretch: A 25fps PAL tape transferred to 24fps film lasts 1 frame longer per second on film, 60 frames per minute and 3600 frames per hour. Said another way, 60 seconds of PAL lasts 62 ½ seconds on film. PAL on film runs 4.1666…% longer (25/24 = 1.041666…) Slowing the audio down to match the film is referred to by THDF as an **audio stretch**. We are encouraging filmmakers to stretch only the camera audio. With a full mix the process of slowing down audio to match the new length can be a very time consuming process. Each individual audio element has to be checked meticulously and tweaked in order to have it sound correct. If a 25fps final mix is brought in to be stretched, the mixer has to go through each element individually and re-build the final. It is best to perform a final mix with the camera audio stretched and the other elements at normal speed.

Canon XL-1 (PAL version): A prosumer Mini-DV camera. The PAL version is about $1000 more than an NTSC. For purchases, there is a company in NYC that we are working with who imports them. I hear that Canon made an announcement at NAB 2000 that they will be selling and supporting PAL. The XL1 meets all our technical requirements namely PAL and progressive scan. The other features that should make filmmakers very happy are the interchangeable lens mount, XLR balanced microphone compatibility, full manual exposure and a FireWire in/out. The optional equipment available (not included in the base XL1 package) are a high resolution b/w viewfinder, full manual zoom lens (no servos), an auto/manual wide angle zoom, an adapter for Canon still camera lenses and an adapter for XLR microphones. The NTSC Canon GL1 meets our minimum requirements except that is a 30fps camera and it doesn't accept professional audio (don't worry, someone will make a widget for that real soon.) I costs less than an XL1. The PAL version is the XM-1. Updates to follow.

MAC G-3/G-4: Provided you order your computer correctly, the blue and white G-3's or the new G-4's out of the box are ready to go. A second hard drive is highly recommended. You don't want to fragment the drive with the operating system. Also one hard drive can not read in two places at one time (DV and application program). An 18GB hard drive holds about 90 minutes of DV. Either an ATA/66 @ 7200 rpm or almost any of the SCSI drives are fast enough to read and write DV. Check with the software manufacturer before purchasing a FireWire hard drive. The transfer rate is borderline and you may drop frames. You should also have at least 128mb of ram. The video card and the two FireWire ports are fine as shipped from the factory. A small color video monitor is a great option. Filmmakers should have one for shooting anyway since focus and exposure are best judged with a monitor. You can view your editing with full screen full resolution playback when the camera is attached to the computer via the FireWire cable and the monitor patched to the camera's RCA jacks.

Edit DV & Final Cut Pro: Editing software from Digital Origin & Apple that supports FireWire DV in/out with full support of the G-3/G-4 and XL1 platforms. The Edit DV Unplugged version is a stripped down low price option that should be fine for most editing. Digital Origin is one of the few software companies you can actually get on the phone (800#) for free technical assistance. Digital Origin used to go by Radius and had terrible customer service, but that is not the case now. We are not sure about Apple's phone support. Both platforms have WWW users groups and there are even some books out there.

FireWire Cable: A 6' cable costs $ 40-50. No wonder it's not included! You'll need a 4 to 6 pin FireWire cable (normal peripherals need 6 to 6 pin). Cameras use their own power supply so the 6 pin goes on the computer (2 for power, 4 for data) and the 4 pin in the camera (data only).

<div align="center">

For more information contact Chris Hauser
212-319-5084   cfh@tapehouse.com

</div>