

SHOOTING DIGITAL

A Guide to Digital Filmmaking

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Introduction

It took me about ten years to make a film.

That was the average. The first one, **THE TEXAS COMEDY MASSACRE**, was shot in 16mm. I worked on it nights and weekends, while earning money during the day as a software engineer for a defense contractor. It was the first film I ever made, and I made a lot of mistakes. Some were simple mistakes, like filming on sets in an empty warehouse with a terrible echo, which meant the entire film had to be dubbed. Others were subtle but just as devastating. All in all, I spent nearly a hundred thousand dollars on something that could have been shot on video and then transferred to film, had the technology existed then. It would have cut my costs in half, at least. And I could have finished it sooner. The project was started around 1981 and was premiered at film festivals in Germany and Italy in 1987. Parts of it played on American television in 1992. Ten years from script to screen.

The second film was no picnic, either. I started work on **REDBOY 13** in 1990 by constructing a soundstage, writing a script, and raising enough money from family and friends to get the thing shot. This time I was working in 35mm Cinemascope, an ancient but still viable film format. The equipment was antique or home-built, some of it dating back to 1921. The film stock was mostly short ends (small rolls of film left over from big-budget movies) and discarded, outdated rolls that were given to me by other producers. Principal photography took four weeks of 18-hour days, followed by two years of second-unit and special effects photography, followed by two years of editing and computer effects work, followed by four years of promotion and marketing. It played in two film festivals in 1997, and made a short run in a local theatre in 1998. And finally in 1999 the film was sold to a

distributor, in 2000 made brief runs in various cities and was released on home video in 2002.

About a tenth of the picture and all of the sound was created digitally, using software that I wrote myself. Nevertheless the final product was a print in 35mm Cinemascope and Ultra-Stereo surround sound, and it was projected on the big screen at the Lincoln Center in New York, my proudest moment with that film. It got me thinking, though— I could have shot the whole thing digital. So with that in mind, I started the millenium off by getting fired.

Actually the company I had been working for in Austin, Texas closed its plant and moved to Massachusetts. I decided to stay in Austin. Out of work, and looking for a way to support myself, I got into the business of transferring video to film for other people's movies. I found that I was able to use the same computer system that I put together for the animation in REDBOY. I could capture films shot on digital video tape and record them onto 35mm film, and in the process make it look like it was shot on film to begin with. The service is now marketed under the banner of DVFilm Digital Transfers (dvwfilm.com).

To lure filmmakers to the company, I packed the website with a lot of useful information about how to make video cameras work like film cameras, based on my own experiments and my knowledge of how the transfers worked. That effort led to the writing of this book. It's my hope to help filmmakers understand the new technology and also to relate some of my own experiences. The information here will help anyone trying to shoot digital film, regardless of whether the final work is shown with digital projection, 35mm or 16mm film.

No doubt about it, digital filmmaking is going to change the entertainment world. Anyone with a \$2,000 video camera can

make a feature film. Writers, directors and actors can make their own films. If the story and the acting are compelling enough, no sets, no lights, no makeup, and no equipment more expensive than a home computer are required. Anyone with access to a camera can make a documentary. Anyone who can draw on paper can make an animated cartoon. Most digital films are going to disappear, others are going to make millions of dollars, and still others are going to achieve a level of individual artistic expression which would have been impossible with film. The collaborative nature of conventional filmmaking can be abandoned, if you choose. It's now possible for one person to make a movie.

It's also possible for you to use a digital camera to imitate a film camera, and make a film that looks as slick as anything produced in Hollywood. That doesn't really take advantage of the possibilities that digital has to offer, but it can be done. This book tells you how to make digital look as much as possible like film, but I leave it up to you to choose whether to imitate the film look or abandon it.

Although to many the independent film world seems like a lottery, with scattered prizes of fame and fortune going only to a lucky few, independent films have a real place in the entertainment business. Most successful movie actors, writers, and directors get their start in small, quirky, low-budget films that don't get much distribution or don't even play in theaters other than in a film festival. The independent scene is like the research and development department of a large corporation. All the new ideas come from the R&D department, but no one expects them to turn a profit. From the filmmaker's point of view, this can mean years and years of struggle before success is achieved. That's certainly been my experience. Some may give up and turn to other professions; however, those others that are talented enough and those that persevere will find some reward eventually. The reward may be emotional rather than financial, but the achievement of a

dream can be satisfying in many ways. My advice is not to take it too seriously, and try to have as much fun as you can.

Dealing with film, though, especially 35mm, can be a serious damper on fun. It's hard to be Vincent Van Gogh when your paintbrush burns one dollar a second.* Not only is film stock expensive but you either need a trained cinematographer on the set or you must teach yourself how to operate a film camera. And even with the best training and experience, there is serious pressure to save film stock when shooting a low-budget film. That means limiting the number of takes that can be shot and pretty much rules out improvisation or multiple cameras. Film cameras are also so expensive that they are usually not purchased, but rented by the day or by the week. A quiet 35mm film camera package rents for 2-4 thousand dollars a week, whereas you could buy a digital camera for that same amount of money, and learn how to use it from the owner's manual and the information in this book. The question remains, though, would you get the same level of image quality from that cheaper camera? The answer to that question may surprise you, and leads directly into our first chapter.

* That's based on 90 feet per minute for 35mm, .50/ft raw stock, .12/ft processing and .25/ft workprint.

Part I PRODUCTION

Chapter One: Why Digital?

Can you really use a digital camera to make a movie, one that can be released theatrically all over the country? Certainly, and there are several reasons why shooting digital can look just as good as film. I'll go through each one of them and explain why.

First of all you need to understand how digital cameras record an image and how that differs from film:

CCD and CMOS

The CCD, or charge-coupled device, is the image-sensing device for most digital cameras. The camera lens focuses an image onto the CCD, which is a square-shaped array of tiny holes. Each hole is an electronic eye, which converts light into electric charge. The more intense the light is, the higher the charge. When the array is scanned, the charge is passed from one pixel to the next and read off the end, and each charge on each pixel converted into a number. The result is an array of numbers inside the camera's microprocessor that corresponds to the intensity of light at each point on the array.

The CMOS Sensor (Complementary Metal Oxide Semiconductor) is another image sensor that collects light like a CCD, but on a CMOS sensor each pixel is a charged plate with its own switch, and the charge is read off the chip one pixel at a time, in a different process to the CCD but one that yields roughly the same result: an array of numbers for light intensity at each point.

In either case, the sensor is scanned repeatedly, at up to 60 times a second, building a history of images which are recorded to tape. On most cameras the CCD or CMOS array has about 400,000 pixels, in an array approximately 700 by 600. Because the array

can reproduce a pattern of about 500 white and dark lines, it is said to have 500 lines of resolution. When I speak of “lines of resolution” I mean TV lines, or pixels, not the engineer’s meaning of the word which means line pairs.

The CCD or CMOS chip is inherently a black-and-white device. There are two methods to getting color information. One of them uses three identical chips, each behind a colored filter of red, green, or blue. This type of camera is known as a three-chip camera. The other method uses only a single chip. With a single-chip camera, each hole in the array has its own, tiny, red, green, or blue filter. The one-chip method has worse color resolution than the three-chip method, but one-chip cameras are cheaper because there is no need to use a beam splitter or scan the extra two sensors.

The chip has a limited range over which it can accurately measure the intensity of light. If the ray of light is too intense, the sensor saturates and measures the same value even though the actual value is higher. This is known as white clipping. Usually the clipping level is about a hundred times higher than the noise level, which is the lowest level the chip can sense without being drowned out by noise. It is noise which limits the low-light sensitivity. The noise is caused by random fluctuations in the electrical charge in the sensor. The ratio between the noise level and the clipping level is the dynamic range. Dynamic range and resolution are the most important characteristics of the chip sensor.

Photographic Film

In the case of a film camera, the light is instead detected by a photographic film. The film is an emulsion (a thin layer) of light-sensitive, silver halide particles, which change their chemical properties when struck by light. When the film is developed, the chemical change allows a certain amount of colored dye to be

washed out of the emulsion. The less light strikes the film, the more dye is washed out, and the more transparent the film becomes after processing. So conversely, areas exposed to more light become more dense. The result is a negative image of the scene. The film must be printed onto a second roll of negative film, the print film, to create a positive image.

Color is created by using three layers of emulsion, each behind successive layers of color filtering which interleave the light-sensitive layers. After processing the filters are dissolved, but the red, green, and blue dyes remaining in the emulsions work together in separate layers to compose a full-color image.

Film is also subject to a saturation effect, but the saturation level is not abrupt. Thus there is no "clipping," but a gradual reduction in sensitivity. It's possible to overexpose film a hundred times higher than normal and still yield a somewhat pastel image of muted color. For the low end, film is also limited by noise, but in this case the noise is the grainy effect of the particles in the emulsion. The graininess of the film also limits the resolution, although very fine-grained film can register incredibly detailed images. It's possible to photograph a newspaper and then read the text off the negative with a microscope (that's how microfilm libraries work). It will be a long time before you can do that with a video camera. The resolution of 35mm film is several thousand lines.

Differences Between CCD/CMOS and Film

The dynamic range, or ability to measure both bright and dark regions within a scene, is greater with film than with a chip. Because film doesn't have a hard clipping effect, it has the ability to read color even if the film is highly overexposed. In talking about range, it's useful to use terms of f-stops, where each f-stop on a camera aperture allows twice as much light as the previous stop. Light meters measure relative amounts of light in f-stops. A

chip has a range of only 4 stops, whereas film has a range of 8 stops or more.

However it's rare for a filmed scene to use the full range of light. The reason is that most films are shown on television, and any scenes which use a five-stop range or more are not going to look very good on TV. Since a large part of revenue for feature films comes from home video or television, there is a great deal of pressure on cinematographers to shoot for acceptable television broadcast. And they do. I would say 99% of the scenes in a dramatic feature film could be recorded with a digital camera with acceptable results. The other 1% are situations where the white clipping of CCD's or CMOS sensors produce a noticeable degradation of the image, but in later chapters I'll discuss how to get around that.

The resolution of 35mm negative film is about ten times that of a typical CCD or CMOS sensor, at least 5000 lines for film vs. 500 for SD video, or 1000 lines for HD chips. But the full 5000 lines of film do not really make it into the movie theater. Because the camera negative must always be printed to another strip of film to create a positive image, the viewer never sees the original film, but a copy, and often it's a copy of a copy of a copy. Theatrical film prints are made from an internegative, which is printed from an interpositive, which is in turn made from the original camera negative. These printing steps are typically accomplished with a 1950's vintage machine called a contact printer, which runs the film through at a blindingly high speed in order to reduce the time needed to make a print. The contact printer has no lenses or shutter, but simply brings the two pieces of film together in a gate, so the light must pass through one piece of film (the master) to expose the other (the print). The contact printer is not perfect, however. The two pieces of film are not tightly held together. The emulsions are not perfectly thin. There is vibration and looseness on the drive

sprockets. Because of these factors, the full resolution of the negative is lost when the image goes through contact printing.

The film projector in the movie theater is also responsible for a great deal of lost resolution. Unlike a movie camera, a film projector does not have registration pins which hold the film steady when the shutter is open. The projector uses a Geneva gear, an intermittent gear movement which is another piece of ancient technology. The steadiness of the Geneva gear is pretty bad, although it's extremely simple and reliable. The consequence of poor registration is that the film shudders and shakes in the projector gate, smearing out the image on the theater screen. The projection lens and the projector focus also limit the sharpness of the image on the screen.

The quality of theatrical presentation varies widely, but even the best theaters do not project with more than 2000 lines of resolution, and a more typical level is between 750 and 1500. My 1980 American Cinematographer's Manual specifies a minimum of only 800 lines of resolution in their focus (depth of field) specifications.* So, considering the state of the art in theatrical distribution and projection, the resolution is not remarkably higher than digital video.

Differences in Frame Rate

Many television programs are still shot on film. And anyone who watches television can observe the difference between shows that were shot on video, like news programs or soap operas, and shows that are shot on film like an hour-long dramatic series. The difference is due not only to the use of photographic emulsions vs.

* It actually specifies a maximum "circle of confusion" of .002 inches in the depth of field tables. This figure divided into the width of the projector gate yields about 400 line pairs of resolution, which is then doubled to get TV lines (800). The circle of confusion was changed in 1990 to .001 inches, which is a stricter standard, but it's doubtful if movie theatres have improved since then.

CCD sensors, but the rate at which images are captured and held on screen. All NTSC video, the video standard used in the United States, samples motion 60 times a second. The movement of an actor's arm, the motion of a moving car, everything that moves is broken up by the camera into tiny steps 1/60th of a second apart. This sample rate is so fast that the steps are not even apparent. The motion looks as smooth as if you were watching it through a window.

Television shows shot on film, however, which include many dramatic series and nearly all made-for-TV movies, are shot at 30 frames per second or 24 frames per second, on film. This is done mainly for two reasons: one, because film equipment used to be easier to use on location than video equipment (this was before the advent of compact digital cameras but the tradition has carried on since); and two, because shooting on film makes the finished project look like a movie.

One of the main reasons for this "movie look" is the slower frame rate. Motion is broken up into larger steps, and the blurring in each frame is greater. The difference between 24 fps and 60 fps is very noticeable, even on simple close-ups. There was even a Monty Python sketch about this on their BBC television series, because BBC shows were shot on both video and 16mm film. The 16mm was used for exterior scenes and the video for interior scenes.

It's hard to say which look is "better," but it's sufficient to note that there's a difference, and when you shoot NTSC for theatrical release, you have to take steps to ensure that the 60 fps to 24 fps conversion will go smoothly. If you use the proper settings on your camera, the 24 fps film version will look as if it were shot at 24 fps. Shooting PAL for theatrical release also involves some care. Also, there are many new HD capable cameras that can shoot at 24fps requiring no conversion or a simple pulldown removal. The information on these techniques is in Chapter Five.

Sound Recording

Sound recording with film production since the 1950's has always been accomplished with separate equipment. For the 40 years the standard was the Nagra recorder, a Swiss-made reel-to-reel tape recorder which used 1/4" magnetic tape. The Nagra had excellent audio quality and many other fine characteristics. However, a digital camera using 16-bit audio recording mode is nearly as good and in some respects is better. Digital recording has better signal-to-noise ratio, and is virtually free from effects like harmonic distortion, wow, flutter, and print-through. Of course you can always record sound with a digital audio tape recorder (DAT), digital Nagra, or digital flash recorder, but as I explain in Chapter Seven, there is no need with modern digital cameras to record sound separately. Having the production sound on the same master tape as the video is efficient, trouble-free, and saves a lot of headaches in synchronization and bookkeeping. Occasionally you may find that it's necessary to have the sound recording separate from the camera, for example when the camera is a long distance away from the actors or in a separate vehicle. In those cases, you'll have to use a separate recorder (or a second camera) and use a slate with a clapper to establish a sync point.

Another advantage to digital sound is that with digital sound production software like Sound Forge, Sony Vegas and Pro Tools, you can create a theater-quality soundtrack with surround sound and stereo effects, using your home computer and a little bit of work. The results can be played using Dolby SR, any of the digital theater sound systems, or the Dolby Pro-Logic system for home video. All it takes is the software, a Pro-Logic (home theater) decoder, some good speakers and a good ear. Chapter Nine also covers this area.

The Case for Digital

So I have argued that with the quality of today's 35mm printing, projection and sound, there is not much point to shooting on 35mm film. Film does have a wider exposure range, but with careful control of lighting and using the guidelines in this book, a digital camera can record nearly any kind of scene with acceptable reproduction of color. The frame rate difference and the sound quality of digital cameras are not barriers either.

For low-budget films where the primary goal is to make money from television and home video rather than theatrical release, and the only theatrical screenings are likely to be in film festivals, the slightly lower resolution of digital video, if anyone might notice, becomes a moot point.

Assuming that digital video has no serious drawbacks in quality, what are its advantages over film? There are many!

1. The cameras are far cheaper, smaller, and run longer before changing magazines or cassettes.
2. Documentary or guerilla filmmakers will find the cameras less intrusive and obvious.
3. There is no reason (other than time spent on the set) to limit the number of takes in order to get the best performance out of the actors.
4. Multiple camera shooting is pretty much a snap.
5. Sound can be recorded on the camera, eliminating synchronization problems and the need for slates.

6. Editing can be performed on a home computer by one person.

7. You don't need an expensive film print until the movie gets distribution or festival invitations.

8. Now that film-quality digital projection has become commonplace, you may not need a film print at all.

Economics of Digital vs. Film

How much do you actually save by shooting digital as opposed to film? It depends on how much you would have to pay the extra personnel required to shoot and edit a film and the costs of the film stock, processing and printing. Here is a rough figure for a low-budget 35mm film with a non-union crew, shooting for 4 weeks and spending 6 months in post-production: fifty thousand dollars. If you care to see a breakdown of that figure, please refer to Appendix B, my budget for REDBOY 13, which was shot in 35mm and edited on film.

If your budget is over a hundred thousand dollars (as it was with REDBOY) the difference of fifty grand may not seem significant. However, much of that money is spent up front, before you begin shooting, so the initial investment is higher. But if your budget is zero, like it is with many independent films, where everything has to be done as cheaply as possible, every dollar saved can mean the difference between completing your film and not completing it.

Digital vs. 16mm

But what about 16mm film? Some of the advantages of shooting 16mm are shared with shooting digital. The cameras are cheaper and easier to use. Because of the smaller gauge of film stock, you use less footage (60% less) than you would with 35mm, and the

cost per-foot is about half. 16mm can be transferred to digital video and edited on a home computer just like something that was shot purely digital. There are strong arguments for shooting 16mm (or Super 16) and editing on digital. At DVFilm we have transferred several films to 35mm that were shot this way, and the results were very good. 16mm does not have significantly better resolution than digital, but since you are shooting on film you have all the advantages of the exposure range of film. The main disadvantages of 16mm vs. digital are the film magazines. They must be changed every 10 minutes of shooting (for 400-ft loads) and the cameras are bulkier and more difficult to use than a video camera. You must also record sound on a separate system and slate every sound take to establish sync. Furthermore, there is one tricky problem with taking something shot at 24 frames per second, transferring to digital video which runs at 30 frames per second, and then converting it back down to 24 for the 35mm print. This problem has been addressed at DVFilm by some special software which I'll discuss in Chapter Six, the chapter which specifically covers shooting and editing 16mm for digital blow-up to 35, but other companies may not have this capability.

The Ideal Format

In summary, shooting digital is the ideal format for a low-budget film. The equipment is relatively cheap, easy to use, and if you follow the guidelines in this book, the image and sound quality you get by shooting digital will yield an excellent 35mm or 16mm print. You will be able to show that print together with movies that were shot on film, and very few people will be able to tell the difference. And since the quality of digital cameras gets better every year, eventually all films will be shot with digital cameras and 35mm production will go the way of 70mm and VistaVision--formats that were once commonplace but have since become obsolete for conventional filmmaking.

Chapter Two: Selecting a Camera

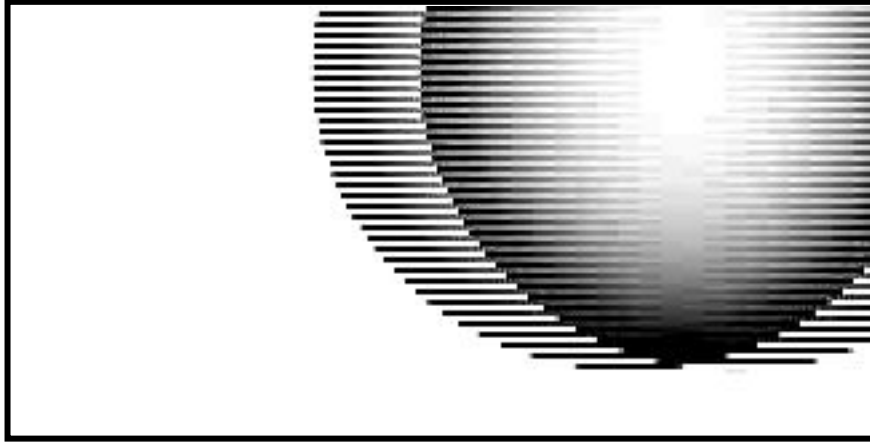
One of the most common questions I get from filmmakers is “what camera should I use to get the best results in a movie theater?” The answer is not an easy one, since there are so many formats and cameras available and the models change from year to year. The specifications are not easy to interpret, and camera manufacturers sometimes conceal or mislead if they think it will sell a few extra cameras. But in order to clear some of the fog, I’ll attempt to describe the most significant video formats and camera models available to the independent filmmaker, and also talk about how to read the specifications yourself to choose the most appropriate format and camera.

Video Technology

To understand the differences between various video formats and cameras, you first need to know the various technologies used in these cameras and videotape recorders. Here are some of the most important ones:

Interlaced scanning

Interlaced scanning was a compromise technology invented in the 50’s to increase the vertical resolution of television without lowering the field rate of 60 fields per second or increasing the required bandwidth. With interlaced scanning, every other field scans a slightly different vertical position, The first field of every frame scans the odd-numbered lines, and the second scan covers the even-numbered lines on the screen:



Frame of video, containing two interlaced fields,
of a ball moving from left to right.

Unfortunately it also means you cannot combine two fields together in a straightforward way to make a still image, because the two fields are sampled at different points in time. In such a combined frame, a rapidly moving object appears to be torn apart by horizontal bands. When interlaced video is transferred to film, it must be de-interlaced with some sophisticated motion-sensitive algorithms. Most digital transfer companies have this capability, although the older, kinescope transfer companies do not.

Interlaced video is often abbreviated as 60i or 30i, which means 60 fields per second or thirty frames per second, interlaced, NTSC. PAL is often called 50i, or fifty fields per second interlaced.

Progressive scanning

Progressive scanning overcomes the problem with taking still frames out of interlaced video footage. Each frame is scanned only once, at 30 frames per second (for NTSC) or 25 frames per second (for PAL). 30p as it is often called, looks similar to 30 fps film converted to video. Unfortunately for filmmakers, 30p progressive scanning for NTSC does not convert smoothly to 24 frames per

second. The reason for this is explained in Chapter Five. However, progressive scanned PAL (25p) or shooting 24P (as with a Panasonic DVX100A or Canon XL-2 camera) **does** convert well to 24 fps film. Also see discussion below on NTSC vs. PAL.

“Frame Movie” Mode

“Frame Movie” Mode, also known as frame mode, is a method whereby the camera processes the image from a interlace scan CCD and converts it to a progressive scan image which has a “film look.” The Canon XL-1 and GL-1 provide this feature, but it is not recommended for projects which need to be transferred to film, because the extra processing done by the camera chip to create Frame Movie Mode degrades the image slightly. Sony DV cameras should always be used in interlaced mode, because their version of frame movie mode or progressive scan only works at half the normal frame rate (15 fps for NTSC cameras and 12.5 fps for PAL cameras). If you like the look of “Frame Movie” mode you should shoot regular interlaced video mode and convert your project to progressive-scan after it is done, using a program like DVFilm Maker (dvwfilm.com/maker). The unconverted, interlaced version should be saved for possible transfer to film.

24P Mode

Some NTSC cameras have the capability to shoot 24 frames per second and convert to NTSC as they are recording.. At this time the only MiniDV models that can do this are the Panasonic AG-DVX100A and the Canon XL-2. 24P-capable cameras have a built-in film look and the video can also be edited at 24 fps instead of 30 fps (NTSC) or 25 fps (PAL), with the use of DVFilm Maker or DVX100-enabled editing programs like Vegas 5, Premiere Pro 1.5, Final Cut Pro HD, and others. 24P has many advantages over shooting NTSC or PAL, and these are covered in detail in Chapter 5.

De-interlacing

De-interlacing means converting an interlaced video to progressive scan for the purpose of achieving a film look. A bad way to do this is to average the two fields together, which unfortunately reduces the vertical resolution by half. “Selective” de-interlacing, on the other hand, handles the pixels differently depending on whether motion is present nearby. This more sophisticated de-interlacing does not affect the vertical resolution (unlike “Frame Movie Mode”).

Time Code

Time code is a clock, which is present on most professional video formats like MiniDV, DVCAM, Beta SP and DigiBeta. It tells you the elapsed time in hours, minutes, seconds and frames for each frame of video. Some tape formats use SMPTE time code, others like MiniDV and DVCAM do not. SMPTE time code is a time code standard which is commonly used in professional editing systems. Even though DV time code is not SMPTE time code, it is still accurate enough for most purposes.

Drop-Frame Time Code

DV formats use drop-frame time code, which tells you the elapsed “real” time for each video frame. Since NTSC video plays back at 29.97 frames per second instead of precisely 30 (a difference of one in 1000), drop-frame time code skips one frame of count for every 1000 frames played back.* This is a somewhat confusing technique but it does give you a more accurate estimate of a

* Black and white video originally ran at exactly 30 frames/sec. When color NTSC was introduced, the added color information was modulated onto a 3.575421 MHz sub-carrier to make it backward compatible with B&W. The frame rate changed ever so slightly to 29.97 so that the color sub-carrier was an even multiple of the frame rate.

program's elapsed time. For a long program the difference can be significant.

Non Drop-Frame Time Code

Non drop-frame time code is an option on SMPTE time code systems and some video editing programs. It counts frames without skipping counts and some editors find it easier to use than drop-frame time code. However, keep in mind that non-drop time code is not "real" time. The non drop-frame time code clock ticks at 29.97 frames per second.

CCD - charge coupled device

The CCD is an integrated circuit that collects light into an array of square holes and then converts the light falling in each hole into an electric charge. The charge is then converted to a number, which represents the brightness of light at that pixel.

Image Compression

All digital cameras compress the video image before recording it onto tape. Compression reduces the amount of storage that it takes to record an image, by using fewer numbers to describe areas in the image which do not contain any detail. Some common compression technologies and the approximate ratio by which they reduce storage (these are approximations):

DV, DVCPRO, DVCPROHD	5:1
MPEG-2	8:1
H.264	10:1

By this table, DVCPROHD compression reduces the amount of storage by a factor of five times less than uncompressed video.

Audio tracks in most digital formats are stored without compression. However MP3 and AC-3 are commonly used compression methods for audio.

Three Chip Cameras

Three chip cameras use 3 CCD or 3 CMOS sensors, one each per red, green, and blue color. These cameras usually have much better color resolution than single-chip cameras.

DSLR – Digital Single Lens Reflex

The DSLR is first and foremost a still-image photography camera whose name derives from the use of a prism and mechanical mirror that displays the image from the lens through to an optical viewfinder. They use interchangeable 35mm lenses and utilize very large chips in comparison to video cameras. Recently, manufacturers of these single CMOS sensor cameras have added full HD video features at 1080p or 720p with frames rates of 24, 25, 30, and/or 60 frames per second. The cameras are capable of very good quality video images mainly because of the use of the larger chip size and because of the ability to use very high quality 35mm lenses. They do have some drawbacks that will be discussed later. Though some of these cameras don't have mechanical mirrors like the Panasonic GH1, they are still usually lumped into the DSLR category.

Rolling Shutter

Single-chip CMOS cameras are scanned relatively slowly, and from the top to the bottom of the image. This is different from the scanning method of CCD sensors, which typically sample the entire image in an instant. The slow method of CMOS sensors is often called a rolling shutter. There are side effects from this method of sampling the image. If an object is moving across the

frame from left to right for example, the delay in sampling the image will cause it to appear to lean in one direction. If the camera is shaking, the object will appear to wiggle .

Wobble or Jello (See Rolling Shutter)

Helicopter shots, and shots with a shaking camera, when recorded with a rolling shutter, can appear to be greatly distorted. This effect must be counter-acted by stabilizing the camera or by using a different type of camera for these shots.

Bayer Filter

Single-chip CMOS cameras use a mosaic pattern of red, green and blue pixels. An example is shown below:

G	R	G	R	G	R	G
B	G	B	G	B	G	B
G	R	G	R	G	R	G
B	G	B	G	B	G	B

In this example you can see there are about twice as many green sensors as red or blue. But when the color samples are combined inside a computer, the combination can be use to reproduce any color. A Bayer pattern is a type of pattern of R, G and B pixels. The pattern is always filtered out by the camera's microprocessor and you cannot see the pattern in the final image.

Color Sampling

Since the invention of the D-1 digital format, a standard has emerged in digital video where the color information in the picture

is sampled at only half the rate of the luminance signal. That means that in a horizontal line of 720 pixels, the color information is updated only 360 times. This is designated as 4:2:2 sampling. It takes advantage of the fact that the human eye perceives color at a lower degree of sharpness than pure brightness. Unfortunately, it makes the assumption that you're looking at a fairly small screen, not one that fills the entire wall of an auditorium. For the NTSC MiniDV and DVCAM formats, the color sampling rate is even lower than that of D-1. It is one-fourth the luminance rate. So in the NTSC-DV world, the color is updated only 180 times across the horizontal line. This is designated as 4:1:1 sampling. 4:2:2 sampling is definitely better than 4:1:1 sampling, especially for colored titles and graphics. Some digital formats such as DVCPRO50 and DVCPROHD use this higher quality method. There is also 4:2:0 sampling, used in digital PAL formats. The color sampling rate in the horizontal direction is one-half the luminance rate (which is good) but color is sampled only every other line in the vertical direction (which is not so good, worse than 4:2:2 or 4:1:1 which samples color on every line). Overall, though, the 4:2:0 color sampling is slightly better than 4:1:1 color sampling. MPEG-2 and H.264 also use 4:2:0 color sampling.

Image Stabilization

There are two kinds of image stabilization: optical and electronic. Optical image stabilization works by means of tiny prisms in the optical path from the lens to the chip. The camera senses the movement of the image on the chip sensor, and then deflects the image by moving the prisms to compensate for the shaking of the camera. Electronic image stabilization is a simpler but lower-quality method: The image data on the sensor is simply shifted up, down, left or right to compensate for the shaking of the camera. Unfortunately with electronic stabilization the image resolution is degraded, because in order to keep the top, bottom, left or right borders from appearing on screen when the camera is jiggling, only

part of the image that falls on the chip is recorded to tape. Because the resolution of the chip is not very good to begin with, electronic image stabilization, and its kin, electronic zoom, are not recommended for production.

Electronic Zoom

Electronic zoom extends the focal length of the zoom lens by zooming the image electronically. That means that a small region in the middle of the chip sensor is extracted and enlarged by the camera's microprocessor to fill the screen. As you can imagine this does not result in a very high quality image. Therefore electronic zoom is not recommended for production.

NTSC - National Television Standards Committee

NTSC was the standard for American and Japanese television before HD was introduced, and most TV's in these countries were strictly NTSC until the recent switch over to digital transmission and the trend toward HD televisions. Almost all DV cameras are NTSC compatible. The only ones that aren't are High Definition cameras and PAL cameras. NTSC is 29.97 frames per second, two interlaced fields per frame, 525 horizontal lines per frame, out of which only 480 are actually visible. Even though DV is NTSC compatible, it is actually of higher quality than NTSC. That means that some of the resolution of a DV camera is lost when you play the video back on an NTSC television set. But all the resolution is still available, if needed, to transfer to film.

PAL -- Phase Alternate Line

PAL is the European standard for television. It has 625 lines (576 of which are visible), and exactly 25 frames per second of 2 interlaced fields per frame. PAL uses a different system to encode color and generally has better color consistency than NTSC (which

some people jokingly call Never The Same Color). The only big disadvantage is that PAL televisions have a noticeable flicker because of the lower frame rate. People in Europe somehow get used to this flicker. However it is very easy to shoot on PAL and convert to NTSC (see Chapter 10 on Computer Editing).

Auto Focus

All consumer and prosumer digital video cameras have an auto focus capability. It works by looking for sharp edges or contrast in the image and changing the focus of the lens to maximize the sharpness. Auto Focus is not magic however, and occasionally fails to focus properly. It shouldn't be used in production unless you're shooting guerilla-style and don't have time to either measure focus or focus, by eye, off of a monitor.

Auto Iris

Auto iris is the capability of automatically changing the lens aperture during changing light conditions. Auto iris is fairly foolproof, although if the iris changes in the middle of a shot it can be distracting. This might happen if a bright window swings into view, for example, on an indoor daytime shot. Problems like this are discussed in Chapter Four.

Shutter

The shutter setting on a video camera is analogous to the mechanical shutter on a still camera. It controls the period of time during which the sensor is exposed to light. Longer shutter times result in more motion blurring and greater light sensitivity. Shorter shutter times result in each field "freezing" the action. Although at 60 fields per second a very short shutter speed can still look realistic, at 30 or 24 frames per second short shutter speeds create a disturbing, strobing effect. A typical shutter setting for NTSC is

1/60th of a second. This is very close to the shutter setting for a motion picture camera running at 24 frames per second, which is about 1/50th of a second. For projects which will be transferred to film, you should always use 1/60th of a second for NTSC and 1/50th of a second for PAL or 24P. Some cameras have a mode of operation where the iris is kept at a constant setting and the shutter speed is varied instead to keep the exposure constant. This mode, called “Aperture Priority” Auto, is not recommended for production. The “Shutter Priority” mode, which keeps the shutter setting constant, should be used instead.

Frame

A frame is two interlaced fields, each of which is a separate image, combined into a single image. On an NTSC or PAL monitor, you never see both fields at once, first you see the first field and then you see the second field, in succession. The only place you might see both fields at once is when looking at frames of video stored on your computer system. A frame can also be a progressive frame. In this case each frame is a single frame with no fields. Progressive frames are closest to the frames shot with film cameras.

Field

A field is one vertical scan of the image. NTSC fields are made of 262 or 263 lines. Two fields lace together to make up one frame of 525 lines.

White Balance

White balance is achieved when the red, green, and blue CCD's are reading the correct balance of color. When the white balance is incorrect, white or gray areas on the screen have a colored tinge. White balance is necessary to reproduce skin tones correctly. Some

cameras have an Auto White Balance capability, but it's better to do the white balance manually. It is done by pointing the camera at a white card and pressing the white balance button.

Zebra Stripes

Some cameras will display zebra stripes in the viewfinder over brightly lit areas which are saturating the CCD sensor. The stripes are not recorded to tape, they are just displayed for the camera person's benefit. The areas marked with stripes are in white clipping, which means that all color information is being lost. Bright red areas will look pure white instead, for example. Film cameras do not clip bright colors, and high-end digital cameras have special circuitry to prevent white clipping. But for many cameras it is up to the cameraman to avoid these situations, which can seriously degrade the image quality. Zebra stripes can help you identify problem areas.

16-bit and 12-bit Audio

Digital audio works by measuring the output voltage of a microphone at a very high sample rate, around 48,000 times a second for example. When the sound is played back the numbers are converted back to a voltage level at the same high rate, and used to drive a speaker or headphone. 16-bit or 12-bit audio refers to the size of the binary (base-2) number that is used to measure the microphone voltage. Since the largest number that can be represented with 16 bits is 65536, and the largest number that can be represented with 12 bits is 4096, the 16 bit method is 16 times more accurate than the 12 bit method. This means that 16-bit audio has a greater dynamic range and less distortion than 12-bit audio. Because of its poor quality, 12-bit audio is not recommended for production, even though the DV format can record 4 channels of 12-bit audio vs. only 2 channels of 16-bit audio.

Aspect ratio 16:9

Aspect ratio refers to the ratio between the horizontal dimension of the screen and the vertical dimension. 16:9 is a wide-screen aspect ratio that is in common use for high-definition TV, where the screen is roughly 1.78 (16 divided by 9) times wider than it is high. Many DV cameras can shoot pictures in the 16:9 mode. 16:9 closely matches the 1.85:1 aspect ratio that is common for motion pictures. However there are different methods to obtaining a 16:9 image and these are discussed in Chapter Five.

Aspect ratio 4:3

The 4:3 aspect ratio, where the screen is 1.33 (4 divided by 3) times wider than it is high, is in common use for NTSC and PAL television. Unfortunately its nearly square aspect ratio is a poor match to a modern movie screen. Chapter Five discusses how to overcome this limitation.

Intraframe Compression

IntraFrame compression means that each frame is compressed individually, and that you do not need the data from more than one frame to reproduce the image. With intraframe compression, each frame is individually compressed. DVCPROHD and AVC-Intra are intraframe compressors. Mpeg-2 and H,264 compressors are not. They compress frames in groups of 15 frames or more.

MPEG-2 Long GOP (GOP = Group of Pictures)

With MPEG-2, every 15 frames are compressed together. Frames 1 and 15 are compressed and the frames in between are analyzed for motion and the software tries to make predictions as to where objects are moving to make the compression more efficient. This is called motion compensation, HDV, MPEG-2 and H.264 are all

Long GOP formats. Long GOP is more efficient, but can present challenges to the editing system.

Motion Compensation

MPEG and other similar motion-compensation formats increase compression efficiency by tracking objects across the screen and simply repainting them a little bit to the left, right, up, or down, as they move. This method can greatly reduce the data storage requirements of video, provided that the computer is fast enough to make the calculations in real time. The drawbacks, however, include possibly junky image quality especially when objects (or the camera) move about randomly or violently. On typical scenes that that you might find in a dramatic film, however, it works extremely well and without noticeable image degradation.

Analog and Digital Recording

Analog recording translates the light intensity levels of a video sensor into a magnetic field and then imprints this field onto magnetic tape. Digital recording records instead the numbers that are generated by the chip sensor and then compressed by the compression chip. The magnetic fields on the tape are always at one of two levels, one level for “zero” and another level for “one”. The digital recording method also has error detection and correction, which uses redundant information to check on the accuracy of the recorded numbers. The result is that digital recording is more accurate and error-free than analog recording. Digital recordings may also be copied without degrading the quality of the image. The advantages of digital recording are lost, of course, when there are drop-outs on the tape (areas where the magnetic emulsion on the tape has been worn off, torn or wrinkled). Sometimes an analog recording will still retain a degraded image when the tape is damaged, whereas a digital recording on the same tape will drop out completely. For this

reason it's important to use high-quality tape and not to re-use tape when making digital recordings. Today there are also many non-tape digital options available. Video can be recorded to flash memory cards. (P2, SDHC, SxS for example). Tapeless digital recording is superior to tape, and represents another revolution in film making technology, The memory cards, although more expensive, are extremely durable, and can be re-used many times.

XLR

XLR mic (microphone) inputs – often referred to in the camera specs, are special three-pronged connectors preferred by sound technicians for connecting microphones to a camera. The XLR connectors have a separate ground connection, a shield, and balanced inputs for noise rejection. There is more info in Chapter 7 (Sound Recording).

Phantom Power

Though some microphones can be powered with a single AA battery, most professional microphones require +48v phantom power. This type of power can be supplied from a mixer, video camera, audio recorder, or an inline phantom power accessory. Some older pro microphones use another form of power called T-power (12v), but these are not as common as the phantom powered microphones.

ND filters

ND (Neutral Density) filters are gray filters that can be placed in front of the camera lens to block light in extremely bright light situations, usually outdoors. Some professional-grade cameras have these filters built in and can they can be switched in and out automatically. This is in addition to the aperture (iris) and

electronic exposure control. This is a good feature for outdoor shooting. There is more info in Chapter 3 (Lighting).

Tapeless Media Storage

Here are the major types of Tapeless (solid-state) digital recording:

P2 – Panasonic’s flash format available from 4gb to 64gbs. Capable of 100mbits write speeds. It’s a professional, robust storage type, but is expensive. There are “A,” “R,” and “E” series cards. “A” and “R” are the same but have longer cycle lives meaning they can be reused more than the “E” series, but the “E” series are cheaper and transfer at a higher rate.

SxS – Sony’s flash memory cards for its XDcam EX series of cameras. Boosts very high transfer rates and is a direct competitor in price and performance to Panasonic P2 cards. There is an SxS and an SxS pro card that work with different Sony XDcam Ex cameras.

SD/SDHC – Secure Digital High Capacity; General media for DSLRs, consumer and prosumer camcorders.

CF – Compact Flash; General media storage card for DSLRs and the new Canon XF camcorder series. Red One cameras record to a proprietary version of a CF card.

Firestore – Focus Enhancement’s portable firewire drive. Various models allow recording of P2 MXF, HDV, XDcam, and quicktime formats onto a hard drive through the firewire port of a camcorder.

Tapeless recording also means a tapeless workflow—in other words, a file-based workflow where instead of video tape you are working with computer files that are created directly by the

camera. Tapeless workflows have many advantages. There is more info on tapeless workflow in Section II, Post-Production.

Video Formats

There is a proliferation of video formats, and the scene is quite confusing. The main thing to remember about each format is the lines of resolution and the color sampling. For digital formats, color is either sampled every four pixels (4:1:1) or every other pixel (4:2:2). 4:2:2 sampling is commonly found only in the high-end professional formats, although the DVCPRO50 and DVCPROHD formats have 4:2:2 with some affordability. 4:2:2 sampling does yield slightly crisper color titles, but for live-action scenes there is usually no apparent benefit. There is also 4:2:0 sampling used for PAL and HDV, which is roughly equivalent to sampling every other pixel, but on every other line. Here is a brief description of each video format, from lowest to highest quality:

4:1:1 Digital consumer formats

MiniDV - 500 lines resolution - DV compression - 16-bit or 12-bit digital audio - probably the best format for super low-budget production with a three-chip camera.

4:2:0 MPEG-2 consumer/pro Formats

HDV – 900 lines resolution - so-called Mini-HD format, highly compressed with DVD-like MPEG-2 compression. The JVC HD-10 uses this format and also the Sony HDR-FX1/Z1U. See discussion below on using HDV. The 60i and 50i (interlaced) versions of HDV can be used for movie production, but not the 30P version.

4:1:1 Digital professional formats

DVCAM - 500 lines resolution - DV compression - 16 bit or 12 bit digital audio – about the same quality as MiniDV, however DVCAM cameras usually have more professional features than their MiniDV counterparts, which may result in better quality.

DVCPRO - 500 lines resolution - DV compression - 16 bit or 12 bit digital audio - also good for low-budget production

4:2:2 Digital professional formats

The cameras for these formats have become affordable to many independent filmmakers:

DVCPRO50 - 700 lines resolution - 2xDV compression - 16 bit digital audio.

DigiBeta - 700 lines resolution - 1.5:1 compression, excellent choice for production or mastering but the cameras are not very affordable. Cannot be used with DV editing systems.

DVCPROHD – about 700 lines resolution and affordable. This format is now available on prosumer Panasonic cameras. (HVX200/HPX170)

High-end Professional formats

These formats are way beyond the reach of most independent filmmakers and cannot be used with home computer editing systems, but I include them for completeness:

HDCAM SR– 1000+ lines resolution digital formats, unfortunately not very affordable, in fact you might as well shoot on 16mm or 35mm unless your uncle owns Sony. (Models Sony SRW-9000, HDW-F900R)

Uncompressed 4:4:4 HD – 1000+ lines resolution with a super 35mm sized sensor, PL lens mount for cinema lenses, and due to sensor size depth of field matching a 35mm film camera. These cameras record to external Harddrives or flash memory drives through dual HD-SDI outputs. (examples Panavision Genesis, Arri D20, Sony F35, Red One) (~\$70,000)

PAL Formats

Most of the above production formats are available in PAL models as well as NTSC. The non-HD digital PAL format uses 576 vertical scan lines as opposed to 480 for NTSC, so the vertical resolution is slightly higher. On the whole, PAL has about 20% better resolution than NTSC.

PAL also samples motion at 50 fields per second instead of 60 for NTSC. The 50 fields when combined to 25 frames per second is a very close match to film's 24 frames per second, and if the video is slowed down by 4% there is a one-to-one direct transfer of video frames to film frames.

The 4% slowdown can be noticeable, so that is also something to consider. Most transfer facilities can correct the audio so that the pitch remains the same, but the apparent motion of actors and cars can have a somewhat dream-like quality. Another disadvantage to PAL is shooting 50Hz video in a country like the U.S. which operates on 60Hz power. Florescent lights and arc lights may appear to flicker if you use a PAL camera in the States, unless the

camera can be set to 1/60th sec shutter speed to equalize the exposure in each frame.

The advantages of PAL over NTSC are greatly out-weighed by shooting in the 24P HD formats.

The Cameras

I have a brief discussion here of the most popular DV and HD cameras. The DV cameras have been made somewhat obsolete by the low-cost HD cameras. Any HD camera is going to yield a much better picture for movie work than a DV camera. However since there are so many DV cameras in existence, especially in the 2nd-hand market, I will discuss them briefly.

DV (Standard Definition Digital Video) Cameras

Canon GL-2

www.canondv.com

The baby brother to the Canon XL-1S is a MiniDV camera with many of the same features as the XL-1S. Like the XL-1S, it does 16:9 electronically but may be used with a low-cost anamorphic adapter. It has a flip-out LCD monitor. The GL-2 has a smaller CCD sensor than the XL-1S, which means that the low-light performance of the GL-2 is not as good as the XL-1S. The GL-2 has frame mode, a (pseudo- progressive-scan mode) and slow shutter speed effects. They can be used to create a film look, but these modes are NOT recommended for digital film production. Does not have manual audio controls like the XL-1S.

Canon XL-1S

www.canondv.com

The Canon XL-1S has many desirable features including an excellent optical image stabilizer and very responsive auto focus capability. The camera can be operated manually, if desired. There are some difficulties with focus at wide apertures. It has electronic 16:9 mode, but unfortunately due to the very wide front element of the lens, cannot be used with a low-cost anamorphic adapter.

The XL-1S has movie frame mode, a pseudo-progressive scan mode, and slow shutter speed effects which can be used to create a film look. However, these modes are NOT recommended for digital film production, they can reduce sharpness and, in the case of the NTSC model, make it impossible to convert to 24 fps film.

The XL-1S is now an old design, no longer sold by Canon, and is probably not a good choice versus a low-cost HD camera like the HVX-200A.

Canon XL-2

www.canondv.com

The Canon XL-2 has all the features of the XL-1S, but also shoots at 24 frames/second. Our recommended settings for the XL-2 are at dvwfilm.com/xl2 and also shown in Appendix G.

It has native 16:9 widescreen shooting mode, and that is the best mode for transfer to 35mm.

SONY

Sony VX-2000 and VX-2100

www.sonystyle.com

The VX-2000 is a MiniDV camera and the successor to the VX-1000, the original MiniDV camera, but it's more similar to the PD-150 in size and shape. It has many of the same features as the PD-150. It has a flip-out LCD monitor. The VX-2100 is an improved version of the VX-2000.

Sony PD-150 and PD-170

www.sonystyle.com

The PD-150 and PD-170 are the "pro" versions of the VX-2000 and VX-2100. They have a 1/3" CCD and a high-resolution black-and-white viewfinder. They also have a flip-out LCD color monitor. The PD-170 is an improved version of the PD-150.

Sony DSR-570WS

www.sonystyle.com

The DSR-570WS, successor to the DSR-500, has true 16:9 capability. It records on DVCAM, the recorded resolution is about 500 lines, same as all DV cameras.

PANASONIC

Panasonic AG-DVX100 and AG-DVX100A

www.panasonic.com

The DVX100 was a competitor for the Canon XL-2, Sony VX-2000, and the Sony PD-150, but like the XL-2 it has the all-important 24 fps progressive-scan mode. In this mode the sharpness can be much better than the VX-2000/PD-150, if you use

it properly. One known problem with the camera is with the focus ring, which is difficult to control manually. This was the first low-cost 24P DV camera. There is more information about this camera in Appendix G.

Panasonic AJ-D610WA
www.panasonic.com

True 16:9 camera uses DVCPRO format which is similar in quality to MiniDV and DVCAM, and supports Firewire. 500 lines resolution as with all DV-format cameras, despite Panasonic's claim (on their data sheet) of 750 lines. Panasonic makes many other DVCPRO cameras besides this one, as they are very popular with TV stations, but this is one of the few wide-screen models.

Panasonic SDX900
www.panasonic.com

Panasonic also makes DVCPRO50 cameras, which compete with Digibeta for high-quality NTSC or PAL. The DVCPRO50 cameras, such as the SDX900, can also shoot 24P. These cameras cost \$25,000 and up. DVCPRO50 can be edited with some desktop editing systems like Final Cut Pro.

HD (High Definition) Cameras

Canon VIXIA HF S20/S21/S200
www.usa.canon.com

The VIXIA HF S20/S21/S200 is an HD consumer AVCHD camera that offers 1920x1080i resolution, 24p shooting and manual controls. However, it has a single CMOS chip, no XLR mic inputs, and a rolling shutter. (\$1000)

Canon XHA1s

www.usa.canon.com

The Canon XHA1s is an HD prosumer HDV camera that offers 1440x1080i, 24p, three 1/3 inch CCD sensors and manual controls. It has built in XLR inputs, ND filters, and many other professional video camera features. It records to mini-dv tape. (\$3400)

Canon XF300/XF305

www.usa.canon.com

The Canon XF300/XF305 are HD professional three 1/3 inch CCD sensor cameras that offers native 1920x1080 (60i/30p/24p) 50Mbps Mpeg2 4:2:2 recording to CF memory cards. (\$8000)

Sony HDR-FX1 or HDR-Z1U

www.sonystyle.com

The Sony HDV cameras were a very exciting development. They shot either 60i (60 fps interlaced) at 1440 x 1080 or 50i (50 fps interlaced) 1440 x 1080, using a widescreen CCD. These are very large frames sizes, and show much more detail than a DV camera. The Mpeg-2 compression technique, although it is more highly compressed than DV compression, is very well designed and does not appear to be a big drawback for most scenes. The audio is recorded compressed, unlike with MiniDV cameras that record uncompressed audio. However the audio compression method (Mpeg Audio layer II) is very high quality and more than adequate for recording spoken dialog. Mpeg Audio layer II is similar to CD-quality MP3.

Sony HVR-V1U
www.sonystyle.com

The Sony HVR-V1U is an HD prosumer HDV camera that offers 1080/60i or 1080/24p, three 1/4 inch cmos sensors and manual controls. It has built in XLR inputs, ND filters, and many other professional video camera features. It records to mini-dv tape. (\$3300)

Sony HXR-NX5U
www.sonystyle.com

The Sony HXR-NX5U is an HD prosumer NXCAM (AVCHD) camera that offers 1080/60i, 30p, 24p, 720/60p, three 1/3 cmos sensors and manual controls. It has built in XLR inputs, ND filters, and many other professional video camera features. There is an optional Sony Flash Memory Unit (\$730) that easily attaches to the back of the camera and provides 128 gigs of storage. You can record to SD cards and the Flash Memory Unit at the same time to create instant backup files. (\$4000)

Sony PMW-EX1R/EX3
www.sonystyle.com

The Sony PMW-EX1R/EX3 are HD professional XDCAM cameras that offer 1920 x 1080/59.94i, 29.97p, 23.98p, 1440 x 1080/59.94i, 29.97p, 23.98p, 1280 x 720/59.94p, 29.97p, 23.98p (native). They have three 1/2 inch cmos sensors that record to SxS memory cards. (\$6300-8300)

Panasonic HMC40/HMC150
www.panasonic.com

The Panasonic HMC40 is an HD prosumer AVCCAM camera. It has three 1/4 inch cmos sensors, a 2.7" flip out lcd screen,

1920x1080 and variable frames rates including 24p. There is an optional XLR adapter to enable the use of two XLR mics with phantom power.(\$300) This camera records to SD cards. (\$2000)

Panasonic HMC150
www.panasonic.com

The Panasonic HMC150 is the big brother to the HMC40 and has three 1/3 inch CCD sensors, a 3.5" flip out lcd screen, 1080 24p shooting and built in XLR inputs. The larger chip size allows better low light shooting. This camera records to SD cards. (\$3400)

Panasonic HVX200a
www.panasonic.com

The Panasonic HVX200a is an HD prosumer camera with three 1/3" CCD sensors, built-in XLR inputs, variable frame rate recording from 12-60 fps including 1080i 24pa, and a 3.5" flip out LCD screen. This camera records to P2 memory cards utilizing the Panasonic codec DVCPROHD with 4:2:2 color space. It can also record SD footage to P2 cards or minidv tape. This model is the same as the original HVX200 except it has the same 3CCD sensor as the HPX170. The HVX200 was the first low-cost HD camera that could shoot 24P (\$3700)

Panasonic HPX170
www.panasonic.com

The Panasonic HPX170 is the successor to the HVX200a and comes with a 16gig P2 card. This camera has three 1/3" ccd sensors, built-in xlr inputs, variable frame rate recording from 12-60 fps including 1080i 24pa, and a 3.5" flip out lcd screen. It records DVCPROHD 4:2:2, DVCPRO50, DVCPRO and DV to P2 cards. The LCD has a flip option for use with a 35mm lens

adapter. It has an HD-SDI output for live HD broadcast, output to the Panasonic HPG-20 P2 recorder, or for uncompressed recording to an external harddrive. (\$4000)

Panasonic HPX300/370

www.panasonic.com

The Panasonic HPX300 is a professional shoulder mount P2 HD camera. It has three 1/3" ccd sensors, built-in XLR inputs, variable frame rate recording from 12-60 fps including 1080i 24pa, and a 3.5" flip out lcd screen. This camera records to P2 memory cards utilizing the Panasonic coded DVCPROHD with 4:2:2 color space or the AVC-intra 100mbps format which performs beautifully with a full-raster 10-bit 4:2:2 based color system, making it the superior codec at its price-point. (\$7300)

Panasonic Varicam

The Varicam is still used for digital filmmaking. It shoots 1280 x 720 HD video at 24P and other frame rates. The image quality is excellent and records DVCPROHD compression to tape. However it's a very expensive camera and usually a rental item instead of for purchase. It was used for the feature film "Borat" for example.

Panasonic AF-100

Since the explosion of the video capable DSLRs on to the scene, film and video professionals have been clamoring for a camera with all the benefits of the DSLRs (large sensor, interchangeable lenses, low light sensitivity) without any of the problems (rolling shutter, bad compression codec, moire/aliasing). The Panasonic AF-100 appears to be that camera. It builds off the success of the Panasonic micro 4/3rds technology used in the Panasonic GH1, but puts it into a traditional video camera body. The single 4/3"-mos type imager is very close to motion picture 35mm size and has a 2x

crop factor so a 50mm lens will become a 100mm. Since the imager is specifically designed for video, the rolling shutter is extremely reduced to be on par with other video cameras and the moiré/aliasing should be highly improved if not completely eliminated. Since the micro 4/3rds system adapts to practically any lens mount, the AF100 can take almost any SLR or Cinema lenses with the correct mount adapter. It has professional connections such as HD-SDI for monitoring or uncompressed recording and two XLR audio inputs with phantom power. The camera records to solid Panasonic AVCCAM up to 24mbps with 4:2:0 color space with LPCM or Dolby Digital audio and capable of several resolutions and frame rates from 1080/24p to 720/60p to VFR (Variable Frame Rates). There is a professional waveform monitor, vector scopes and focus assist along with three built-in Neutral Density filters of 1/4, 1/16 and 1/64. The AF-100 records to two SD card slots or out the HD-SDI or HDMI ports. With certain Panasonic lenses, the AF-100 is capable of full auto focus control. The body is also modular so the handle and handgrip can be removed so other accessories can be attached. Though this camera will not be officially released until December 2010, the potential of it and the solid track record of Panasonic, who created remarkably innovative cameras like the DVX100 and HVX200, all but guarantees the Panasonic AF-100 will be a revolutionary camera for independent and professional filmmakers alike. The MSRP from Panasonic is \$4995, but it is available for preorder for \$4795 at the time of this publication.

JVC GY-HM100U

www.pro.jvc.com

The JVC GY-HM100U is a prosumer HD camera that shoots 1920x1080 24p, 25p, 30p, 50i, 60i. It uses three 1/4" sensors to record mpeg-2 video to SDHC cards at 35mbps at the highest quality setting. It has two XLR inputs with phantom power. It is

capable of recording to .mov format for use with FCP or ISO Base Media for PC editing systems. (\$2800)

JVC GY-HD250U

www.pro.jvc.com

The JVC-HD250U is a prosumer shoulder mount HD camera that shoots 720p 24p, 25p, 30p, 50p, 60p. It uses three 1/3" sensors to record HDV clips to mini-dv tapes. It has dual xlr inputs and many professional features. If you want to mount it on a tripod you will have to purchase the KA551U Tripod Adapter Plate. (\$270) This camera is *not* capable of recording full HD 1920x1080. (\$6000)

JVC GY-HM700

www.pro.jvc.com

The JVC GY-HM700 is a professional shoulder mounted HD camera capable of 1080i 60i recording and 720p 24p, 30p, 60p. You can record in the Sony XDCAM format to SxS memory cards with the optional KA-MR100G SxS Media Recorder Module. (\$900) Tripod mounting plate is optional. (\$270) The shoulder mount JVC cameras use expensive Anton Bauer batteries. (\$400) This camera is only capable of shooting 1080 60i not 24p. (\$6700)

RED

RED ONE

www.red.com

The RED ONE camera is capable of recording 4k (4096x2304) video using the Red RAW codec which is very much like shooting raw with a DSLR. Red RAW gives the filmmaker a great deal of latitude by which to adjust footage in post. It has a sensor the size of a Super 35mm frame and works well with high-quality cinema lenses. This camera has been used on big budget films like,

“District 9”. Companies like ARRI and Panavision offer similar high-end digital cameras. This is a camera to rent, preferably with an operator, due to its high price tag. Other cameras by Red: Scarlet, Epic.

DSLR Video

The newest development in the area of independent film making has come in the form of a digital still camera. When Nikon released the Nikon D90 in 2008 it started a revolution. The Nikon was soon followed by the Canon 5d mark II and the Panasonic GH1. These cameras offer HD video and selective depth of field. Most video cameras have much smaller sensors leading to everything in the frame being in focus. With the DSLR you can get 1920x1080 video at 24fps and the ability to pull focus, and select what you want in focus in a scene. The down side? These cameras use a single CMOS sensor which can cause rolling shutter artifacts during panning and action. These artifacts can cause the frame to look slanted or askew. They can also suffer from moiré effect, the crazy lines you get when shooting a screen door. They do not have XLR mic inputs requiring an additional adapter to attach XLR mics to the camera. The shallow depth of field can make filming difficult and focus critical. Some of these cameras suffer from overheating which forces them to shut down until the temperature returns to normal.

Nikon

Nikon D5000

The Nikon D5000 shoots 720p 24p video with no audio inputs. A built in mic records mono sound. There is auto control of aperture, shutter and exposure. The video format is motion jpeg. (\$630 no lens)

Nikon D90

The Nikon D90 shoots 720p 24p video with no audio inputs. A built in mic records mono sound. There is auto control of aperture, shutter and exposure. The video format is motion jpeg. (\$900 no lens)

Nikon D3S

The Nikon D3S shoots 720p 24p video and has a stereo audio input for capturing high quality audio. This camera also has full manual control of aperture, shutter and exposure. Useable ISO of 2000. The video format is motion jpeg. (\$5200 no lens)

Canon

The video format for the Canon DSLR is H.264 quicktime. Normally this video format is difficult to edit, however DVFilm has two products that make it easy: DVFilm EPIC I software can be used to edit these files in Sony Vegas Pro/Movie Studio without transcoding (see www.dvfilm.com/epic) or DVFilm EPIC I for Mac enables direct editing in Final Cut Pro.

Canon t1i

The Canon t1i shoots 1080 20p and 720 30p video with no audio inputs. A built in mic records mono sound. It has auto control of aperture, shutter and exposure. (\$600 no lens)

Canon t2i

The Canon t2i shoots 1920 x 1080 Full HD video at frame rates of 24 (23.976), 25 or 30 (29.97) fps. It also shoots 1280x720 video at 50 and 60 fps. It has a built in mic and a stereo mic jack input for capturing high quality audio with a self powered mic. This camera

also has full manual control of aperture, shutter and iso. Usable ISO of 1600. The video format is H.264 quicktime. (\$800 no lens)

Canon 7d

The Canon 7d shoots 1920 x 1080 Full HD video at frame rates of 24 (23.976), 25 or 30 (29.97) fps. It also shoots 1280x720 video at 50 and 60 fps. It has a built in mic and a stereo mic jack input for capturing high quality audio with a self-powered mic. This camera also has full manual control of aperture, shutter and exposure. Usable ISO of 1600. The video format is H.264 quicktime. (\$1700 no lens)

Canon 5d Mark II

The Canon 5d Mark II shoots 1920 x 1080 Full HD video at frame rates of 24 (23.976), 25 or 30 (29.97) fps. It has a built in mic and a stereo mic jack input for capturing high quality audio with a self powered mic. This camera also has full manual control of aperture, shutter and iso and audio. Usable ISO of 2000. (\$2500 no lens)

Panasonic

Panasonic GH1

The Panasonic GH1 shoots 1920 x 1080 Full HD video at frame rates of 24 fps. It also shoots 1280x720 video at 30 and 60 fps. It has a built in mic and a stereo mic jack input for capturing high quality audio with a self powered mic. This camera also has full manual control of aperture, shutter and iso. Usable ISO of 1600. Video format is AVCHD. (\$1200 with lens)

Drawbacks of DSLRs

DSLRs offer very high quality video with interchangeable lens at a very affordable price, but they do have many drawbacks. One thing is the form factor is not designed for video recording since it is a still image camera first. Most have an LCD on the back of the camera that does not move, but a few do have articulating LCDs for easier monitoring. Another drawback is the rolling shutter which leads to the “wobble” or “jello” effect if you do not control camera movement.

Because of the rolling shutter, it is important to use these cameras on a tripod, crane, dolly, Steadicam, or other supporting device. See Chapter 4 on Camera Support.

Digital HD Compression Format Comparison

There are many HD compression formats or codecs available today. Every camera manufacturer has their own proprietary HD compression format that is used with their brand cameras. Some of the codecs are 1080 lines of resolution while others have 720 lines, but they are all different in various ways and some are better than others.

HD Codec		Tech nology	Bitrate In Mbps	Color	Audio
DVCPRO HD	Intraframe	DV	50-100	422	4ch. PCM
AVC-INTRA	Intraframe	h.264	50-100	422	4ch. PCM
AVCCAM	Motion compensation	h.264	24	420	2ch. AC3
JVC 35mbit mpeg2 encoder	Motion compensation	Mpeg2	35	420	2ch. PCM
HDV	Motion compensation	Mpeg2	25 max	420	2ch. Mpeg1 or PCM in 720p
XDCAM EX	Motion compensation	Mpeg2	35 max VBR	420	2 ch. PCM
Canon XF	Motion compensation	Mpeg2	50 max CBR	422	2ch. PCM
AVCHD	Motion compensation	h.264	24 max	420	2ch PCM or AC3
H.264	Motion compensation	h.264	varies	420	2ch. PCM
NXCam	Motion compensation	Mpeg4	24 max	420	2ch. PCM
AVCHD lite	Motion compensation	h.264	17 max	420	2ch. 48k AC3
Motion Jpeg				420	2ch.

Camera Comparison

The following table summarizes the differences between the most popular of the cameras I have described:

Video Camera	Sensor Size	Lines TV	4:2:2 color	Min. LUX	Elec. 16:9	True 16:9	Shoot 24P	~ Cost
XL-1S	.33	400			•			-
VX-2000/2100	.33	400			•			-
PD-150/170	.33	400			•			-
HF S20/21	.38	1000		.3		•	•	1000
HMC40	.25	1000		1		•	•	2000
DVX100B	.33	500		3	•		•	2600
GY-HM100U	.25	1000		3		•	•	2800
XL-2	.33	500		5.5		•	•	3300
HVR-V1U	.25	1000		4		•	•	3300
XHA1S	.33	1000		-		•	•	3400
HMC150	.33	1000		3		•	•	3400
HDR-FX1	.33	1000		-		•		3700
HVX200a	.33	1000	•	3		•	•	3700
HXR-NX5U	.33	1000		1.5		•	•	4000
HPX170	.33	1000	•	3		•	•	4000
GY-HD250U	.33	1000		-		•	•	6000
GY-HM700	.33	1000		-		•	•	6700
HPX300/370	.33	1000	•	.8		•	•	7300
PMW-EX1R	.50	1000	•	.14		•	•	7500
XF300/XF305	.33	1000	•	.8		•	•	7500
RED 1	35mm	2300	•	-		•	•	20,000+
Varicam	.67	1000	•	-		•	•	60,000

(continued)

DSLR video	Sensor Size	Lines TV			Elec. 16:9	True 16:9	Shoot 24P	Cost +/-
T1I	35mm	1000				•		600
D5000	35mm	1000				•	•	630
T2I	35mm	1000				•	•	800
D90	35mm	1000				•	•	900
GH1 w/ Lens	35mm	1000				•	•	1200
7D	35mm	1000				•	•	1700
5D Mark II	Full 35	1000				•	•	2500
D3s	Full 35	1000				•	•	5200

Choosing the Right Camera

With the multitude of video formats and wide choice of cameras, it can be tough deciding which camera to buy and how much to invest. Often the budget you have to work with determines the choice of camera rather than the particular features a camera has. Nevertheless, here are the most important things to consider:

1. Lines of resolution

Every camera should have a spec for lines of resolution. This is the most important characteristic. Don't be confused by the resolution of the lens, which is often higher than the overall resolution of the camera, or the number of pixels in the sensor. Lines of resolution is a universal characteristic which should be independent of what technological tricks are being used. More lines are better, up to the limit of the DV format, which cannot reproduce more than 500 lines. If you want more than 500 lines you have to go with DVCPRO50, DigiBeta, HDV, DVCPROHD, DSLR or HDCAM. DigiBeta cameras have about 700 lines of resolution. HDV about

900 lines. HDCAM and DVCPRO-HD have about 1000 lines or more.

2. Sensitivity

Low-light sensitivity is important if you are going to be doing night shooting. Camera sensitivity can be specified in lux, a unit of illumination. A typical color television camera's sensitivity is about 20 lux at maximum (widest) aperture. Some low-light and security cameras can sense down to 0.5 lux. Be aware of the fact that camera data sheets often specify the sensitivity in their low-light mode, which is often at maximum gain (i.e. very noisy) and/or at very low shutter speeds which are unusable for transfer to film. Generally the larger the CCD sensor the more sensitive the camera is at low-light. The size of the CCD, usually specified in a fraction of an inch, is perhaps a more reliable way to judge the sensitivity.

3. Focusing

Manual focus is very important, and it's good to have distance markings on the lens so you can focus by measuring tape instead of focusing by eye. Unfortunately many DV cameras are limited in their manual focus capability. The DVX100 for example, does not have distance markings and is very hard to focus manually. With a camera like the DVX100, you need to have a large, studio quality monitor on the set for focusing by eye, especially if you are shooting close-ups at wide apertures like f/4 or wider.

With some cameras you can get a remote focusing knob that has a place to mark focus. The "focus puller" (a camera assistant that operates the focus) can use these marks to match the focus settings to pre-determined positions on the floor of the set. This is a way to get around the lack of focus marks on the lens itself.

4. Manual shutter control

Manual shutter control is a must-have, and you must be able to set the camera shutter to 1/60th of a second for NTSC or 1/50th second for PAL. Often the camera uses these shutter speeds when the shutter selection is “Off.”

5. True 16:9 capability.

Check to see if the camera can be used in 16:9 mode without image degradation. This can only be done if the camera uses a rectangular-shaped, 16:9 CCD. DV Camera models that are native 16:9 are usually designated W or WS in the model name. The alternative to native 16:9 is to use an anamorphic adapter. These adapters squeeze the image optically by a factor of 25%, and can be bought from two different companies (see Appendix E , Resources). They are limited in the diameter of the lens for which they can be used and the range of focal lengths they can accommodate without vignetting the image. So be sure to try it first. The adapters are \$700-900. For transfer to 35mm, you either need a true 16:9 camera or a camera that will accept the 16:9 adapters.

6. True 24P Capability

This feature has recently become available from Panasonic, Canon, and other camera makers. It makes the editing and transfer to film process much easier, and can yield better resolution compared with non-24P cameras in the same price range. Also the 60i HDV format, when converted to 24P, outperforms MiniDV 24P cameras for resolution. Ultimately, any of the HD 24p cameras out perform 24p SD cameras.

7. Three-chip CCD or CMOS

Three chip CCD or CMOS, with one sensor per color, are required to avoid the rainbow artifacts that occur with one-chip CCD's, and usually give better resolution overall. Single chip CMOS cameras perform very well but can have issues with rolling shutter artifacts or the “jello” effect.

With these things in mind, you should be able to make an intelligent guess as to which camera will best suit your needs. In general you should get the best camera you can afford.

Chapter Three: Lighting for Digital Cinematography

As it was mentioned in Chapter One, the CCD or CMOS sensors of most digital cameras have a more limited range than film. With a film camera and a high-speed film stock like Kodak's Vision 500T, you can pretty much shoot anything that's visible to the human eye and end up with something that looks good in the movie theater, provided the aperture of the lens is set correctly by using a light meter. But if you tried that with a digital camera, very dark areas would show up as pure black and very bright areas as pure white. So it's important to control, if possible, the dark and bright areas on screen.

Film-Style Lighting

The reason why multi-million-dollar film productions look so good is because a lot of time and care are taken in their production, and one of the most time-consuming aspects of shooting such a film is either lighting the sets and locations or waiting for the natural light to achieve a certain state. For example, it's not uncommon for a cinematographer to wait all day for a 10-minute period (just before sunset, usually) when the sun is at just the right angle and color. It's also common for a cinematographer to spend many hours lighting a set. When the production goal is to shoot no more than one page of script a day, this leaves time for the camera crew to prepare elaborate lighting setups.

In a very low-budget film there is not enough time to do much lighting. However there are some basic tricks you can use to greatly improve the appearance of locations and sets, which are neither time-consuming nor expensive. Mostly they are methods to reduce the amount of contrast which naturally occurs in most interior and exterior spaces.

Automatic Exposure Control

All digital cameras have the option of automatic exposure control. For guerilla-style filmmaking where there is no control over lighting, the automatic exposure method is best. However you should be aware that there are two possible methods for automatic exposure, and your camera operator's manual will tell you how to set these modes. The modes are Shutter-priority and Aperture-priority. NEVER use the Aperture-priority mode. This mode will cause the camera to use very short shutter speeds in high-brightness conditions. Short shutter speeds will destroy the smoothness of motion and smoothness of lines of an eventual video-to-film transfer; the shutter should always be set to 1/60th of a second (or 1/50th for PAL cameras). Therefore if you're using automatic exposure, be sure to use the Shutter-priority mode with 1/60th or 1/50th of a second*.

In high-brightness conditions the camera may not be able to close the aperture down far enough. Many cameras have an ND filter switch (neutral density filter) which drops in a dark filter in front of the sensor. This will help cut down the light intensity to the camera in bright exterior locations.

Your camera may also have a -6dB or -12dB setting on gain. This can also be used to reduce the brightness of the image.

Manual Exposure Control

When shooting on a set or a controlled location, it's best to use manual exposure control. All digital cameras have their own built-in exposure meters and it's possible to light a scene using the camera itself. If you're lighting a set, use a large television monitor pointed back towards you as you adjust the lighting (you'll need a large monitor anyway to check focus). The camera can be set on

automatic aperture (automatic exposure control) while you set the key light (the highest or most intense light which usually strikes the actor's face from the front or side). Then switch to manual exposure control and set the aperture (or f/stop) to get the best-looking picture for shooting.

Using a Light Meter

If you have time to use a light meter you can get finer control over the lighting on a set. Light meters are available for about \$200-\$300 from a photographic equipment store. The light meter must be set to an ASA rating which ordinarily is the speed of the film you are using. For a video camera you must set it to the effective ASA of the camera. This is done by pointing the camera at the set, allowing the camera to set the lens aperture automatically. Then point the light meter at the camera while standing in the set. Press the button to take a reading. The meter will indicate an f-stop. Change the ASA setting up or down until the meter reads the same f-stop as the camera. From this point on, as long as you don't change the shutter, gain setting or the ND filter setting on the camera, the light meter is calibrated to the camera. You can then use the light meter to predict what f-stop setting the camera will use for different lighting conditions. You can also measure the difference in light intensity between the key light and the other lights, an important relationship which is called the "lighting ratio."

Lighting Ratio

A 4 to 1 lighting ratio means that the key light is 4 times higher than the highest of the other light sources. So for example, if your key light reads 100 foot-candles with the other lights turned off (or shaded off the light meter with your hand), and the other lights read 25 foot-candles with the key light turned off, then the difference is 4:1. Shooting film allows you to get higher lighting

ratios like 8:1 or more, but a 4:1 ratio is about all a typical CCD sensor can handle and still read accurate color. A 4 to 1 ratio implies a fairly intense amount of fill light. This amount of fill light will not bounce off the set itself, it must come from either a second light pointed at the set, or a white card or screen held just off-camera.

Another way to achieve this lighting ratio is to use an extremely soft key light. Get a large piece of silk material, such as a car cover or a parachute, and stretch it over a large wooden or metal frame. The silk hangs over the set or stands upright just off camera. Then your key light is positioned behind the silk or pointed towards it. The silk creates a large, diffuse source of light that spreads evenly throughout the set. With the use of a silk, fill light is often not required.

A third way to achieve even fill light is to position a light right on top of the camera. Often you will see cinematographers working with a diffuse light source that is mounted on top of the lens. This is useful for close-ups where you want to fill in shadow areas and reduce contrast in the actor's face.

Many people don't like the look of a 4:1 lighting ratio. It looks like soap opera lighting. However, the contrast can be raised when the video tape is transferred to film, to achieve a film look. If you want to see how that looks the best way is to shoot a minute or two of video and get a test transfer made to film.

Shooting daytime interiors

Daytime interiors present a special problem on video. If there is a window in the shot, the inside of the room will look normal but everything through the window will look washed-out if not pure white. The ideal solution to this problem is to leave the off-camera windows open but close the on-camera window with curtains or

dim them with neutral-density filters. ND filters can be purchased from theatrical lighting supply stores in roll form that is about five feet wide. The ideal type is ND6, which cuts down the intensity two stops. If the room is being lit with tungsten lighting (i.e., ordinary movie lights) instead of natural light, you may want CTO+ND6 which also corrects the color balance of daylight to the more yellowish color of tungsten light. (CTO stands for Color Temperature Orange, because the filter changes the color "temperature" or shade, and has an orange color). Unfortunately if you're going to be shooting from every angle within the interior, you'll have to move the gel material from one window to another as you change camera angles. This is because you don't want to gel the windows behind you that are providing light into the room. The Zebra Stripe feature of some DV cameras is helpful when deciding how much to reduce the light through the window. You may not be able to eliminate the stripes completely, but if there is some detail visible through the window, that will look better than a window that is pure stripes (in other words, clipping into pure white).

Shooting Daytime Exteriors

The best way to control contrast on daytime exteriors is with a bounce card. This is just a white or light-pink card at least four feet across which is held up by an assistant during the shooting of a close-up. It serves to lighten up shadow areas and will cause the camera to close down the aperture if you're using automatic exposure. The further distance you are from the actor the larger the card will have to be.

In some cases it may be possible to hang a silk above the actor and let the sunlight diffuse through the silk material. This will reduce contrast and prevent white clipping on sunny days.

Night Shooting

Night shooting is easiest for the digital camera. Most prosumer digital cameras are extremely sensitive to light and will work well in low-light conditions. There are a few things to watch out for, though. Don't be tempted to use the +6dB or +12dB gain settings on your camera unless it's an emergency. These higher gain settings will make the image grainy. (Of course there are some people that like graininess Just make sure you are consistent). Also avoid slow shutter speed settings like 1/15th second or 1/30th second. These slow shutter speeds will prevent a smooth transfer from video to film. The only exception to this is when you shoot with a 24P camera, in which case 1/24 sec shutter speed is acceptable.

If things are just too dark the best thing to do is to somehow get more light on the subject. Of course you may not have a huge budget for lighting, and many big-budget films do spend an extraordinary amount of money lighting up an entire city street with huge lights and generators. However there are some things you can do with a budget of a few hundred dollars and a small amount of construction.

Moonlight

Often there's a need to create some light on a night exterior. Simulated moonlight is one way to bring out areas of the screen that would otherwise look pitch-black. My favorite way to do this is with multi-mirror projector bulbs. These are 100 to 300 Watt bulbs made by General Electric (GE), for example GE type EYK, with built-in dichroic reflectors that are sold through lighting stores or through mail-order supply houses. They cost from five to twenty dollars each. The cheapest I have seen EYK is about six dollars, you have to search around a lot to find them that cheap. These bulbs are designed for slide projectors and overhead projectors, but

they have the ideal color and intensity for video work. They come in 12V and 120V types. You will also have to buy the plugs for the bulbs since they do not use ordinary screw-type sockets. The sockets can be bought from www.topbulb.com (part number QCX-40). Seven of these 300W bulbs mounted on a metal plate equals more than 2000 Watts, enough power to light up the side of a building. On location of my last film we had a plate with 19 bulbs, more than 6000 Watts, for lighting up half a city block. Be careful with it because the metal plate will get extremely hot. You'll need thick gloves to move the plate around once the lights are on. Also it's best to move the plate with the power off, if possible, since movement damages the filaments when they are hot. By the way don't expect great lifetimes on these bulbs, they are only good for a few hours when used close together and with no cooling fan.

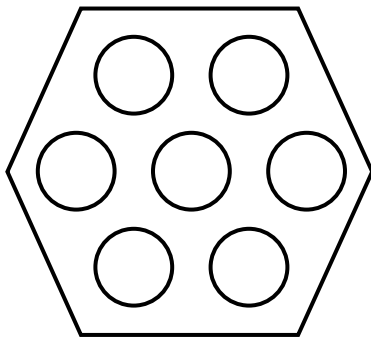
The blue cast of moonlight is most easily created after you shoot the scenes. If you use a light orange gel on every light except for the moonlight, you can then alter the overall color balance of the scene so the smaller lights look normal and the big light looks blue.

You will also need to raise the light up so that it is high off the ground. If you know someone who has a pickup truck or a trailer, a long metal pole can be mounted on a bolt to the side of the truck or trailer. After the light is attached to the end of the pole, the pole can be swung into a vertical position and locked into place. The disadvantage of this method is you cannot adjust the direction of the light once it's in position. You have to swing it down, make the adjustment, and then swing it back up. Even so, it's a lot easier and cheaper than using scaffolding or a crane.

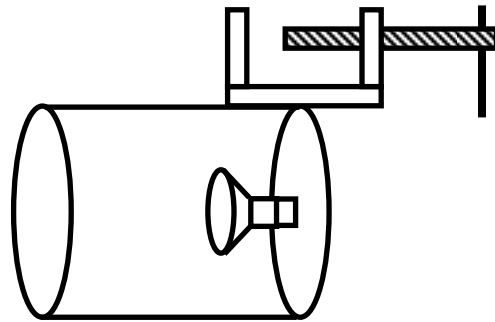
Coffee Lights

The same multi-mirror bulbs can be used for smaller night-time exteriors and interiors. In this case you don't need as much light, so the bulbs can be mounted individually into the inside of an

empty coffee can. The coffee can serves to block stray light from the bulb and also allows you to attach pieces of aluminum foil or colored filters to the light, without touching the hot light bulb. The best way to mount these lights is to attach them with wire to a C-clamp, and the clamp can then be used to fix the light onto doors, car windows, etc. My estimate is that these lights can be built for about \$10-20 each including the bulb. One time I built ten of them at once to light a gigantic set. The initial cost was high but allowed me to keep the set available for shooting for almost a year, without having to rent lights or take the time to set the lights up more than once.



MOON LIGHT



COFFEE LIGHT
WITH C-CLAMP

Filters

Don't use diffusion or misting filters when shooting digital for transfer to film. These filters intentionally soften the image, and although they have been used by video and film makers for decades, when video is transferred to film it is already slightly softer than something shot on 35mm. So there is no need to exacerbate or exaggerate the shortcomings of DV by additional degradation.

Other filters are OK, like gradient filters, polarizing filters and UV filters (which block out invisible ultraviolet rays and darken the appearance of blue sky on film or video). They do not soften the image and are acceptable for use.

My rule of thumb is that if you can read a newspaper through the filter then it's OK to use.

If you want soft light, then you should put softening filters on the light sources themselves, but never put them on the camera.

Depth of Field

One of main characteristics of the "film look" is the degree to which cinematographers control the depth of field. If you have ever done movie camera or still camera work, you know that even if the lens is properly focused, objects in front of or behind the subject can appear out-of-focus. With 35mm still cameras and 35mm movie cameras, this effect can be dramatic, and usually intentional. It forces the viewer's eyes to concentrate on the area of the screen that is sharpest in detail.

Also, in the case of digital video, because strong horizontal lines in the background may interfere with the scanning lines of the camera, creating a Moiré, or swimming effect, it's important to

throw the background out of focus when the camera is moving. Obviously the subject must still be in focus, so the only way to do that is to limit the depth of field.

In video it is harder to obtain this effect due to the physics of lens systems. The smaller the area that the image is focused on the larger your depth of field, and the CCD sensor is very small, only a fraction of an inch compared with almost a full inch for a 35mm camera. The small area of a video camera sensor creates more depth of field than is usually desirable. How do you get around this?

Limiting Depth of Field

The easiest way to limit depth of field is to move the camera back and zoom in on the subject. Also the lens aperture must be set at the widest setting possible. So instead of shooting a close-up, for example, two feet away from the actor, at f/16 with lens all the way wide, you should instead move the camera back to 8 feet, zoom in, and shoot at f/2.8 instead. If the lighting is too bright to shoot at f/2.8, then you must put neutral-density filters on the lens (ND filters), use the ND filter built in to the camera (if it has one), and/or reduce the gain setting from 0dB to -12dB (for example), if possible.

Rack Focus

Another effect commonly seen in movies is the rack focus. In this style of shot the focus setting of the camera is changed to move the focal point of the lens from one object to another. For example, in a close-up of an actor, the focus starts on the actor's face. The actor turns to look at a doorway in the background. The focus ring of the camera is turned until the camera is now focused on the doorway instead. This technique usually requires a manual focus ring on the camera, which is marked in feet or meters. An assistant camera

operator rotates the lens ring until the marking reads the distance to the doorway (which was previously measured with measuring tape). Unfortunately this type of lens, called a "manual" lens, is rarely sold with DV cameras costing less than \$10,000. The exception is the Canon XL-1S. The other way to assume control of focus in this manner is with a remote focus control. The remote control has a large knob, which can be marked in distance units and used just like a manual lens. If you are interested in this effect, check with your camera salesperson to see if this kind of remote focus control is available.

The Pro35/PS+Teknik Adapter/Cinevate/Letus/Red Rock

These adapters are made for video cameras and allow you to use professional camera lenses or 35mm still lenses, where the video camera is pointed at a spinning or vibrating ground glass, and instead of focusing an image directly on the camera sensor, the lens focuses on the image on the ground glass for the video camera to shoot. This is a clever idea that enables the camera person to achieve very narrow depth-of-field effects. The ground glass can introduce some diffusion and softness to the image. However, improvements in recent years have greatly reduced these effects making these adapters a viable option for shooting an independent feature film

DSLR

Using the Canon 5d mark II, for example, to capture video enables you to limit depth of field and pull focus. With a fast f1.2 Canon lens it is possible to narrow depth of field to less than an inch depending on distance to subject. In addition, you can stop down to f4 or f5.6 and get depth of field similar to motion picture cameras.

Chapter Four: Camera Support

Fluid camera movement and steady close-ups can greatly improve the appearance of your film. Although a hand-held camera gives a sense of urgency to a film, shooting everything hand-held will tire a movie-going audience. It might be OK on video but on a huge screen in a darkened room a constantly shaking camera will make people seasick.

There is another, purely technical reason why a steady shot will look better on digital video. When fine horizontal lines appear in sharp focus in a scene, like the railing of a fence or the rooftop of a house in a daylight shot, you will often notice a Moiré, or aliasing effect on those horizontal lines. It will look like a pattern of dots is crawling along the line. This effect only appears if the camera is tilting or moving around randomly. The ways to avoid this distracting effect are either to 1) reduce the depth of field so the background is out of focus, or 2) lock down the camera, or 3) avoid settings with a lot of horizontal lines. The first method, reducing the depth of field, means opening up the aperture of the camera, or moving back away from the actor and zooming in. That's not always possible. The second method involves using camera support.

Tripods

The best tripods are so-called fluid heads which use an oil forced through a valve to dampen the movement of the camera when it's being panned or tilted. These can be expensive. There are also fluid-effect heads, somewhat cheaper, which use heavy grease between opposing plates to dampen the movement. They don't do as good a job but are more in the price range of an independent filmmaker. Bogen is one manufacturer of these tripods. The third type of tripod, the friction-head tripod, has no provision to smooth

out pans or tilts, but can nevertheless hold the camera steady during a locked-off shot.

Car Mounts

Car mounts are indispensable for the ubiquitous road movie. Sometimes it is simply a tripod lashed to the side of the car, with the tripod head tilted all the way over so the camera points straight back at the car. Another kind of car mount is specially built to attach to the door. Yet another kind of mount is one that secures the camera to the hood of a car. Fortunately most video cameras are fairly light and these mounts can be hand-built out of tripod parts. The hood mount, for example, can be made by removing the head off a tripod and bolting it to a large piece of plywood lined with thick rubber on the underside. The plywood is then strapped down with rubber straps or rope.

These car mounts are susceptible to vibration, so it's wise to pick as smooth a road as possible, and perhaps even to put the car on top of a large flatbed trailer and tow the trailer with another vehicle. The advantage of towing is that you don't get the engine noise since the car being towed has its engine turned off. Another trick to shooting in a moving car is to go much slower than the characters in the film would actually be driving. Depending on the camera angle and how close you are zoomed in, you may not be able to tell that the speed is 20 miles an hour rather than 120.

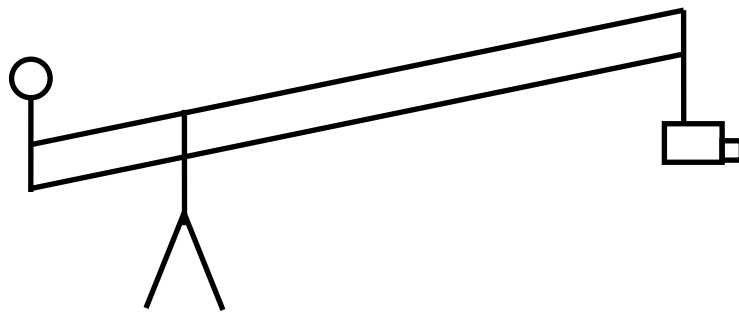
Steadicam and Alternatives

A Steadicam™ is a spring-loaded arm with a balanced gimbal which holds the camera. A Steadicam requires some training to use, and is unfortunately rather expensive to rent or hire. There are some cheaper versions which have the gimbal but not the spring arm, which are made specifically for digital filmmaking. These work well and if you think you'll have a lot of tracking shots,

following characters through doorways and up stairways, for example, you might want to invest in one. There is an even cheaper alternative which works in a pinch: tape the camera to the end of a pole so the camera hangs down from the bottom of the pole but points forward. You move the camera by grasping the pole at the top and walking or running with it.

Camera cranes

Digital cameras are so light that it's possible to build your own camera crane to get the sweeping, dynamic movement of a crane shot without the expensive rental of a real crane. A tripod head can hang down from a pole holding the camera upside-down (which means you'll have to flip the shot over during the editing process) and the pole is attached to a movable parallelogram made of additional wooden or metal poles. The parallelogram is mounted to a fixed pole (through two bolts) which is in turn mounted to a tripod. See diagram. The short end of the makeshift crane is counterweighted with barbells.



Panning and tilting the camera during a crane shot may be accomplished by purchasing an inexpensive security camera head and substituting that for the fixed camera head. These security heads allow you to pan and tilt a small camera by means of a joystick control. They are commonly used in large office buildings by security guards and can be bought for about \$300. Even without

the joystick-controlled head you can still do some amazing shots. A really long crane arm can even substitute for a camera dolly, by sweeping the arm in an arc three or four feet off the ground.

Camera Dollies

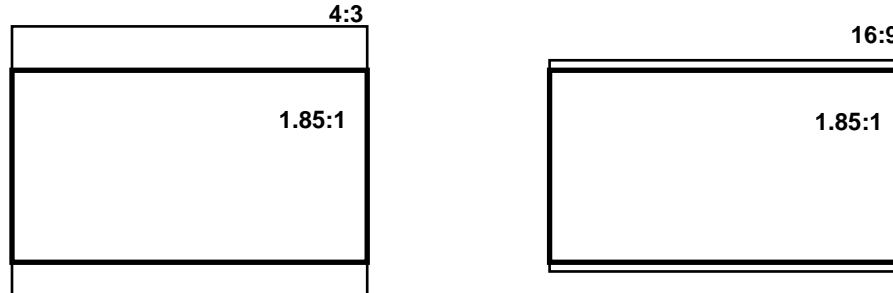
Camera dollies are another expensive rental item which can be bypassed when you use a lightweight digital camera. Good substitutes are wheelchairs (for low-angle indoor work) and bicycles. The bicycle is used by taping a light tripod to the frame of the bicycle, taping down the front wheel so it doesn't steer off, and walking with the bicycle to achieve a tracking shot. If you're tracking over rough ground or over the steps of a building you can lay down some homemade dolly track, which for the bicycle dolly can simply be three two-by-fours nailed into a channel. Another method is to take the tires off the wheels and run it over PVC plastic pipe. For outdoor shots where there is a road nearby, shooting off the bed of a pickup truck can work equally well. Instead of using the truck's engine to move it, however, have some assistants push the truck by hand.

Chapter Five: Framing and Frame Rate Issues

Unfortunately the shape of the television screen is different from that of the movie screen, at least since the invention of wide-screen pictures in the 1950's. Television is just now catching up. There is a fairly close match between the 16:9 (sixteen by nine) aspect ratio, which is used for high-definition TV and some digital cameras, and the 1.85:1 (one-eight-five to one) movie screen, which is one of the two standards existing today for 35mm projection (the other is the so-called "scope" standard which is 2.35:1).

How does 16:9 television work? With all the digital formats from MiniDV through DigiBeta, the image is squeezed horizontally by 33% so that it fits within the standard 4:3 aspect ratio. The image is then un-squeezed by the same amount when viewed on a 16:9 monitor, or when transferred to film.

The advantage of using 16:9 for transfer to 35mm film can be seen in the following diagram.



The left-hand figure shows that a significant portion of the 4:3 image is cropped away when projected on 35mm film. But the right-hand figure shows how closely matched 16:9 is to the 35mm frame. It is just slightly taller.

The consequence of shooting 4:3 and cropping it for 1.85:1 is that a large portion of the image, about a fourth of it, is wasted. This is bad, because the vertical resolution of video is not very good to

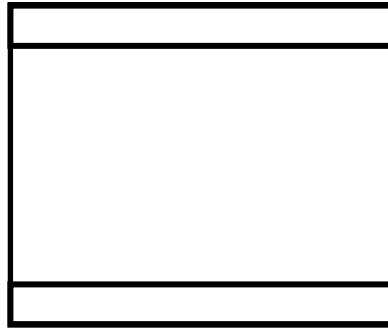
begin with, and with one-fourth of the approximately 480 lines (for NTSC) missing, that leaves only 360 lines left.

On the other hand, if you shoot 16:9 virtually all the 480 lines make it to the screen.

Are there any reasons not to shoot 16:9? 16:9 is not appropriate for transfer to 16mm, because 16mm uses the 4:3 aspect ratio. Also if you think your film will be shown on commercial television, where the 4:3 aspect ratio is still preferred, 16:9 is also not appropriate. For other electronic forms of distribution like home video and the “art” channels (like Bravo/IFC) it is acceptable to use the letter-boxed format, which is 16:9 squeezed down to normal proportions with a black border on the top and bottom. Remember, though, not to apply the letter-boxed format to your 16:9 project until after the transfer to film has already been accomplished. The full-screen format is the best format to submit the tape for transfer to film.

Shooting 4:3 and protecting for 1.85

For those who must shoot 4:3 for whatever reason, there are two options when transferring to 35mm film. One of them is to frame the shots so that when the top and bottom are cut off by the projector, that still leaves all the important things in the shot, like the actors’ eyes and mouth. It will help to compose your shots this way by making a mask for your viewfinder and monitor. The mask is best made out of transparent, colored material such as red gel, and cut in such a way that the height of the unmasked area is equal to the width divided by 1.85. For example if your viewfinder is four inches wide and three inches tall, the unmasked area should be $4/1.85 = 2.16$ inches. The mask would be made out of two strips placed 2.16 inches apart and centered on the screen (see following diagram):



The other option is to compose for 4:3, and then make a vertical letterbox transfer to 35mm film. That means that the 4:3 frame is in the middle of the movie screen, with black borders on the left and right:



Some people are prejudiced against this format in a movie theater, but it is perfectly acceptable and most audience members do not notice the almost-square shape of the image once the movie has started.

How to Shoot 16:9

There are three ways to shoot 16:9 video, in increasing levels of cost:

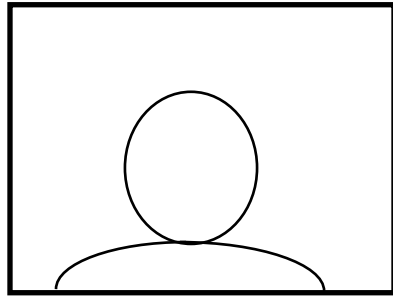
1. “Electronic” 16:9

The cheapest way is the “electronic” 16:9 mode available on cameras like the Canon XL-1S, Sony PD-150 and Panasonic DVX100A. No special equipment is required and in the case of the Sony and DVX100A, the viewfinder shows you what the 16:9 framing will look like on a 16:9 monitor. The problem with this mode is that it is not much better than shooting 4:3 and cropping to 1.85. The camera throws away information at the top and bottom of the CCD (which for these cheaper cameras is shaped like a 4:3 television screen) and stretches out the remainder of the image data so that it fits the 4:3 format. This stretching process often results in an image which is slightly softer when viewed on a 4:3 monitor. However, when viewed on a 16:9 monitor, it looks as sharp as a 4:3 image. The advantages of the electronic 16:9 mode are minor, but possibly important: one, it forces you to frame for the movie screen and two, it results in a slightly lower degree of image compression. The compression chip does not have to work as hard with a 16:9 image, so more of what you have makes it onto tape.

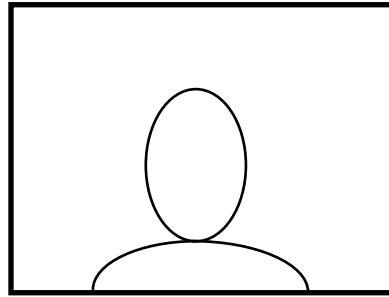
Nevertheless there are better ways to shoot 16:9, and neither cropping 4:3 nor electronic 16:9 are recommended for professional-looking 35mm films.

2. Anamorphic lenses

A much better option is to buy a 16:9 anamorphic adapter. This is a lens that fits in front of your regular lens and applies a sight squeeze to the image. The result uses the entire CCD sensor and does not suffer from the reduced resolution of the “electronic” 16:9. The lenses cost from \$700 to \$900. One disadvantage to this method is that you have to get used to looking at a squeezed image in your viewfinder:



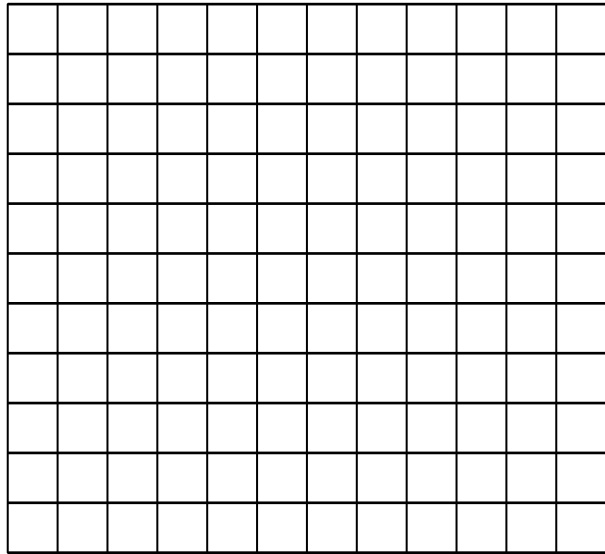
Viewfinder without adapter



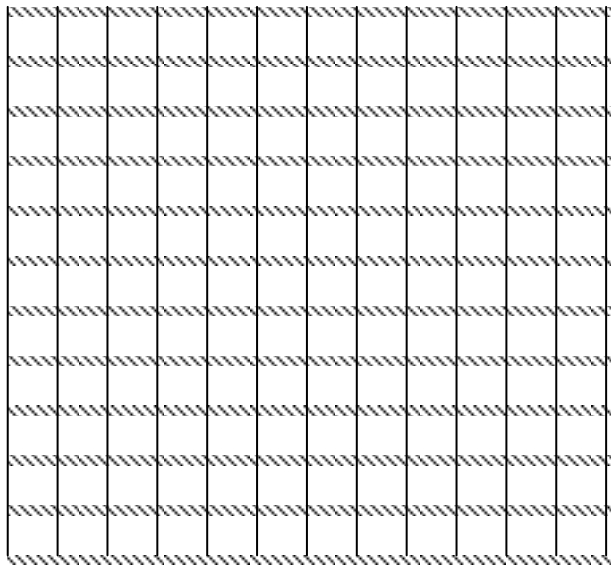
Viewfinder with 16:9 adapter

The squeezed image may look a little strange at first, but you quickly get used to it. The image is stretched back out to normal proportions when you play it back on a 16:9 monitor or when it is transferred to film.

There are reports from many filmmakers that the optical anamorphic adapters soften the image so much (due to the extra amount of glass supposedly) that it negates any advantage to using the lens. This might be true if the object you are shooting is out of the focus range of the 16:9 adapter. The adapter is a fixed-focus device, and you must not exceed a certain distance that is dependent on the f/stop of the lens. A way to find out where the limits are is to make your own chart. For each f-stop starting at f/2.8, you would focus on a piece of paper having both horizontal and vertical lines. Find the closest distance that you can place the piece of paper and still get both vertical and horizontal lines in sharp focus. This distance is the closest distance you can place your subject from the camera, for that f-stop.



Focus chart used with anamorphic lens:
both horizontal and vertical lines in focus



Vertical lines in focus but horizontal lines are
not: camera too close or too far from subject

Low-cost and High-Cost 16:9 Adapters

There are two kinds of adapters now for sale with a wide separation in price. The high-cost adapters (over \$2000) have higher-quality glass and can be used with nearly any camera. The low-cost adapters (under \$900) can only be used with cameras with fairly small front lenses (about 50mm). Cameras like Canon XL-1S have to be used with the higher-cost adapters, because their front elements are so large. Cameras like the PD-150, GL-2, DVX100A, etc. can be used with the smaller, cheaper adapters. In the case of the DVX100A, the adapter lens is made by the camera manufacturer (Panasonic) and can be purchased as an accessory.

3. True 16:9

The third and best way to shoot 16:9 is with a true 16:9 camera. Luckily, just about all modern HD cameras shoot native 16:9. In this case the CCD sensor (and the viewfinder) is actually shaped like the movie screen. The image when viewed on a regular television monitor still looks squeezed, but is stretched out to normal proportions when you play it back on a 16:9 monitor or when it is transferred to film.

Shooting Scope on Video

It is also possible to shoot Cinemascope format, or “Scope”, on video by using a special lens or combination of lenses. The Scope format has a final aspect ratio of 2.35:1. This very wide format is used by many Hollywood films and by many films in Europe and Asia. It was first used in epic pictures like THE ROBE, then popularized in the 1960’s, and continues to be used in the Star Wars films and other big-budget theatrical pictures. To efficiently shoot video for this format, you have to use either a 1.75x anamorphic lens on a regular video camera, or use a 16:9 adapter

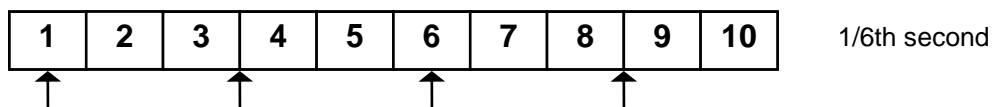
with a native 16:9 camera. Unfortunately there is no manufacturer I know of which currently makes the 1.75x adapters. The adapters that do exist are custom-made or were made in limited production for a specific film (like DANCER IN THE DARK). However using a 16:9 adapter with a 16:9 camera instead is a very good alternative. The Panasonic 16:9 adapter can be used on the Sony HDR-FX1 for example, to achieve a Cinemascope format.

The Scope image when played on a regular television monitor will look highly squeezed. The squeezed image is squeezed even further onto the 35mm Scope print (which has a 2x anamorphic squeeze ratio) and then stretched back out to 2.35:1 by the projector. Nearly every movie theater in the world can project in this format, Scope is even the preferred format in some countries including India. Most movie theater projectors have both Scope and “flat” lenses (for the 1.85:1 format) mounted on a turret to the front of the projector and can switch back and forth in a few seconds.

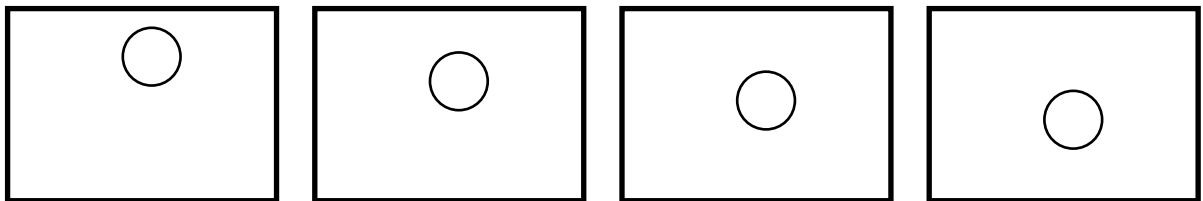
Frame Rate Issues with non-24P NTSC

The frame rate and shutter speed issues with non-24P NTSC cameras are important to understand. Making the wrong decision can ruin your chances of making an acceptably smooth film transfer.

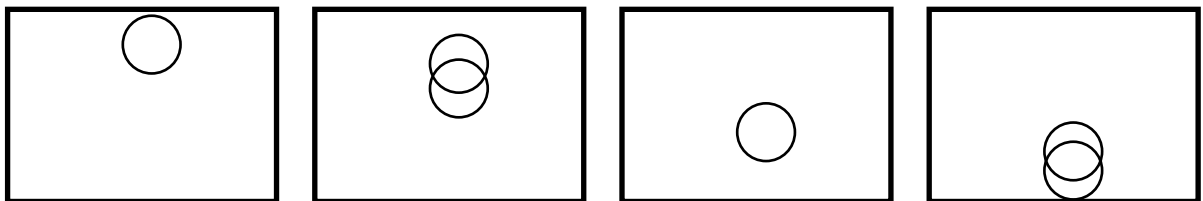
The diagram below shows how a 60 fields-per-second video is converted to 24 frames-per-second film. The diagram shows a group of 10 fields. It takes six of these groups to make up one second of video. So the squares represent each field present during an interval of one sixth of a second:



The arrows represent the ideal sampling time for a frame of 35mm film. There are four arrows, because in one-sixth of a second only four frames of film occur (to make 24 frames per second). The arrows are spaced evenly, and you can see that sometimes the arrow appears in the middle of a field and sometimes exactly between two fields. To keep the conversion smooth, the conversion software must take a whole field when the arrows falls in the center of a field, but it must average two fields together when the arrow falls between fields. Unfortunately, this means that every other film frame is composed of a blend of two fields.

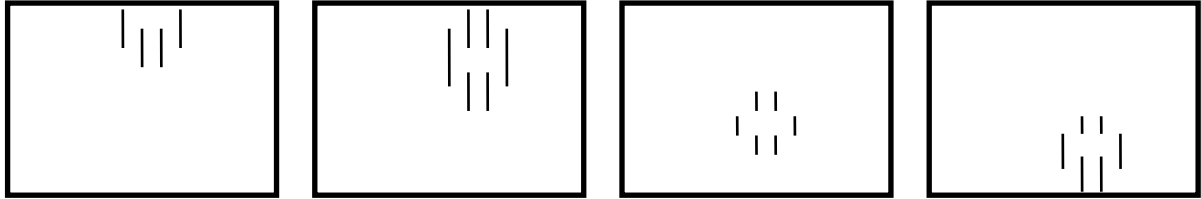


Video frames of a ball dropping, at 60 fields per second.



Film frames converted from the sequence above

Because every other film frame is a blend, there will be a double-image effect unless there is enough motion blur created by the camera. For this reason, the conversion process works best when the shutter speed is set at 1/60th of a second (see following diagram):



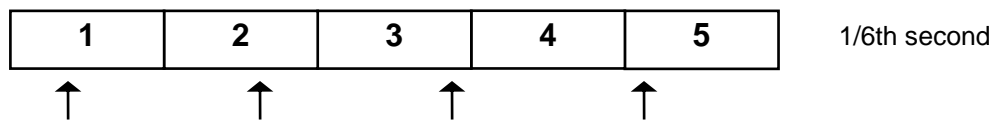
Same sequence with 1/60th sec motion blur

With 1/60th of a second motion blurring, the image doubling effect is not apparent and the rate conversion looks perfectly smooth.

Fast and Slow Shutter Speeds

It is important not to use 1/100th sec shutter speed, or any faster speed than 1/60th. On some cameras this means setting the shutter to the OFF setting, but check with the operator's manual. It also means you cannot let the camera set the shutter speed automatically.

Slow shutter speeds are not necessarily better. You might be tempted to use a setting of 1/30th or 1/15th of a second, which some cameras can do in order to increase light sensitivity or produce a "film-look" effect. However most of these slower shutter speed effects reduce the frame rate to 30 frames per second-- in other words, each pair of fields is identical. These modes have the same problem as progressive scan or "frame movie" mode (as it's called in the Canon line of DV cameras). Here is why:



In this diagram, the video field pairs are identical, and you are reduced to 30 frames per second. So five frames make up 1/6th of a

second. In this same period of time, only four film frames are required to be sampled. But, as you can see, the arrows do not line up evenly. The best re-sampling method would be to take film frame 1 from video frame 1, film frame 2 from video frame 2, film frame 3 from video frames 3 and 4 blended together, and film frame 4 from video frames 4 and 5 blended together. But this method is inexact, which leads to a stuttering effect which breaks up the smoothness of the original video. Also, the frame blending is much more noticeable. For this reason, the conversion of 30 frames per second progressive scan or “frame movie” mode does not yield a good conversion to 24 frames per second, unless of course there is little or no motion present in the shot.

Converting from Interlaced to Progressive Scan

Even though with a non-24P camera it is best to shoot interlaced mode, many filmmakers still need to convert interlaced video to progressive scan before they present their movie with digital projection or on a video monitor. Progressive-scan, even when played back on an interlaced set, gives you the film-like feeling you get from shooting “frame movie” mode at 30 (NTSC) or 25 (PAL) frames per second.

In the past the only way to do this was to use the built-in de-interlacing function in the editing software, such as provided in Premiere or Final Cut Pro, or in video-effects software like After Effects. However these simple de-interlacers reduce the vertical resolution by 50%, because the information in half the fields is dropped in order to make the conversion. A better solution is to use a specialized program like DVFilm Maker to convert interlaced video to 24 frames/sec progressive scan. DVFilm Maker is available at dvfilm.com/maker at a very low cost for Windows and the Macintosh. It uses motion analysis to de-interlace only the portions of the screen in which movement is actually taking place. The other areas of the screen are left untouched, and you get the

full sharpness and resolution of the original image. The conversion should be applied after you have the final cut of your film. You will need to save the unconverted, original interlaced version, for possible transfer to film. There is more information on using DVFilm Maker in Chapter 8, Computer Editing.

PAL Conversion to Film

PAL converted to film is treated differently from NTSC. In PAL conversions, the sequence of 50 fields per second is de-interlaced to 25 frames per second, and then simply slowed down from 25 to 24 frames per second. This means that the length of the film increases by 4% and the speed of movement is also slowed down by 4%.

This degree of slowdown is usually not noticeable, except in the soundtrack. If the soundtrack were slowed by 4%, and otherwise unaltered, you would notice that the pitch of the actor's voices were lower (women's voices sound masculine, etc.) and music would sound off-key. Most video-to-film transfer services can harmonize, or pitch-correct, the sound to compensate for this. The frequency of the soundtrack is shifted back up.

Because PAL digital video is not re-sampled, the issue with avoiding progressive scan or "frame movie" mode is not as important. Unfortunately, on the Sony cameras TRV-950, PD-150, etc. the progressive mode only takes 12.5 frames per second (half the normal rate of 25 fps) so the mode cannot be used for movie work. For the Canon DV cameras, the XL-1S and GL-2, PAL "frame movie" mode samples at 25 frames/sec, and yields a good transfer to film. DVFilm and other companies have recommended this mode of shooting in the past. However the method that these cameras use to create "frame movie" mode does create some problems. For static-framed shots there is a slight loss of resolution because the green sensor is delayed by one scan line in order to

sample both fields simultaneously. Also as a consequence of that there is a slight color-fringing effect on rapidly moving objects. A better solution now is to shoot regular interlaced mode, then use a de-interlacer like DVFilm Maker, to convert to progressive scan as the final step in post-production. Or use a 24P camera.

The standard shutter speed for a PAL camera is 1/50th of a second. In the case of PAL, there is less restriction on different settings of shutter speed, although with very high shutter speeds, faster than 1/50th of a second, there is a strobing effect which can sometimes be distracting (or intentionally disturbing, like the battlefield footage in “Saving Private Ryan”). Settings slower than 1/50th of a second may reduce smoothness or cause excessive blurring of motion.

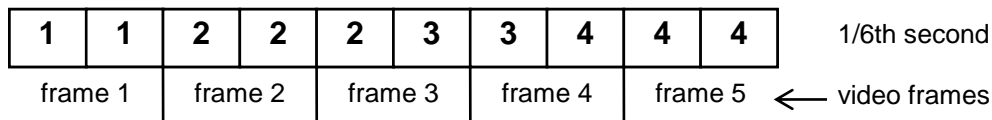
PAL Conversion to NTSC

You can shoot and edit on PAL and then convert to NTSC for broadcast or presentation on a monitor or digital projector. The advantage of showing the movie on an NTSC monitor is that it doesn't flicker noticeably like a PAL monitor. In the past it was necessary to send out the PAL master tape for conversion to NTSC, but now it can be done on your own computer with a conversion program like DVFilm Atlantis, available for Windows or Mac at dvmovie.com/atlantis. In the process of converting the PAL to NTSC, Atlantis first de-interlaces PAL to convert it to progressive-scan, and then distributes each PAL frame over 2 or 3 NTSC fields as required to play back at the correct speed. This is the same method that is used to convert 24 fps film to NTSC, so the result looks remarkably like film converted to video. There is more information on Atlantis in Chapter 8, Computer Editing.

Shooting with 24P Cameras

A 24P camera like the Panasonic DVX100A or Canon XL-2 gets around many of these problems if you shoot in the 24P Advanced mode, and convert the footage to true 24P before editing, using DVFilm Maker or with DVX100-enabled editors like Final Cut Pro 4, Avid DV Express Pro or Vegas 5.

24P cameras sample motion at 24 frames per second, but convert (while shooting) to NTSC using one of 2 methods called 3:2, and 2:3:3:2 pulldown. In 3:2 pulldown, the 4 film frames in 1/6th of a second are converted to 5 video frames per 1/6th second as follows (each "film" frame is shown as a digit from 1 through 4):



3:2 pulldown

The four "film" frames are distributed among 10 fields or 5 video frames. The first "film" frame uses 2 video fields, the second "film" frame uses 3 video fields, the third frame 2 video fields, and the fourth frame 3 video fields, as shown above. This is the same method used to convert 24 fps film (something actually shot on film) to NTSC video. Since the 24P video camera does exactly the same thing, the result looks very much like film converted to video.

Unfortunately there are a few problems with converting NTSC video that has this 3:2 pulldown structure back into 24 fps for transfer to film or to a 24 fps DVD (which is a new standard format for movies on DVD). The problems are:

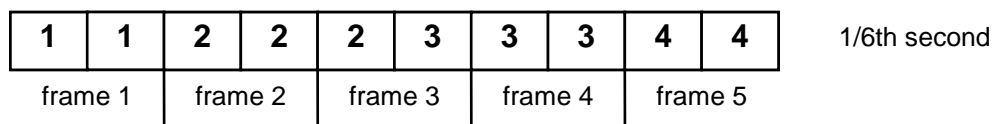
1. Detecting the pattern of the 3:2 pulldown to restore the 24 film frames per second can be difficult, especially if the shot has been

slowed down, sped up, dissolved or superimposed over another shot, or combined with computer graphics or digital effects. Also the pulldown pattern changes every time there is a cut, which can confuse some pulldown removal programs.

2. Removing the pulldown for a 24 fps DVD can be difficult for the same reasons.

3. Removing the pulldown can result in a loss of quality, due to the way DV compression works. Since individual fields are not compressed separately in the DV format, recombining fields in order to remove the 3:2 pulldown leaves exaggerated compression artifacts and results in lower image quality.

Fortunately there is an alternative, and that is the 2:3:3:2 pulldown, used by the 24P Advanced mode in the Panasonic DVX100 and the Canon XL-2:



2:3:3:2 pulldown

In this format, "film" frame 1 is used in 2 fields, "film" frame 2 in 3 fields, "film" frame 3 in 3 fields again, and "film" frame 4 in 2 fields. The original "film" frames can be recovered by simply deleting video frame #3, and no recompression of the frames is required. DVFilm Maker, in its 24P mode, can be used to remove the 2:3:3:2 pulldown, without recompression or loss of quality, and you do that before editing the clips together. Then the clips are edited in a 24P timeline, just as you would edit a movie on a film editing machine.

Once the movie has been edited at 24 fps, it can then be converted back to NTSC if required. Some editing programs like FCP4 can do this on the fly in real time (if your computer is fast enough) or you can use DVFilm Maker to perform this function.

24P Shutter Speed

The shutter speed when shooting with a 24P camera should be set at 1/48 or 1/50th sec (1/50th is the default, or OFF setting on the Panasonic DVX100A), unless you are trying to achieve a disturbing effect by using a faster or slower shutter speed. Fast shutter speeds look like the battlefield sequences in "Saving Private Ryan" or certain fight sequences in Ridley Scott's "Gladiator." Slower shutter speeds can improve light sensitivity, but may add excessive smearing or motion blur and will look like a dream or flashback effect.

In some cases, both PAL and 24P cameras may have to be set at 1/60th sec shutter speed, to avoid strobing effects with florescent lights or arc lights in 60 Hz power countries like the U.S. This works because the electronic shutter is "open" for exactly one power cycle, so even if the camera speed is slightly different from the power line speed, exactly the same amount of light is gathered in any case. This not important under natural light conditions or with tungsten filament lights (ordinary light bulbs), where there is never a flicker problem.

Limits on Pan and Tilt Speeds

Shooting film at 24 frames per second at standard shutter speeds can result in a strobing effect when the camera is rapidly panned or tilted. Cinematographers have always followed a rule about panning and tilting a movie camera to reduce the strobing effect. Video camera operators have never followed this rule because with interlaced video's higher sampling rate the effect is not noticeable.

But when you shoot video for transfer to film, it's good to keep in mind that the sky is not the limit on camera movement. In the American Cinematographer's Manual, the limits on panning rate are expressed in degrees per second and the focal length of the lens. But to put it in a nutshell, if you pan or tilt the camera, an object should have at least a few seconds to pass across the screen for the pan to appear smooth. The same rule applies to video that is being shot for transfer to film, and applies for PAL, NTSC, or 24P video cameras alike.

Slow-Motion Effects

Many films contain at least a few shots where the motion is slowed down from normal. With NTSC there is only one slow-motion rate which can be smoothly converted to 24 frames/sec film, and that is 40% of normal speed. The reason is because at 40% normal, each field of video is converted 1-to-1 to a frame of film ($24/60 = 40\%$). For PAL or 24P only 50% normal speed looks perfectly smooth. Other rates will necessarily require skipping frames, repeating frames, or blending fields together and it may not look very smooth after the conversion to film.

Here is the procedure for slow-motion for standard interlaced video:

1. Slow the shot down to 50% normal speed, with the deinterlace option turned on, so that each field is converted to a full frame of video. If you're editing PAL, this is the last step.
2. Export the 50% normal speed shot to a movie file.
3. Re-import the 50% normal speed shot and slow it down to 80% normal speed, with frame blending turned off. This will force the editing program to simply repeat one out of every 4 frames.

4. When the video is transferred to film, the film transfer company will convert the shot to 24 fps by simply deleting the repeated frames.

If you need additional slowing of the shot, a program like Twixtor (www.revisionfx.com) might be used to "morph" in-between frames to create a very slow-motion effect. This technique has limitations, though, because if objects are passing in front of other objects, or a static background, image distortion will result. Morphing programs also sometimes have trouble detecting the motion properly.

You should consult with the company making your transfer to film before doing extensive slow-motion work. The safest thing to do is provide the transfer company the original shots, at normal speed, in case the slow-motion effects need to be re-done. On the other hand, any slow or fast motion effects performed in a 24P timeline will always look exactly the same on film as they do on your screen, so that is another good reason to shoot or edit 24P.

Summary

In summary, the preferred modes of operation are:

35mm

Use 16:9, with either an HD (16:9) camera, an anamorphic lens, or the built-in "electronic" 16:9 mode as a last and desperate resort.

16mm

Use 4:3 mode

NTSC

Use interlaced (normal) mode at 1/60th sec shutter speed.

24P NTSC

Use Advanced 24P or native 24P at 1/50th sec shutter speed,
1/60 sec for florescent lights or arc lights
If using 24pa or 24p remove appropriate pulldown before editing.

24p HD

Use Advanced 24p or native 24P at 1/50th sec shutter speed.
1/60 sec for florescent lights or arc lights
If using 24pa or 24p remove appropriate pulldown before editing.

PAL

Use interlaced (normal) mode at 1/50th sec shutter speed.

For Film-Like Motion in NTSC/PAL

Use DVFilm Maker or Atlantis in post-production instead of
shooting “frame movie” mode

Computer Animation with 60i or 50i Live Action

There are special considerations to adding computer animation to interlaced video. A common mistake is to overlay 30 frames/sec animation, with no interlaced fields, onto interlaced NTSC video and expect the film transfer company to convert this to 24 frames/sec. It cannot be done, the graphics will not have smooth motion.

The best way to do this is convert all the video shots that require effects work from 60i to 24P, using DVFilm Maker and do the effects work in a 24P project (or from 50i to 25P for a PAL project).

Chapter Six: Shooting Film for Digital

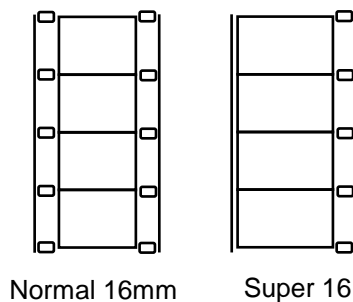
The small-gauge film formats like Super-8, 16mm, and Super-16 are ideal for capturing images for conversion to digital video and eventual enlargement to 35mm film. The problem with projecting these formats is not their resolution or color, but the reproduction of sound. 8mm and 16mm film simply do not move through the projector fast enough to allow high-fidelity audio. But, if the location sound is recorded on a digital format like Digital Audio Tape and the finished project is then projected on 35mm in stereo, the finished film can have an extremely polished feeling to it. If the sound is good then any graininess in the film just adds atmosphere to the project.

Digital is best way to convert Super-8 to 35mm because the optical printers to covert 8mm to 35mm do not really exist. There are many labs which can blow-up 16mm to 35mm, but this process is costly and is difficult to do properly. For example, if extreme care is not taken in the 16mm splices, the picture will take a jump every time there is a cut. Also, the slightest amount of dust on the 16mm negative will show up as huge white blotches on the screen. Laboratories charge up to \$75,000 to do a 16mm to 35mm blowup.

Is there a loss in resolution when doing a digital blow-up to 35mm? Not if the right steps are taken with the initial film to video transfer. The most important thing to do is to use the 16:9 format. Since 16:9 is such a close match to the projected 35mm frame, this format makes the most of the capacity of the video format. The second most important thing is to use a high-quality digital video format, like PAL DVCAM. The beauty of the Super-16 system is that it is also closely matched in aspect ratio to 16:9. Super-16 cameras are made by companies like Aaton and Arriflex and can be rented in Los Angeles by rental companies like AbelCine (www.abelcine.com) and Clairmont (www.clairmont.com).

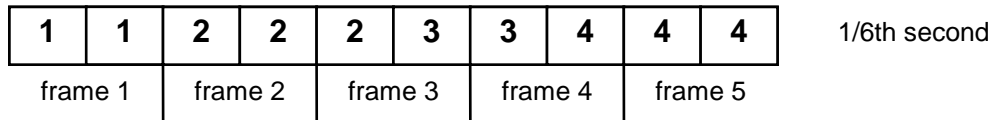
Super-16 vs 16mm

There are two formats for 16mm, Super-16 and normal 16mm. Super-16 is the more modern format and is specifically designed for movies that will be projected on 35mm, and the frame has a roughly 16:9 aspect ratio. It must be shot on single-perforation film (film with only one row of perforations), on a camera that is designed for Super-16, and also the film laboratory must be set up to handle the single-perf film in a way that does not scratch the film in the extended area of the picture. Super-16 film has about 20-30% better sharpness and is less grainy than regular 16mm, once the image is projected on 35mm widescreen (1.85:1) format. Incidentally there are no Super-16 projectors, it is an acquisition format only.



Frame Rate Issues for Film Origination

The video editing process on NTSC-DV is easiest if the film is converted from 24 frames per second to 30 frames per second for editing. Unfortunately, the telecine transfer machine adds one frame of video to every four frames of film in order to convert from 24 to 30 frames per second. This is done with the 3:2 pull-down, as in the following diagram:



The diagram shows the ten fields of video (or 5 frames) which occur in 1/6th of a second. Each field is taken from one of 4 frames of film indicated by the numbers inside the boxes. As you can see, film frames 2 and 4 are printed into three fields instead of two. When you look at video captured into a computer that originated on film, what you see is a pattern of frames that repeats every five frames of video. Two out of five of those frames contain fields which do not match up if there is motion present in the frame. If the video has been edited, this pattern changes on every cut.

Fortunately some digital-to-film transfer service companies, like DVFilm, have the capability to remove those extra fields and restore the original 24 frames per second when they are transferred back to film. This is done by comparing field pairs and looking for a close match, and removing those frames that do not have matched fields.

To take maximum advantage of the video format, the 16mm or Super-16 footage should be transferred in the 16:9 format, where a widescreen image is taken off the film and squeezed horizontally to fit into the 4:3 video frame. When the image is transferred to 35mm, the squeeze is taken out again.

Another option is to shoot Super-16 and transfer to 16:9 PAL. There is no pull-down consideration because film can be transferred to PAL 1:1 (at 25 frames/sec). This speeds up the film of course by 4%, but when it is transferred back to film it's slowed back down by 4%, to 24 frames/sec, restoring the original speed. Your sound should be sped up and slowed down in the same manner.

Chapter Seven: Sound Recording

Getting good sound and preserving its quality is a tremendously difficult and frequently overlooked task for a low-budget film. Digital recording is capable of nearly ideal sound quality, but a few guidelines have to be followed to avoid ruining your sound.

Don't rely on the camera's built-in microphone. These microphones often pick up a lot of hum from the camera, and the position of the microphone (above the lens) is not ideal. You need to have the microphone closer to the actors, and supported on a boom, which is a long pole held up by an assistant. A good but possibly rather crude rule of thumb is that if an actor cannot spit on the microphone, it's not close enough.

Selecting a Microphone

There are two kinds of microphones typically used in film production. One is the shotgun mike, and the other is the lavalier.

The shotgun mike is a highly directional microphone. It is actually two microphone pickups, one positioned directly behind the other in a long tube with slits running down the tube. The signal from the front pickup is subtracted from the signal from the second pickup, which tends to reject sound coming from the sides of the microphone and select sounds coming from the front (but slightly out of phase since there is a separation between the two). One of the best shotgun microphones is the Sennheiser ME66, which must be purchased with a K6 power module. The combination is about \$500. It's well worth the money and you will get a decade of service out of this microphone.

Lavalier microphones are tiny, pea-sized microphones which can be hidden in the actor's clothing. Unfortunately, there are many headaches with using these mikes. The mikes can pick up rustling

in the actor's clothing. Also, you must hide the microphone wires by running them down the actor's leg, or by using a wireless transmitter. Wireless transceivers are available from several companies, including Sennheiser. Their EW112PG3A wireless kit is about \$600. I don't believe a wireless mike is absolutely necessary, though, for quality sound, provided that you plan your dialog shots carefully.

Sound Cables

Shielded sound cables and XLR connectors are a must-have for microphones. Otherwise you may have problems with picking up hum from power cables and power lines, or even from radio signals.

Booms and Wind Covers

If you use a shotgun microphone, you must also use a wind-cover and a boom. A simple wind-cover is just a piece of soft foam that fits over the end of the microphone like a sock. A more sophisticated (and expensive) type is a "Zeppelin" which is a fur-covered wire cage with rubber band mounts for the microphone inside. These devices are great for shooting outdoors in windy conditions. It's possible for you to make one yourself, by bending some "hardware cloth", or wire mesh, into the shape of a tube, capping the ends with more wire mesh, and hanging the microphone inside with rubber bands. The wire mesh must then be covered with synthetic fur. (The fur cover is called a "cat").

The boom can be purchased, but often a simple metal or wooden pole can be used with a microphone holder attached to the end.

Microphone Placement

The shotgun microphone is pointed directly at the actor from either on top of the actor or from underneath, just off-screen. The closer the microphone is to the actor, the better sound quality you will get. This is a good reason to shoot your dialog in close-ups, so you can get the microphone closer. Also, if you can shoot in the 16:9 format, there is more room under the actor's face to hide the microphone beneath the frame line.

What Level to Record

One important thing to remember about digital sound is that if the level is set too high, the sound will clip and severe distortion will result. This distortion is so bad that the recording is virtually useless. So it is very important to set the recording level during rehearsal and leave a comfortable margin of 10dB, which is about 1/3rd less than full-scale on a typical level meter. But, resist the temptation to record at too-low levels where the margin is 30 dB or more (where the level is less than one-fourth full-scale on the level meter). If the levels are too low, quantization noise may become apparent when the dialog is boosted back up to normal levels (which you will have to do during the editing process). Quantization noise sounds like a buzzing which comes and goes with each spoken syllable, and is due to the digitization error in very low-level signals.

Digital Recorder vs. Camera Recording

The microphone can be plugged into the camera and recorded directly onto the digital videotape or memory card. Some cameras have miniature plugs and you have to get an XLR to mini-plug adapter to plug in a regular microphone cable. But all digital cameras have CD-quality recording capability, provided you have the 16-bit recording option turned on.

The one difficulty with recording into the camera is having to monitor the sound levels. The cameraman is often too busy to do that, so someone else must stand nearby, watch the sound level, and adjust the gain controls during the shot. If no one is available to do that, you can use the camera's automatic gain control, or limiter, to reduce the gain automatically when the loudness increases. But the limiter cannot anticipate an actor raising his voice in the middle of a take, whereas a sound mixer can (if he was awake during the rehearsal). Also if the limiter must reduce the gain because the dialog got too loud, there will be a long delay (of a few seconds) before it brings the gain back up again. Unfortunately, you have no control over that delay.

An external mixer can be obtained which allows the sound crew to adjust the levels before they go into the camera. In this scheme, the microphone cables run to the mixer box, which is often battery-powered and attached to the sound mixer's body. Then the amplified sound is sent from the mixer to the camera. The mixer box has its own level meters and headphone output, so the sound levels can be monitored.

If a sound mixer and an assistant camera person are available, you can also record sound on a digital recorder, or a second digital video camera dedicated to sound. With this method, the assistant camera person must slate each take. The slate provides a way to synchronize the sound on the videotape with the sound on the digital recorder or the second camera. Later, during the editing process, you have to match the video frame of the slate being clapped down with the audible crack on the soundtrack. The sound on the digital recorder or second camera is then used to replace the recorded sound from the main camera, before inserting the shot into the movie.

If you do use a digital recorder to record sound, it will also be important to log every shot and sound take. The log should contain the shot number, take, and any comments by the sound mixer which will later help you locate the sound for each shot during the editing process.

Recording Dub Tracks and Ambience

Sometimes because of traffic noise or severe echoing it is simply too hard to record decent sound. In those cases you should still record sound while taping, for what is called a “scratch track.” Then following the shooting of the scene, you should record the same exact dialog for sound only, with the actors standing directly in front of, and a foot or so away from the microphone. Sometimes in film work this is done weeks or months later in a dubbing studio, with the actor watching his or herself on a screen. However, many actors, especially amateurs, are not very good at doing this and lose a lot of their energy trying to get the words to come out exactly the same. Fortunately with digital sound editing, it is much easier to take clean sound recorded from a sound-only take and match up each syllable with the “scratch track” as a reference. It’s still important to try to get the actors to use the same words and cadence, but the exact timing of each phrase and syllable is not required to be the same. As you can imagine, to perform this process for an entire film would be an incredibly laborious task. That is why it’s vitally important to get clean sound, while shooting, for nearly every situation.

Also, be sure to record a minute or two of ambient sound while shooting on location. This ambience will be useful later when you are editing sound, especially when trying to make dubbed dialog sound like it was recorded on location.

Tricks on How to Improve Location Sound

If you are shooting in a crowded room, and you have some control over the crowd, it's best to get the background players to pretend to talk rather than actually talk. This way their mouths move as if they were talking, but the crowd noise in the room is practically absent. Your dialog will record a lot cleaner, and you can always add in crowd noise later in post-production.

Shooting in automobiles is always a challenge to the sound recordist. The engine and the traffic noise conspire to drown out all but the loudest conversation. There are several ways to help. One way is to shoot nighttime car interiors in a warehouse, with a video projection screen behind the window of the car playing footage of the street passing by, and assistants with hand-held lights playing them over the car as if streetlights were passing overhead. It sounds stupid, but it works amazingly well. For daytime car interiors you can't really use this method. The best thing there is to put the car on top of a flatbed trailer, and tow the trailer at about 10 to 20 miles an hour.

Recording Sound Effects

Your soundtrack will be a lot more effective if you record sound effects, on a separate tape, while on location. Things like a door closing, the shuffling of papers, footsteps on a wooden floor, all will sound a lot better in your film if you record them separately and mix them in later, in post-production. While shooting, the microphones are pointed at the actors (where they must be pointed to get noise-free dialog), so the other sounds in the room are suppressed. They must be emphasized with the added effects later. The net result is the same as if you had placed a microphone in every corner of the room, and creates a heightened sense of reality. Of course, it's a lot of work, but most of the effort is in post-production when you have time to polish your film.

Echoes

Often when shooting in a large room, warehouse or studio, you get a bad echo which may be inappropriate for the scene. This often happens when shooting on a small set which has been constructed in a studio. There are some steps you can take to reduce the echo. If possible, the walls which are creating the echo (like the walls of the warehouse or studio, not the walls of the set) must be covered with a sound-absorbing material. An inexpensive material which works well is second-hand shag carpeting. Restaurant-sized egg cartons, which hold 144 eggs each and are made from pulp, can be purchased from a chicken farm supply company, for less than \$0.10 a square foot. These egg cartons can be tacked onto almost any surface and a couple thousand can easily cover up a large wall. It also helps to hang carpet from the ceiling. You can also build a large wooden frame to support a piece of carpet, and position it behind the camera during shooting. If your microphone has an electronic wind filter setting, which cuts out low frequencies, some of the echo may be suppressed with the filter turned on.

In summary, the most important steps to take to get a professional-sounding recording are:

1. Use a high-quality shotgun microphone protected from wind and supported on a pole by a boom operator. Get the microphone close to the actor.
2. Monitor recording levels carefully during rehearsal and shooting. Use an external mixer if possible.
3. Record sound effects and ambience while on location.
4. Record extra takes of the dialog for sound only with the microphone close in.

5. Try to control noise on location and get the cleanest possible dialog track.
6. Reduce echoes with absorbing material.

PART II
POST-PRODUCTION

Chapter Eight: Computer Editing

Selecting an Operating System

Unless you're planning on using a "turn-key" computer editing system such as an Avid Media Composer or a Media-100, you have the decision of which desktop computer and operating system to use with your film-editing software. Although some people will prefer to use either Macintosh or Windows systems because of their past experience, others may have used both and wish to know if there is any advantage to one or the other. I have summarized the advantages and disadvantages of each:

Macintosh systems

The Apple iMac and MacPro(\$2500) towers have built-in firewire capability so you can capture video from a DV camera without any added hardware. However, these computers sometimes require SCSI or Firewire disk drives. Since you will need a lot of disk space, the cost of these added drives is important. Firewire disk drives are substantially more expensive than the equivalent IDE disk drives (used in Intel platform computers and some Macs). Firewire drives cost more than twice as much as internal IDE drives for the same amount of storage space.

The Macintosh operating system is somewhat more user-friendly than Windows. And since Apple controls all specifications for hardware and software for the Mac, this software tends to work better together and have fewer cross-compatibility problems. It sometimes occurs in Windows systems that two software packages cannot be loaded and running at the same time. For example, I have a Windows NT-system where the tape backup software cannot run when the video capture system is running; both create "virtual" disk drives and the way they do it is not mutually

compatible. This sort of hair-pulling situation does not occur in Apple computers.

Wintel Systems

Into this category I discuss all Intel and AMD compatible systems running Microsoft Windows and its variations. My recommendation is to use Windows 7 64 bit if your editing or production software is compatible. If not, then Windows Vista or Window XP will work.

The main advantage of the Wintel platform is cost. You can expect to pay a third more for a Macintosh system than for the equivalent Wintel platform. This goes for the computer, the disk drives, and the software. It's simply because the Wintel platform is sold in much higher volume, and with more competition between manufacturers. For the same reason, there is a wider availability of software from different manufacturers for Windows than for the Mac. Also raw processor speed seems to be higher for the Windows platforms than the Mac.

Building Your Own Computer

I used to recommend that technically-savvy filmmakers build their own Intel platform computer from parts to save a thousand dollars or more. However since the first publication of this book companies like Dell Computer and Gateway have started selling PC's with built-in video editing capability for pretty much rock-bottom price (for example, less than \$800.00). These systems have approximately the same features and performance as Mac G4, but at much lower cost. A typical such system would include:

Intel dual or quad core or compatible CPU

2 GB memory

500 GB hard drive

Firewire port
High-resolution display card
Sound card
Color monitor
Windows 7 or XP

This is everything you need to edit digital video.

Selecting the Editing Software

The most popular editing software packages in use today are Adobe Premiere Pro and Final Cut Pro. Vegas Pro is also popular. Premiere Pro CS5 can run under Windows or Mac. Final Cut Pro 7 is available only on the Mac. Vegas Pro and Pinnacle Studio run on Windows. The latest version and approximate price for each of these packages is:

Vegas Pro 10	\$680	www.sonycreativesoftware.com
Premiere Pro CS5	\$800	www.adobe.com
Final Cut Pro 7	\$1000	www.apple.com
Avid Media Composer	\$2300	www.avid.com

There are also much cheaper, "toy" editing programs, which usually sell for under \$100, or come free with the computer, but these cannot be used to make a real film because they have limited audio editing capabilities. Examples are iMovie, Pinnacle Studio 7, MGI Video Wave, Video Factory, and Ulead Video Studio. Most of these will not edit at 24 frames/sec, but only in PAL or NTSC (sometimes only in NTSC for the US version).

Visual Effects Software

Visual effects software is used to alter images in some way. For example, you can shoot your actors in front of a green background and drop in another background in post-production. To do this you

need to buy Adobe After Effects (www.adobe.com) or a similar package such as Commotion (www.pinnaclesys.com) or Boris FX (www.borisfx.com). After Effects costs about \$1000.

Deinterlacing and Film-Look Programs

Getting a film-look on video tape without actually transferring to film is achieved by specialized programs. These are available as stand-alone applications, like DVFilm Maker (see dvmaker.com/maker) which converts interlaced video to 24 fps progressive-scan and optionally adds film grain and film color. There are also plug-ins to After Effects like CineLook which try to simulate everything from film grain, gate weave, dust, scratches, film motion artifacts and film contrast. Some editing programs like Premiere and Final Cut Pro will also work with these plug-ins and you can use the plug-ins without having to tackle After Effects, a rather complicated and challenging task. Film-look plug-ins run about \$300. Their principle advantage is the gate weave (the slight shaking effect which film has when being projected), animated scratches, dirt and film contrast simulation, although in my experience these effects can be distracting and always come at the expense of overall image clarity and resolution. Gate weave, in particular, is hard to simulate in DV because this effect, in reality, is smaller than a DV pixel. Intelligent deinterlacers like DVFilm Maker, on the other hand, are designed to create the film-motion look but leave the sharpness, resolution, and stability of the original footage intact.

Sound Editing

Video editing programs often do not have all the tools you need to modify, mix, or create, sound effects for your soundtrack. Frequently in the process of editing a film the music and sound effect tracks need to be pre-mixed before final synchronization with the picture. For example if you needed to change the pitch of

an actor's voice, or mix together a music track containing separate drum, guitar, vocal, and synthesizer tracks, you would need software specially designed for sound editing. Some examples of this are Sound Forge Pro (\$375) and ProTools (\$600), which are computer multi-track mixing programs.

You will find that the best way to create a movie soundtrack on a computer is to first edit the video and dialog together, using the DV editing package to create a rough dialog track, then export the dialog track to a sound editing program to do dialog replacement, mix in the sound effects and music. Import the new soundtrack back into Premiere or a similar program to preview it with the picture and create your master tape.

Some full-featured editors have enough to do this all in one application, like Vegas Pro, where video and sound editing can be done together in a single application.

Selecting a Video Capture Card

The first type of video capture card is a Firewire card, which is a special type of serial interface used with DV and HD cameras and recording decks. A Firewire card can both record video into the computer and play it back for recording onto tape. It does audio and video together. Most new PC's come with a built in firewire. A fair price for a Firewire card for the Wintel platform is \$100. Many Wintel computers now come with Firewire built-in. Mac G3, G4, G5, and iMac all have Firewire built-in.

The second type of capture card is an analog capture card which must be used with video cameras and decks that do not have Firewire, like a Digibeta camera for example. For cameras that do not have Firewire you have to use the component analog video signals (Y, R-Y and B-Y signals) or the S-video signal as a last resort.

The third type of capture card is for recording uncompressed video directly from your camera to the computer hard drive. This can be done if your camera has an HD-SDI out or an uncompressed HDMI out. This is not an ideal setup since you need to be tethered to your computer whenever shooting.

Firewire capture cards or firewire ports can also be used with some DVCPRO50 decks, and with HDV cameras and decks.

Hard drives: SCSI vs. IDE arrays

SCSI (Small Computer Systems Interface) used to be the only game in town for high-speed disk drives fast enough for video work. However, nowadays the Ultra-ATA, EIDE, or SATA drives are also fast enough for DV work, and are much less expensive. The cheapest way to build up a large amount of disk space is to buy a SATA RAID (Serial ATA, Redundant Array of Independent Disks) driver card such as the Fasttrak by Promise Technologies (www.promise.com). This inexpensive card (\$120) will allow you to support up to 4 hard drives, and operate the drives in parallel, making the drives appear to be four times faster than they really are. If each drive were 80 Gigabytes, that would allow you to have 320 GB of hard drive space! That is far more than you will ever need to edit a feature film on DV, since the storage requirement for DV is only 0.2 Gigabytes per minute. Many computer motherboards have an IDE or SATA disk array controller built in.

How Much Hard Drive Space Do I Need?

The price for large capacity hard drives have come down making it possible to have several terabytes of hard drive storage space. If not using a RAID a minimum of two drives, one for the operating system and editing software and a second for storage. Storing your video on a drive other than your system drive makes your system

more efficient and increases performance. You can use firewire or USB-2 external drives to back up your footage.

Video Monitors

You'll need a large color monitor to review your footage and look at the finished cut. The monitor can be a professional studio monitor or simply a large, high-quality television set with an S-video input. Most computer video cards have an s-video out that can be connected to a monitor or TV to preview your project.

PAL issues

If you shoot on PAL you're going to need a PAL monitor and a PAL camera all during the editing process. Some professional studio monitors can switch back and forth between PAL and NTSC, and can also play back in 16:9 mode. Such a monitor is a good investment. An example is the JVC TM-1600SU (about \$700).

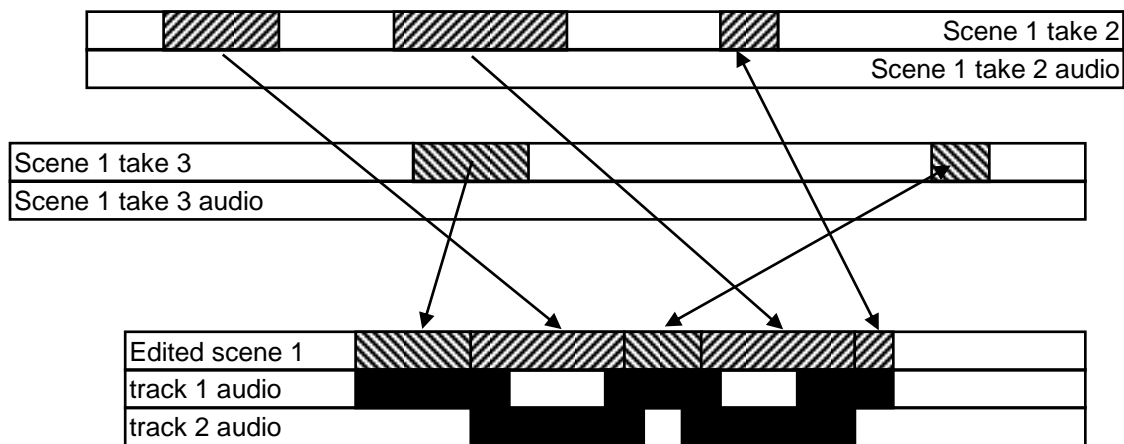
Firewire cards will typically support both PAL and NTSC. Analog video cards will either support one or the other, with a few exceptions.

The Editing Process

Once you've put together the editing system, you should experiment a little bit with capturing footage and recording it back to tape. Once you've made sure that your system can successfully capture video and record it back, you can start doing some serious editing.

Editing is best done on a scene-by-scene basis. A scene is a group of shots that occur together in one location. To edit together a scene, you first need to capture all the shots that you know will be

used in the scene. Capturing can be done with the capturing software that comes with the DV card, or sometimes it can be done directly through the editing program. You then import all the clips into the editing program. For each shot you specify an “in” and “out” point (the beginning and end of each shot) and then paste that clip into the construction window (or timeline) in the approximate place that it occurs. The manual which comes with your editing software will explain in more detail how that is done. The timing and placement of individual shots can be adjusted at that point. A schematic diagram of a the typical assembly of a scene is shown here:



Note that as the clips are brought into the timeline, the audio is brought in as well, into either track 1 or 2. At first, the start and end of the audio clip matches up with the start and end of the video, but after the audio is put into the timeline, the start or end of the audio clip can be extended out to overlap with audio from the adjoining shots.

The editing of dialog scenes is a complicated process and definitely a matter of taste. My personal preference is to cut dialog with a lot of close-ups, and use wide shots and two-shots for action only. The advantage of using close-ups for dialog is that you can get the microphone closer and get a better recording. It’s also a lot

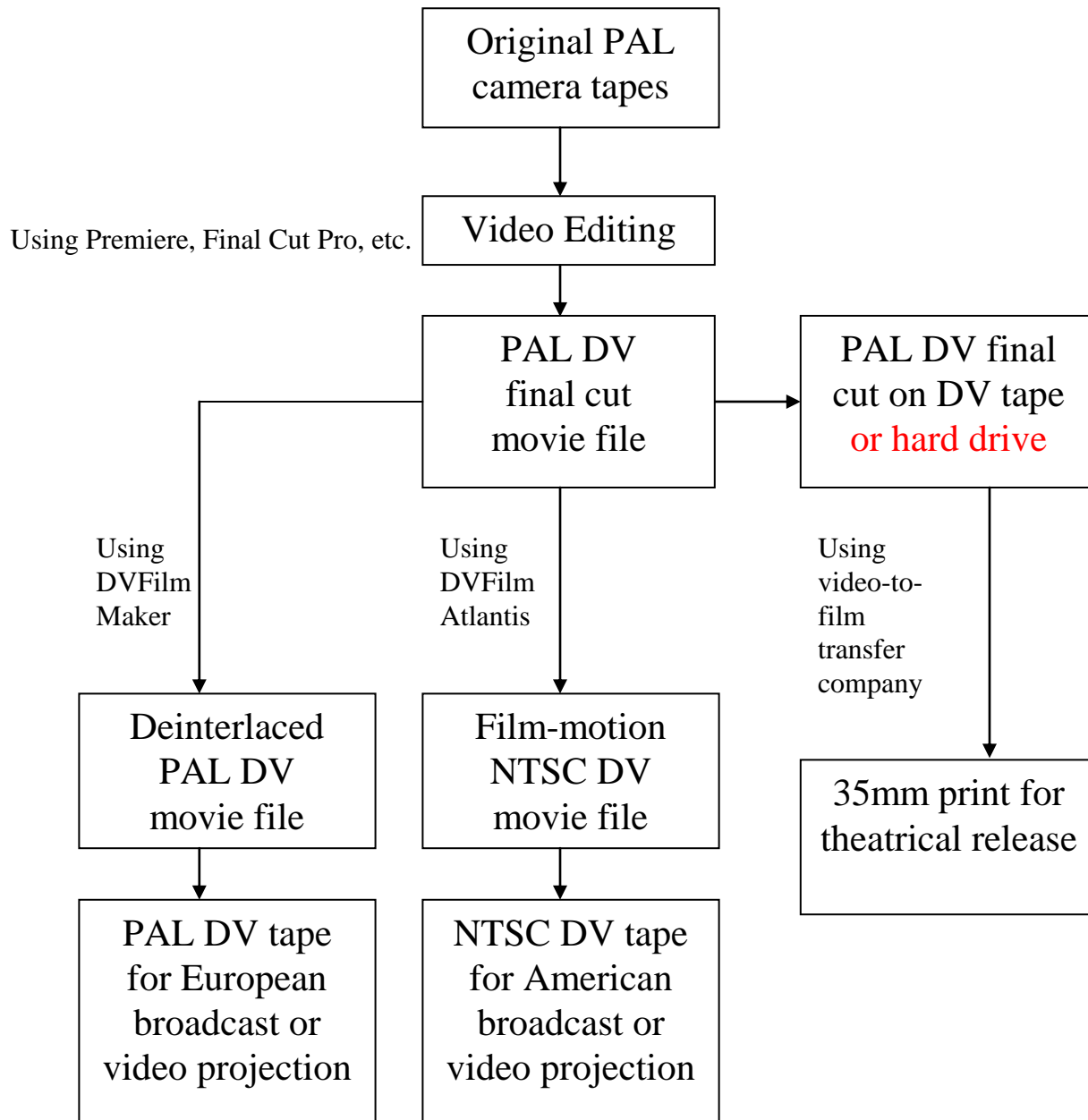
easier to read the actors' expressions when you're closer in, especially with a relatively low-resolution format like digital video. Also, a rule more often followed than not is to draw an imaginary line between two characters having a dialog. Always position the camera on one side of that line or the other, but not both. That means that with two close-ups of two actors talking to each other, for example, one actor looks to screen right and the other to screen left.

On the other hand, action sequences are frequently a random mix of close-ups, medium shots and wide shots. There is often parallel action with inter-cutting between two occurrences. The only general rule of thumb is to keep action flowing from a consistent screen direction, in a particular group of shots. For example, a car chase sequence of five shots might have the cars always going from right to left.

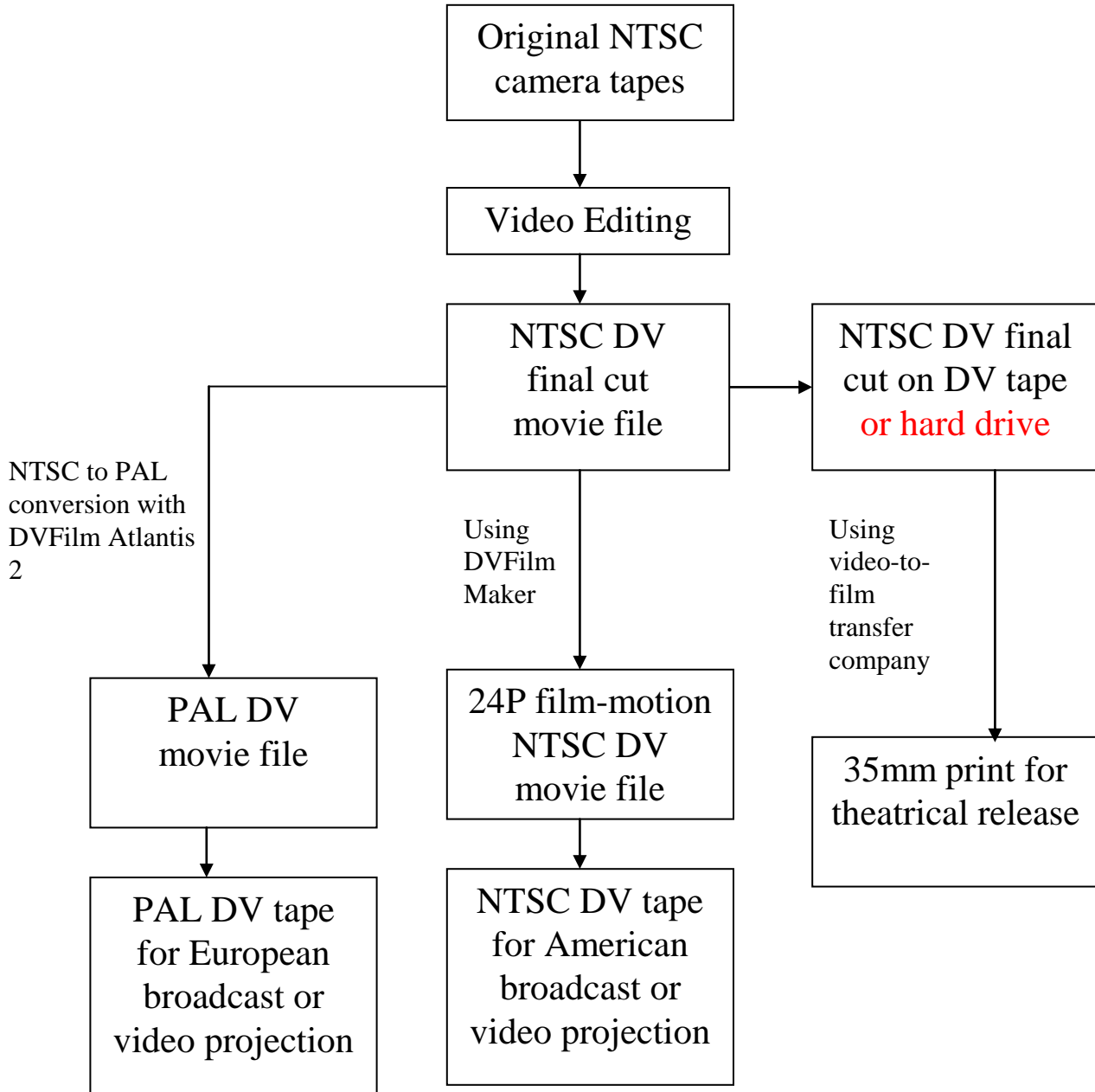
The best way to learn these rules is to watch a couple of your favorite movies and try to pattern any scene you might be shooting or editing on scenes that are found within that movie. Keep a particular watch on where the actor's eyes and faces are pointed and how close-ups are mixed with wider shots. Listen for how dialog is overlapped with the picture and where the sound for a particular scene may begin before we see the scene or it may continue as we see another character's reaction.

Suggested Workflow for a Digital Picture

Since your digital picture will have multiple methods of presentation, I have a suggested workflow for the editing process. The first case is with a movie shot on PAL interlaced (50i):

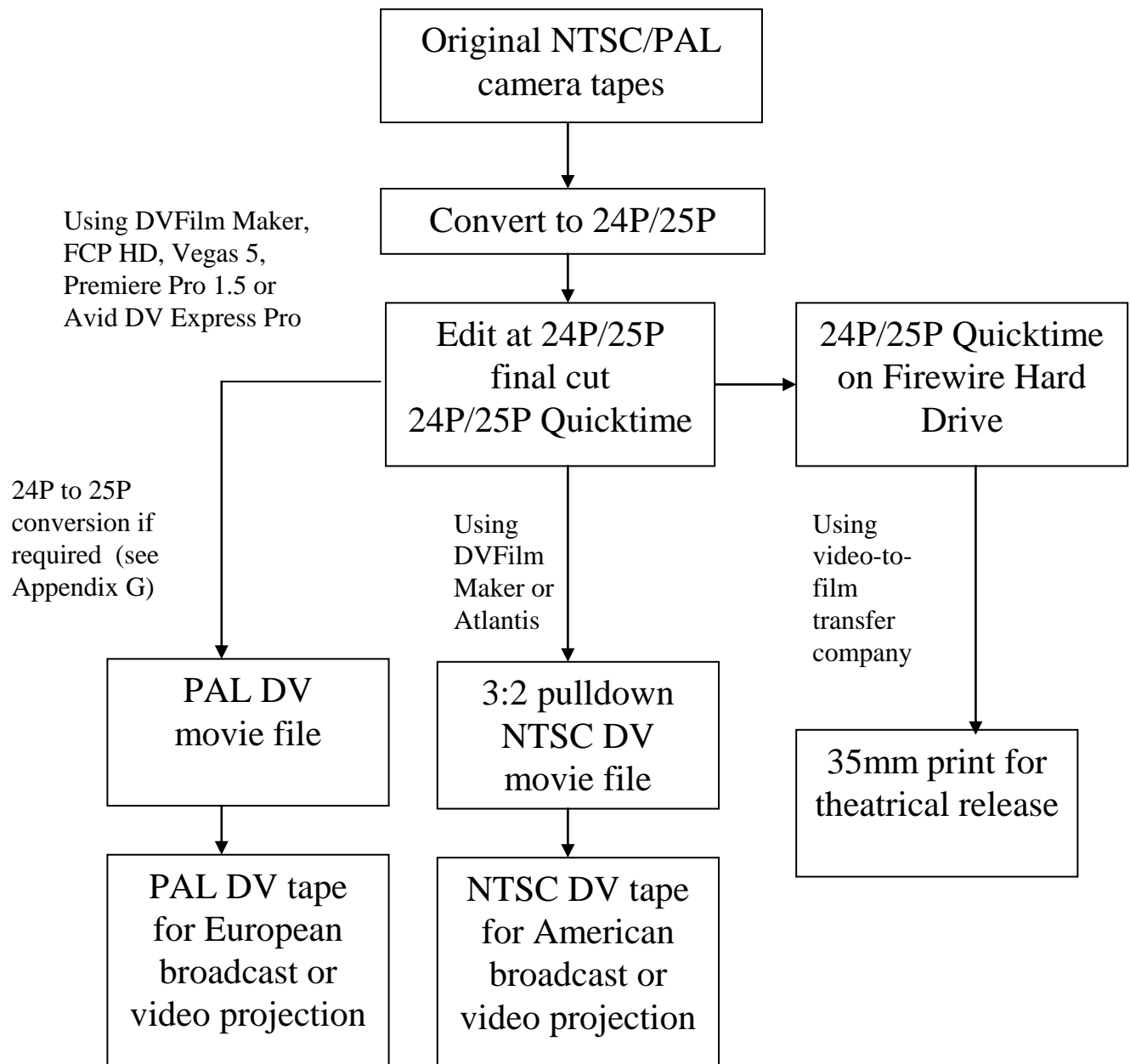


Here is a suggested workflow for NTSC interlaced (60i) camera projects:

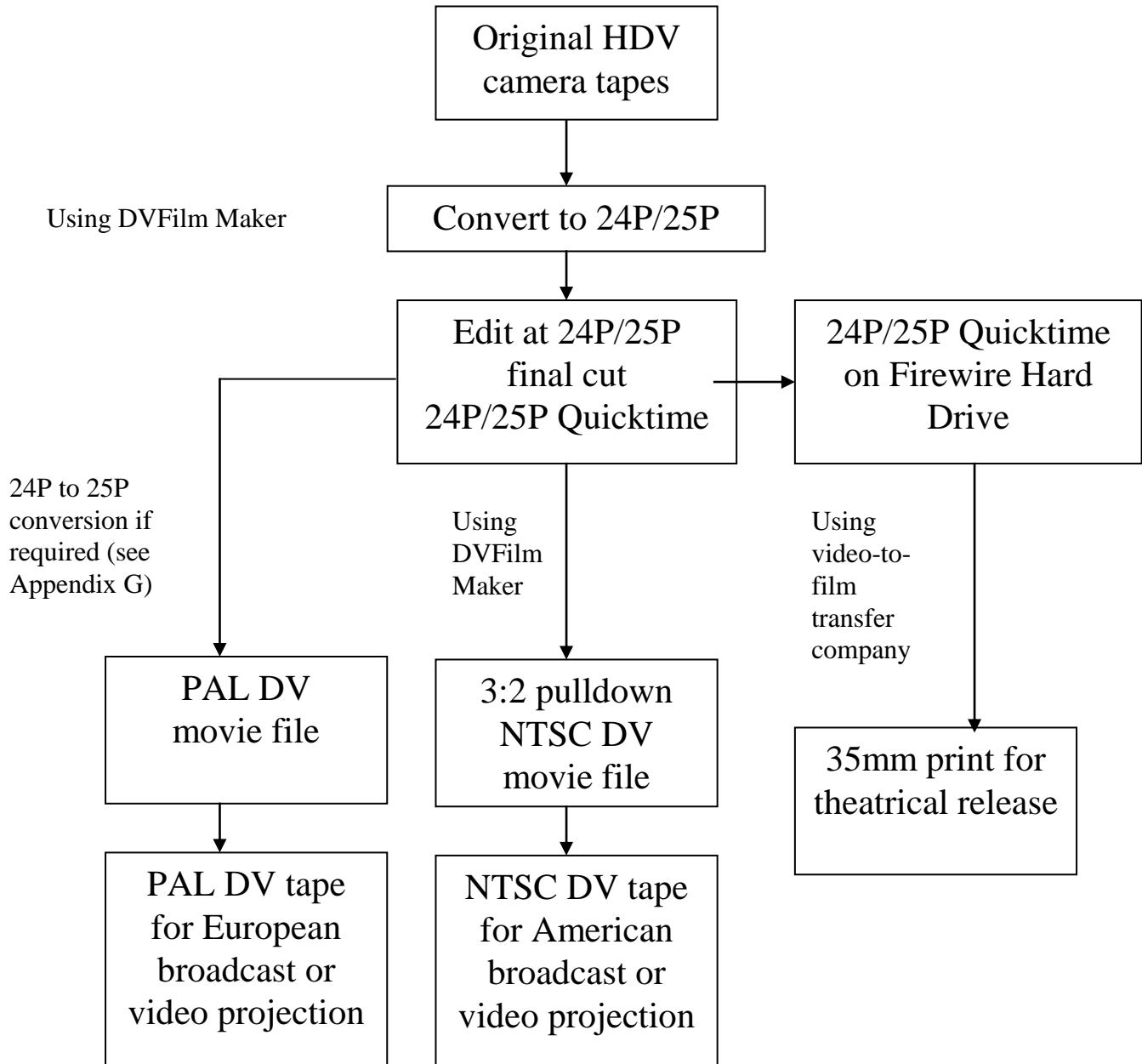


* DVFilm Atlantis 2 will do a film-motion conversion from NTSC to PAL as well as PAL to NTSC.

And here is the workflow for a project shot in 24P or 25P:

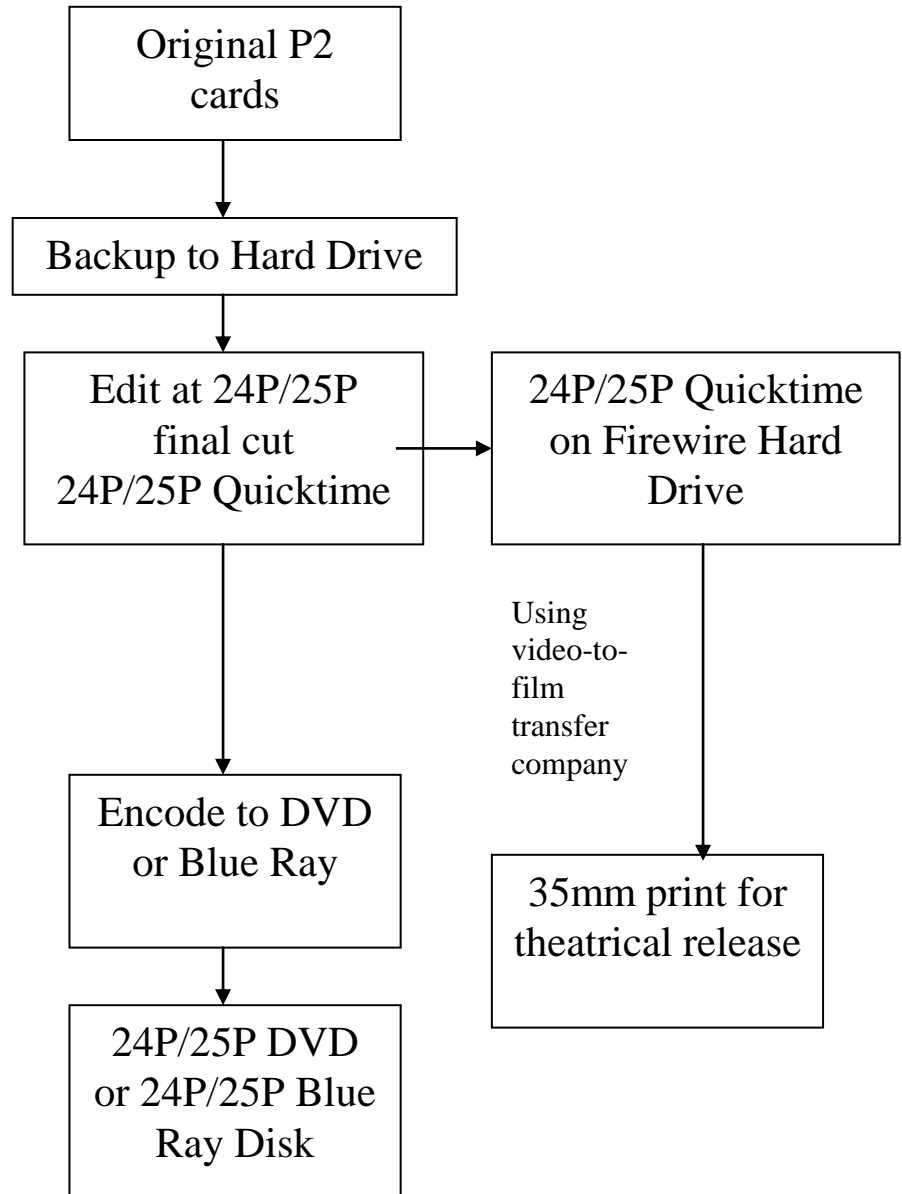


Here is the workflow for a project shot 50i or 60i HDV, where the clips are converted to 24P before editing. Our latest recommendations on this process are at dvfilm.com/fx1



Finally here is a “Tapeless” workflow for a P2-card based HD camera:

Using P2 CMS



Chapter Nine: Mixing and Preparing Sound for Theatrical Presentation

As I mentioned in the previous chapter, the preparation of the soundtrack is best done using the combination of a video editing program and a multi-track sound editing program. The video editing program must be used to build up the original dialog tracks, which may have two, overlapping tracks that are mixed together (to allow for one actor's voice to run over the other's, for example), but are synchronized with the picture (see following diagram):



You must import these tracks into the multi-track sound editing program to replace any scratch tracks with cleaner tracks, with dubbed dialog, and mix in sound effects, ambience, and music. Some of the sound effects may have to be built up within the video editing program to make sure they sync with the picture.

When you import and export audio tracks within two different applications, make sure each application is using the correct sampling rate. DV editing is almost always done at 48KHz sampling rate. Make sure that when you import this audio to a sound editing program, the sampling rate of the sound editing program is also set to 48KHz. Otherwise, the software may try to convert the soundtrack to a different rate, and these conversions always worsen the quality of the sound. Unfortunately, it may do so in a way that is barely detectable until it's too late to fix it, so double check this the first time you try it.

Premixing and mastering

Within the sound editing program you can prepare sound effects and pre-mix them if necessary. This means taking several sounds and combining them together before introducing them into the sound effects track. The same is true for music tracks that you have produced yourself, where you have to pre-mix all the instruments that were recorded separately.

When finally you have music, dialog, and sound effects tracks, you can use the sound editor to create a final mix that has all the tracks combined together. This is also usually the point where any surround effects are created. Surround effects are phase-encoded (with a surround-sound plug-in) creating a stereo track that is mixed into the final stereo mix. The phase encoded sound effect, when played through a Dolby Pro-Logic home theater system, will be directed to the surround speakers.

Do it Yourself Surround Encoding

For my film REDBOY 13 I did my first sound mix with a rented Ultra-Stereo surround encoding system. I had to pay a one-time license fee of \$2000.00 to Ultra Stereo. Then a couple years later when I had to create a new sound mix for the released version of the film, I discovered that it was possible to do my own surround encoding and save a lot of money. The second version of the soundtrack had a lot more surround effects, sounded a lot better, and I did it all on my computer without renting any special equipment.

If you're proficient with the sound editor or with software you can do your own surround encoding. One way to do it is to convert a mono effect into stereo by duplicating the sound into the left and right channels and then invert the right channel (in other words,

make the positive peaks negative and vice-versa). This method works perfectly well, but unfortunately if the sound is played through a monaural system the left and right channels will exactly cancel out and the effect will not be heard on a monaural system. An alternate method which avoids this problem is to create a slight delay between the left and right channel. The amount of delay you choose depends on the frequency range of the sound. High frequency effects (like a bird chirping) require a small delay, about .0002 seconds, and low frequency effects require a large delay (for example, .002 seconds for an automobile engine). Keep in mind that listeners cannot hear the direction of low frequency sounds, so there's no point in directing low frequency effects to the surround channel. The surround encoding can be checked with a Dolby Pro-Logic home stereo system. Once you have the proper delay, the stereo effect with encoding can then be mixed in with your other tracks.

Stereo Issues

Other than surround effects, the stereo mix can be used to direct dialog to the left or right speakers instead of always to the center, where the left and right tracks have equal volume. Your sound editing program will have a way to take a monaural track (such as a line of dialog) and convert it to stereo with a preference for the left or right speaker. If you do use left-to-right effects in dialog or in the sound effects, make sure your headphones and speakers are carefully labeled left and right so you don't get left and right confused. Left and right steering is usually not used for dialog. Even for sound effects, it can sometimes be distracting.

Getting Surround Sound to Work in a Movie Theater

Theater sound systems default to Stereo or Mono when the projector is started up. Only when they detect a fairly large presence in the surround channel does it switch to surround mode.

When I screen SR prints at the movie theater chain here, I always put an Ultra-Stereo or Dolby SR logo-trailer (a trailer provided by Ultra-Stereo or Dolby which has their logo and usually has a huge amount of music directed to the surround channel) at the head of the print, which guarantees the surround mode comes on before the movie starts. Usually you hear it kick in, in the middle of the logo. If you don't use a logo-trailer the surround mode may not turn on until the middle of your movie, or it may never turn on.

If you want to get some of these logo-trailers the movie theater usually has them, or you can get them at this website: www.rsem.com, search for item UST-1SR (Ultra Stereo type SR trailer, \$13).

You can also make your own logo-trailer by presenting your company logo at the start of your film, with about 10 seconds of loud music directed 100% to the surround channel.

The other option is the projectionist can manually switch on the surround, but he has to remember to do it, and you may not be there to poke him with a stick.

Another problem with surround systems is very often the surround speaker system is simply not working. My guess is that in multiplex cinemas, 10% of the screens do not have a working stereo-surround system. Frequently people ask me if SRD, (aka Dolby Digital), or the other digital theater formats like DTS and SDDS solve this problem, but unfortunately the answer is no. If a movie theater cannot play SR properly then it will not play digital formats properly either.

Digital Pops

A common mistake with editing digital sound tracks is to use a simple cut to begin or end a sound clip. If you do this there will be a tiny, almost imperceptible “click”. That’s because even though the clip may be silent at that point, there may still be a small residual amount of audio which will be abruptly cut in or cut out, creating the click. People with good hearing will be annoyed by these clicks and it can ruin an otherwise perfect soundtrack. The only way to get rid of the clicks is to put a small, one-or-two frame fade at the beginning and end of the clip. The fade will smooth out the click. Of course, it’s a lot of trouble to put these fades in, but some sound editing programs will put them in for you automatically.

Equalization

Film projected in a movie theater gets its sound from something called an optical track which runs along the side of the film. This optical track is a pair of wiggling lines, with the wiggles corresponding to the ups and downs of the voltage that drives the theater speakers. Because the optical soundtrack system is somewhat noisy, all modern theaters use either Dolby A, Dolby SR or a compatible noise reduction system.

When your video is transferred to film it will be encoded for Dolby A or Dolby SR compatible noise reduction, which is required for theatrical-quality optical soundtracks. This will give your soundtrack a near CD-quality level of reproduction, in full stereo with an optional surround channel. However the encoding process places certain restrictions on the range of frequencies that you present to the encoder. For example, there are problems encoding soundtracks that have an excessive amount of low frequency signals, especially below 20 Hz. This means that wind noise should always be filtered out of dialog tracks, and also that you

should be careful with synthesized music that has a lot of bass. If your music sounds like it's coming out of a boom box with the bass controls cranked all the way up, for example, it probably cannot be encoded for theatrical presentation. When in doubt, present your soundtrack ahead of time to the company that will be making your video-to-film transfer, and they will tell you if it's acceptable.

Mastering to Hard Drive

The last step in the post-production process is creating the master tape that will be used to make the video to film transfer. The soundtrack music, effects, and dialog tracks are mixed down to a single stereo track, and then your DV capture card is used to record the picture and sound back out to tape. Even though you may have edited the film in many separate scenes, the DV capture card will allow you to "chain" or "batch" a series of scenes so the entire film can be played back continuously without breaks. Most video-to-film transfer companies require that you put breaks at 20-minute intervals, however, because 20 minutes is the size of a 35mm projection reel. Chapter Eleven describes other steps that are required in preparing a master tape for transfer to film.

Also some transfer companies may prefer to get the movie on computer hard drives instead of video tape. DVFilm in particular prefers Quicktime or AVI files on Firewire drive, and the sound in WAV or AIFF files, instead of tape. This is because some tape formats (like MiniDV) suffer from frequent dropouts. Check with the transfer company and see if files on computer disk are preferred. Also check to see if the transfer company will be handling the 25P to 24P time expansion of the audio track, if it was shot PAL or 25P. If so they may require the dialog and music to be sent on separate tracks.

Digital Sound Formats for Movie Theaters

There are three competing systems for digital movie theater soundtracks: Dolby Digital, which is also known as Dolby SRD, DTS (Digital Theater Systems), and SDDS (Sony Dynamic Digital Sound). By the way, "5.1" is not one of them, which is a common misconception. 5.1 is a home theater format used for DVDs. Lucasfilm's THX is also not a digital theater format, it is a theater amplifier and speaker system (and also a DVD system). The three formats SRD, DTS and SDDS compete with each other, and it is possible to create a movie print that has all three formats on it simultaneously, although that would be an expensive proposition for a low budget movie, and probably not necessary. DTS used to be the most common digital system, although SRD has recently surpassed it in number of theaters installed. SDDS is a distant third. All of these digital formats require a license fee to the company that promotes the format, and the final sound mix must be done at that company's facility or at a sound mixing facility that is licensed for that particular system. The license for a feature film can run about \$5000 for Dolby SRD for example. The added costs for the SRD mix can be another \$5000. The optical sound track can be another \$2000 more for each digital system employed.

Is it worth the extra money to create a print with digital sound? In my opinion, for a low-budget movie, the answer is no. The advantages of digital sound for theaters are slightly better signal to noise ratio, extra surround channels, and better dynamic range and fidelity. However Dolby SR, the non-digital format which is license-free and universally recognized, has better than FM-radio quality, a surround channel, and better noise characteristics than you really need for a movie theater with an air conditioning system and an audience. You can create an Academy Award-winning soundtrack with Dolby SR and no one is going to complain, or even know that digital sound was not used. But of course producers have their own, non-technical reasons for choosing a

digital theater format, it's just too cool of course to say your movie is in Dolby Digital.

If you do make a Dolby Digital or SDDS mix, the mixing company creates a digital print master disk, and this disk is then turned over to the company that makes the digital to film transfer. For DTS you will also be making CD's that are played back in the movie theater along with the film print.

PAL Time-Expansion to Film

As stated before PAL projects are projected on film 4% slower, because the rate is changed from 25 to 24 frames/sec. The audio track must be time-expanded by 4% accordingly. Some filmmakers may wish to do the time-expansion themselves rather than leave it in the hands of the video-to-film transfer house. Time expansion slows down your sound track without changing the pitch of the audio, which can make female voices sound too masculine. Here is some information on how to do it.

How does time expansion work? It breaks up your audio into chunks, puts a little fade before the beginning and after the end of each chunk, and then cross-dissolves the chunks back together again. High-quality time expansion can be done with a program like Sound Forge (Windows) or ProTools (Mac). This usually works great, except in the following circumstances: the cross-dissolve distorts an "s" sound; the cross-dissolve changes the phase of a pure note of music, or creates a warble in the note. For this reason, you should always time-expand your tracks separately, check them for quality, and then mix the results together, rather than trying to time-expand your entire mixed track in one step. Sometimes it's better to slow down music rather than time-expand it, and accept the change in pitch. If it's original music most people will not notice the change in pitch or tempo. Voice-over narration and occasional sound effects do not need to be time-expanded,

either, just re-edit the tracks in a 24 frames/sec timeline to increase the amount of silence between each "cut".

Slowing down a Track instead of Time-Expanding It

To slow down a track rather than time-expand it, which may be more appropriate for music and sound effects, use the following method in Sound Forge (www.sonicfoundry.com): Choose Process->Resample and change the sample rate from 48000 to 50000 with re-sampling. Select the anti-aliasing filter. After the resample is done, choose Process->Resample again and change the rate to 48000 **without** re-sampling. The new file should be about 104% the size of the old file, and will be slightly lower in pitch and tempo.

Chapter Ten: Color Correction and Titles

Fixing the Color

It often happens that the colors in some shots do not match the other shots in that same scene. This is called a matching problem and is usually due to: 1) a change in lighting when the scene was being shot, or 2) the shot was made in a different location, or 3) the camera's color balance changed or 4) it was shot with a different camera. One of the most common errors I see in films shot on location is where some shots are made in direct sunlight and others made when the sun was behind a cloud. This is the most extreme case and is virtually impossible to correct.

To avoid severe and potentially uncorrectable matching problems, be sure to periodically white-balance your camera (Chapter 2), make sure you are shooting under consistent weather conditions, and try to make notes of lighting setups in case you need to re-shoot a closeup later on, or in a different location.

If you do have to correct a color matching problem, most editing systems have the capability to do that. It is usually done by displaying two shots on the screen together and tweaking one of them to match the other. What you tweak are the filters, or color controls, and the controls typically used for color correction are brightness, contrast, and levels. Levels gives you separate control over dark levels, medium levels, (also known as gamma control) and bright areas of the screen, and for red, green and blue separately and for all colors combined ("luminance"). Another useful control is saturation, both for all colors and for individual colors. Some color correction tools can even try to match two shots automatically, and you can try that. To fully describe how color correction is done would fill an entire book of this same length, so unfortunately I cannot address it in much detail. However if you do find yourself frustrated and unable to correct the color in your

movie, many film transfer companies like DVFilm do offer a color correction service, where the correction is done by a specialist and (usually) does not add much to the cost of the transfer. DVFilm uses an internally-developed software program called Rembrandt to do color correction, and this may be released as a commercial product in the near future. In the meantime it is available as a service, even if you do not need a transfer to film. Information and rates on the Rembrandt Service can be found at dvmovie.com

Color Effects

Color effects and other effects can be easily applied in your editing program. For example suppose you want to imitate the "bleach bypass" look of a film like *Minority Report*. Programs like Magic Bullet (\$1000), which is a plug-in for After Effects can do this, and there are also plug-ins for Premiere, Final Cut Pro and Vegas. Some editing programs like Vegas and Premiere have film effects filters built-in. It might be advisable to set aside a version of your movie that does not have film effects in them, since they may interfere with getting a good transfer to film. The film transfer house will have advice on which effects can be used and which ones are better done in the film transfer itself. After Effects, programs like it, and some editing programs can be used to do basic effects, like for example to create diffusion for a flashback effect. Diffusion is made by creating a blurred, transparent layer superimposed over the original layer. Also there are "cookbook" ways of getting standard color effects, for example the "Magic Projectile" suite of looks provided in Barry Green's DVX100 book (dvxuser.com).

Titles

The creation of titles is extremely easy with a video editing program, but there are some pitfalls to avoid which might cause trouble later when you transfer to film.

In general, if you are working with NTSC, any titles that are scrolling or otherwise moving are to be avoided. Some video-to-film transfer companies will re-do your scrolling titles at high resolution and 24 frames per second so they look just like real movie titles (DVFilm will do this for no extra charge). But some companies will not, and you might consider using static titles that fade in and out, especially if there's live action in the background.

Animated Hi-Res Titles for Transfer to Film

You can also save some money and prepare your own high-resolution titles using After Effects. In this case After Effects' time base is set to 24 frames per second, and the output resolution to 1280 horizontal by 720 vertical (for 35mm) or 1280 x 960 (for 16mm). Other acceptable sizes for 35mm are 1920 x 1080 or 2048 x 1152. You create the title cards and animate them, making sure that the animation speed is restricted to whole pixel increments (for example, 8 pixels per frame and not 8.5 pixels per frame). It must be animated by whole pixel increments to avoid aliasing effects. Without that, the fine lines in the title font will shimmer in an undesirable way when they scroll up the screen.

To animate in whole pixel increments in After Effects, for example, you choose two keyframes. A keyframe is a designated frame where the animation must have a certain position. The keyframes will set the position for exactly P pixels of total movement and they will be F frames apart, where P/F (P divided by F) is equal to 1, 2, 3... pixels per second, or any whole number. For example if your scroll needs to go about 7000 pixels from top to bottom in about 2500 frames (100 seconds), that is $7000/2500 = 2.8$, but 2.8 is not a whole number. You would instead choose 3 pixels/sec, and so P/F must be exactly 3. So P can set be set to 7200 and F set to 2400. The titles would be animated from a position of 0 pixels (in the first keyframe) to +7200 pixels (in the

second keyframe), with the two keyframes exactly 2400 frames apart. Notice that you don't get the exact speed you might need so you modify the length of the title music or the height of the scroll as required. This method eliminates the shimmer however.

The resulting title sequence is then written to a DVD or external hard drive as an image file sequence. The best file format is the JPEG file format, which can easily compress white titles on a black background without loss of quality. Use the highest quality setting for the JPEG compression. If you use JPEG the entire sequence will easily fit onto a single DVD.

If you don't want to tackle scrolling titles in After Effects, you can also submit your title scroll as a single, very long image file and let the transfer house do the animation for you. For example, a title sequence can be created in Photoshop with a file that is 1280 pixels wide by 10,000 pixels high. Other acceptable widths are 1920 pixels and 2048 pixels.

Chapter Eleven: Preparing the Uncompressed Quicktime for Film Transfer

There are some special requirements for preparing the uncompressed file for transfer to film, and here I will describe the specifications that are used by DVFilm.

Breaking Up the Film into 20 Minute Reels

The film must be broken into “reels” or sections that are no more than 21 minutes and zero seconds in length. They can be shorter, but they cannot be longer than that. The beginning and ending points of these reels must be carefully chosen. In some theaters feature films are projected in a “changeover” system, where two projectors run side-by-side, and when one 20-minute reel runs out, the next 20-minute reel is started on the other projector. The changeover sometimes causes an abrupt transition where part of the end of the 1st reel may be cut off or part of the beginning of the 2nd reel may be cut off. In other theaters a “platter” system is used where all of the film’s 20-minute reels are spliced together with tape and run together on a giant horizontal reel. The transition from one reel to another is smoother, but if you’re lucky enough to be playing in several film festivals or movie theaters, the transitions are unspliced whenever the film is shipped from one theater to another and re-spliced when projected again. Several frames may be cut off when this happens many times in succession.

For these reasons, film editors plan the 20-minute reel transitions carefully. The best place to have them is between two scenes, where there is no music or dialog that bridges the two scenes together.

Sync Pops

There must be a sync pop at the beginning and end of each 20-minute reel. These pops are removed when the film is projected, but they must be on the master tape so the optical soundtrack can be synchronized to the picture track.

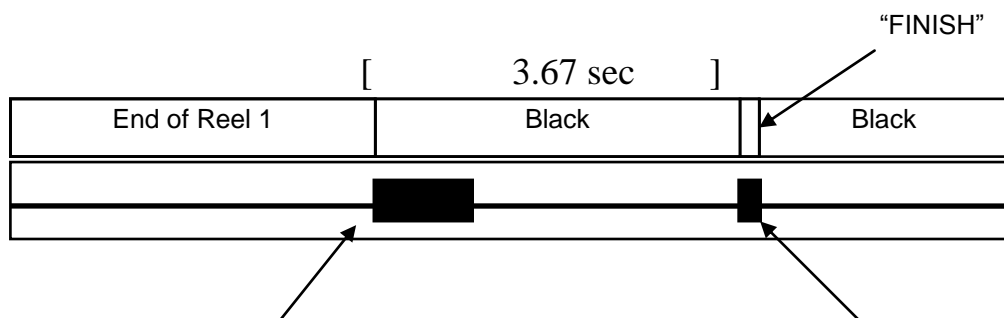
The sync pop at the beginning of each reel is the number “2” accompanied by a .05 second beep (the frequency of the beep is usually 1KHz). You can download this beep at www.dvfilm.com/beep.wav. The “2” and the beep must occur 2 seconds before the first frame of picture.

The sync pop at the end of each reel is the word “FINISH” accompanied by another .05 second beep. This beep must occur around 3.67 seconds after the last frame of picture.

Pull-ups

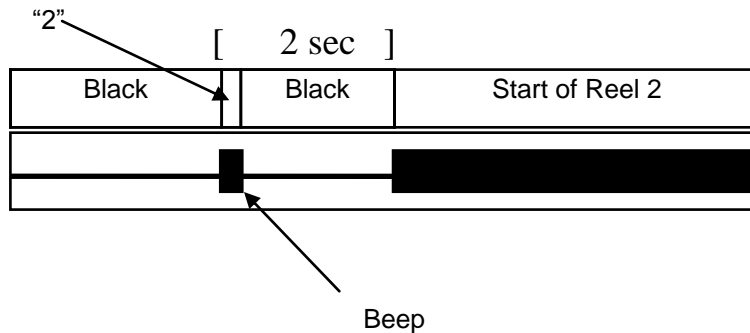
Because 35mm optical sound precedes the picture track by 21 frames (due to the design of 35mm projectors), if you make a splice on the print the sound is being spliced about $21/24 = .875$ seconds before the picture is being spliced. For this reason, it’s important to have a little bit of sound at the end of each 20-minute reel which is taken from the start of the next reel. This is called a pull-up. It is made in your editing program (for example) by copying about 1 second of audio from the beginning of the second reel and pasting it under the black frames which follow the end of the first reel (leading up to the tail pop).

The pops and pull-ups are illustrated here:



One second of sound from Reel 2

Beep



Time Code Issues

If your NTSC master tape is in the DVCAM, DVCPRO, DigiBeta or Beta SP tape format, it's best if the tape is recorded with non-drop frame Time Code. NTSC plays back at 29.97 frames per second, but film runs at exactly 24 frames per second, Consequently, NTSC is speeded up slightly from 29.97 to 30 fps when converted to 24 fps film. Therefore, non-drop Time Code, which counts actual frames of video, gives a more accurate estimate of the exact running length of the film and non-drop Time Code is preferable for a tape that is being submitted for transfer to film.

For the MiniDV format, drop-frame Time Code is always used, but this is acceptable for transfer to film.

There should be no time code issues with a 24p uncompressed Quicktime.

Film-Look Effects

Make sure there are no “film look” effects on the master tape which you submit to the tape-to-film transfer company. The transfer process creates its own film look and there is no need to add anything to that. In fact, if you use a deinterlacer like DVFilm Maker, the reduction in sample rate (from 60 fields per second to 30 frames/sec) will actually interfere with a smooth transfer from video to film, so make sure that if you use DVFilm Maker, you save the original, interlaced video for transfer to film.

Also do not be tempted to “crush the blacks” (darken or increase contrast) or any other special alterations to the video. Most film transfer companies prefer a color-corrected master tape, prepared as if it were going to be broadcast on television, with no letterboxing. Also if the project was shot 16:9 anamorphic, it should be submitted in the original full-screen, anamorphic format, and not letterboxed.

Chapter Twelve: Authoring a 24P DVD

DVD encoding and authoring programs are very common now and the disk drives for burning DVD's have become very affordable, so it is economical for filmmakers to author their own DVD master disks in preparation for a home video release, or for screening in a digital projection room, or simply to provide DVD's for family and friends. Most NLE software includes DVD/BD DVD authoring and encoding right from the timeline. Before buying separate software you will want to check out the capabilities of your editing software.

A 24P DVD is a kind of DVD that is commonly used by companies that shoot on film and release movies in movie theaters as well as home video. 24P DVD's are universally playable all over the world (assuming that region zero is selected in the copy protection options). They can be played back by both PAL and NTSC players. The player does the conversion in real-time as the playback occurs. Also HD-capable DVD players and television sets can play back 24 frames per second just like in a movie theater, and there is no frame rate conversion. This method yields the smoothest and most movie-like motion possible in digital projection.

How do you make a 24P DVD? First check if your DVD encoding and authoring software (which sometimes is bundled with the video editing program) has the option to make 24P DVD's. If so that is the easiest way. Otherwise you will have to get 2 inexpensive applications that will do the job for you.

In the Windows world the most flexible DVD encoding program is TMPGEnc (Tsunami MPEG Encoder), available at tmpgenc.net. This program takes a 23.976 frames/sec Quicktime and creates a .vob (Mpeg-2) file that can be used to burn a 24P DVD. The steps that must be taken are:

1. In your editing program export your final cut as an NTSC Quicktime or DV-AVI. Then convert the Quicktime to 23.976 frames/sec using DVFilm Maker. For those who are editing at 24P, you can export a 23.976 movie file directly from the editing program. If you shot on PAL or 25P, then convert the movie first to 24P using DVFilm Maker and your editing program (see details at the end of this chapter).

2. Do some basic checks on the movie file before you encode it. Open it with the quicktime player and select Window->Show Movie Info. The frame rate should read back as 23.98. Then drag the clip into the DVFilm Maker viewer and step through it frame by frame using the frame advance buttons. Find a shot with motion and make sure there are no skipped or duplicate frames and there is no interlacing in the frames.

3. Open the movie file with TMPGEnc (set file name filter to "All files").

Use the wizard in TMPGEnc to set the basic settings:

Choose format = DVD, NTSC, High Quality (720 x 480, 29.97 fps), and CBR Linear PCM Audio.

Next screen

Select video type = non interlaced

Select aspect ratio as appropriate (4:3 or 16:9)

Select content = Film movie

Next screen

Deselect all filtering

Next screen

Video resolution = 720 x 480

Average video bitrate = 8000 kbits/sec

Select DVD-R (4.7GB) disk type

Next screen

Uncheck Start encoding immediately (i.e. do not start).

Click OK

Then click on settings, go to the Video Tab, make sure it says MPEG-2 Stream type, 720 x 480, frame rate of 23.976, Constant bit rate (CBR) of 8000 kbits/sec, 3:2 pulldown when [during] playback, DC component precision = 9 bits, Motion estimate search (fast). The settings for Rate control, bitrate, motion estimate, etc are OK to be changed by advanced users.

Then go to the Advanced Tab, and turn OFF the inverse telecine option if it is selected (this tries to remove 3:2 pulldown from the source movie - not good). Turn OFF the 3:2 pulldown option if it is selected (this adds pulldown BEFORE playback - not good). Basically all of the Advanced option check boxes should be deselected, Make sure on the Advanced Settings it says Video source Type = Non-interlace, Field order (doesn't matter) Source aspect ratio 4:3 or 16:9, 525 line NTSC.

Save and close settings and hit Start to start encoding.

You know when you have done it correctly when the movie plays back smoothly on the TV, and you can step through the frames on the DVD without seeing duplicate or missing frames vis-a-vis the original 23.976P Quicktime.

Mac Platform

On the Mac platform you need to download MPEG Telecine at homepage.mac.com/DVD_SP_Helper/Download/Download.html

The 23.976 fps Mpeg-2 is encoded in Final Cut Pro, then modified with MPEG Telecine so it looks like a regular NTSC Mpeg. Then it is burned to disk with iDVD or DVD Studio Pro with NTSC project settings.

Burning the DVD

Once you have encoded the movie into an Mpeg-2 (.m2v) file, you then take that into a DVD authoring program to create the .vob file and burn it into a disk. There are many authoring programs and I cannot cover them here, but most are fairly self-explanatory. They allow you to create the menus and chapters, etc. for the disk. One low-cost authoring program for Windows is Tmpgenc DVD, also available at tmpgenc.net.

Converting PAL to 24P

PAL or 25P can be converted to 24P to make a 24P DVD. The advantage of this is that the DVD can be played anywhere in the world including the US and Japan, not just in PAL countries. To convert, export a 25 fps PAL quicktime or PAL DV-AVI, and if it is not 25P but interlaced PAL, then deinterlace it with DVFilm Maker.

Export the audio track to a WAV or AIFF file. Slow down the audio track to 24/25ths normal speed by using Sound Forge, Goldwave (goldwave.com), Protools, or similar program. For example in Sound Forge: Choose Process->Resample and change the sample rate from 48000 to 50000 with re-sampling. Select the anti-aliasing filter. After the resample is done, choose Process->Resample again and change the rate to 48000 **without** re-sampling. The new file should be about 104% the size of the old file, and will be slightly lower in pitch and tempo.

Drag the new soundtrack into a 24P timeline (actually 23.976) and drag in the 25P or deinterlaced PAL Quicktime. Use the clip stretch tool to stretch the video track out to match the length of the slower audio track. This changes the frame rate to 23.976. Then render out a 23.976P Quicktime with the 720 x 480 frame size, using the highest quality settings so that the frames are resized smoothly.

PART III FILM FESTIVALS AND MARKETING

Chapter Thirteen: Film Festivals

Once you've finished your film and shown it to your closest friends, you ought to submit it to some film festivals. Why? Film festivals are the best way to generate publicity and to get the movie industry interested in your film and in your talents. In theory you could submit your film directly to film distributors without going to film festivals first. But unless your film has an obvious marketing hook (for example, big-name stars, based on a best-selling novel, or it's in a hard-core genre like sex or horror) they will not be very responsive. The typical independent movie does not attract the better distributors unless it has already gotten a lot of great reviews and a lot of great publicity. And pretty much the only way to do that is by entering and doing well in a lot of film festivals.

To submit your film you are only spending 25 to 50 dollars on the submission fee for each festival and a VHS dub (or DVD) of your film which is mailed to each festival. Find out when the deadline is for each festival. Be sure to submit early. Don't wait until the last minute and submit just before the deadline. Your chances at being accepted get lower and lower the longer you wait to submit, because the festival programmers are making their choices as they receive films and only have a limited number of slots to fill at the festival.

Keep in mind that because of the large number of independent films made every year (thousands) , the chances of getting into a particular festival are very slim. Therefore, try to choose wisely and pick festivals that are suited to your film, and submit to all those festivals simultaneously (i.e., without waiting to see if you are accepted before submitting to the next one). There is a partial list of festivals and websites at www.dvfilm.com/links.htm.

What to Do If You Can't Get Into Any Festivals

If you collect nothing but rejections letters you might need to re-examine your film and the type of festivals to which you are submitting. The bigger and more prestigious a festival is, the more difficult it is to get in. A lot of filmmakers bet everything on getting into Sundance, for example, because of its high reputation. Getting into Sundance without known actors or without the help of industry insiders is a bit like being struck by lightning. It doesn't happen very often for feature films. Before you submit to a festival you might look at the type and quality of films they have shown in previous years. If it's mostly high-brow art films for example, submitting your teen comedy or slasher film is a waste of time. On the other hand for almost every type of film there is a festival that supports and encourages that genre. For example there are festivals that specialize in fantasy and science fiction. There are documentary-only festivals. If you're an Hispanic filmmaker, for example, there are many Hispanic festivals, etc.

Another thing to consider is maybe your project needs some fine-tuning or even a makeover. There is hardly a first-time movie made for example that can't have a few unnecessary scenes trimmed out or the whole picture tightened up a bit. The last film I made started with a first cut of two hours, dropped to 104 minutes before its world premiere, then lost a few scenes and ended up at 87 minutes in its final incarnation on home video. Each round of cutting was the result of audience feedback and written reviews of the film. Of course it is always best to make your cuts before going to the expense of a 35mm print. But even after the print is made the movie can be trimmed down (literally, with scissors) by dropping entire scenes, and making the same cuts on any version that you might have on tape. Audience testing, which is used by major film distributors, can be a revealing and sometimes heart-breaking experience but will tell you how the general public or the film-

festival-going public will react to your film. Like it or not, movie making is entertainment and even the most artsy and esoteric films are playing to an audience. The trick is to find that audience and find out what it likes and dislikes about your film.

What to Do If You DO Get Accepted to a Festival

If you're lucky enough to get into a big film festival (believe me lucky is the operative word) then it's time to make your 35mm print if you haven't done so already. At the risk of unfairly boosting my own industry, I'm going to say that your chances of making a big hit at the festival are 3 times better if you show your film on 35mm rather than 16mm, and 10 times better still than showing it on video. Many festivals show stuff on video, (and some do not), but the video projection is usually of poor quality. Not only that, but you often get stuck in the "video" section of the festival, which is typically ignored by the press and industry.

Where do you get the money to make the 35mm print? From an informal survey of our customers I would say it is usually borrowed money (credit cards), money from investors, or grant money. For a 90-minute film it costs about \$25,000 for 35mm and \$16,000 for 16mm. If you have a great film, some companies (like DVFilm) might do a 35mm transfer for as low as \$20,000, especially if you give them lots of time to do it, like 12 weeks or more.

The next thing to do is get your materials in order to properly promote the film. You'll need press kits, which are folders containing 3-5 still photographs, a synopsis of the film, biographies of the people who made the film, a complete list of the cast and crew, and anything else you think a reporter or film critic might need to write a proper review or article about the making of the film. One thing I have done for my own press kits which is kind of unusual is to include a "canned" interview, in other words,

an interview which is already prepared by you with the questions (asked by a fellow filmmaker or a fictional interviewer) and your answers in plain text format. This item can be very inspirational to a reporter who is trying to pick an angle on your story, and don't be surprised if some of the better turns of phrase in that interview (or your synopsis) show up verbatim in the press or in the festival publicity. You can read a sample interview in Chapter Fourteen.

Yet another thing you might put together is a collection of clips, or the trailer from the film, on Beta SP tape. TV reporters love those things, and will almost always include a clip in any TV news stories they might do about the film festival or your film. Make sure there are a lot of very brief shots (1-2 seconds each) strung together for at least part of the tape, since TV audiences have such short attention spans that's what is most likely to be used. And you might as well save the TV station editor the trouble of putting those shots together. By the way, if you process the video first using DVFilm Maker, with the letterbox option, it will make it look different than ordinary broadcast video and make your project stand out.

Getting Good Press

It's hard to know how much to bug reporters and film critics on writing something about your film. Too much harassment might backfire. Nobody enjoys stalkers. Just sending them the press kit is not enough, though. Try to use your own judgement. One or two phone calls after sending the press kit is certainly fine. Try to present yourself as an underdog, in other words, not arrogant, assured of success, or self-centered, but unprepossessing, self-deprecating, and perhaps even filled with self-doubt. It will certainly be refreshing since most filmmakers are terribly impressed with themselves.

Local Screenings

A way to bypass the competitiveness of film festivals is simply to have your own festival with one film— yours. All it really takes is a local movie theater that is willing to project your film for a price. Most of them will project a movie for \$200 if you're willing to do it before regular business hours, like before noon on a weekday. If you insist on an afternoon or evening screening they'll ask you to buy every seat in the house which can run the cost well past a thousand dollars. Also you will have to whip up your own publicity, and it might be advisable in this case to find someone who does that for a living, a publicist.

In rare cases you might be able to get a theater to run your film as a midnight show or during their regular show-time hours, and do a split of the box office. This is a good deal for you because it involves very little monetary risk on your part. The theater owner will have to be very convinced, though, that enough people will show up to make it worthwhile. That pretty much means you've already gotten a lot of advance press and publicity, like rave reviews from a previous festival screening.

Good luck with it. If you have an exceptional film, the sky is the limit!

Case Study: Slacker

What can happen if you get into some really good festivals? An example is a little movie called "Slacker".

I first heard about the movie "Slacker" (directed by Rick Linklater and released by Orion Classics) from my friend Lee Daniel who shot the film. We were hanging out in the machine shop behind the house that I shared at the time with Dan Morris, and Lee told us about a movie they were trying to make with no real script or

actors but as Lee put it, “just a bunch of tracking shots.” I was pretty skeptical, and we all had a pretty good laugh. They had plans to show the film in a rough cut at the next IFP Market, which is a type of film festival geared towards the film industry which is held in New York. (Unfortunately the IFP has changed a lot recently and has become more like a conventional film festival).

Their screening at the 1989 IFP (Lee told me later) was pretty disappointing, only a few people showed up. However, there was a man who bought and sold films for German television who took an interest in the movie and provided some money to get it finished. They had to cut the negative, (it was shot in 16mm), finish the soundtrack and make a 16mm answer print. The money was provided to them in exchange for the German distribution rights.

The movie went from there to a film festival in Seattle, a rave review in *Film Comment* (a New York-based film journal), to other film festivals and a long run at the Dobie Theater in Austin, in the middle of the neighborhood where the movie was shot. It launched Rick’s career and within ten years he was directing multi-million-dollar pictures and providing employment for a lot of my friends in Austin. So it goes to show you how a festival screening can make a difference, even if only one person there likes your film.

Chapter Fourteen: Distribution

The issue of distribution of independent films is so thorny that I am pretty much going to confine my advice to this: get a competent entertainment lawyer if any distributor approaches you with a distribution deal. It's okay to talk with distributors about your film, but don't make any handshake deals or sign any papers until you've discussed it with an attorney that is experienced in the business.

Dealing with Distributors

The great thing about dealing with distributors is that they have no idea what you spent making your movie. If you shoot on high-quality DV but transfer to film and either show people your film print or the video processed through film-look software, no one is going to know that you shot it on tape. And there's no reason to tell them. Even better is when you have one or two name actors in your film, who hopefully appeared in the project because the script was interesting or provided them a different type of role. The distributor can only assume that you had to pay them big bucks to do it. So if you think you might get some money in advance from the distributor, then never, never, never tell them (or anyone else for that matter) what your budget was or how much money you spent. And never tell a member of the press. Be evasive. At the film festival they always have a question-and-answer period after the screening of your film, and someone is guaranteed to ask you what you spent on the picture. A good answer to "What was your budget?" is "What would you guess?" and then try to keep a straight face while they shoot out some numbers.

Some Jargon

Here are some things people talk about when discussing film distribution, so you might want to familiarize yourself with these

terms. Some of these are generic contract terminology but have a specific meaning when applied to films:

Worldwide Rights - This means that the distributor acquires the right to sell your film all over the world, in every medium (i.e. both theatrically and on video).

Foreign Rights - The right to sell your film in countries other than the US or Canada.

Domestic Rights - The rights for US and Canada.

Expenses - Money the distributor has to spend to promote and sell your film. They can include everything from the cost of making a poster to the phone bill.

Net Profit - Profits after expenses are deducted. This is a tricky thing because some contracts do not specify allowable expenses nor place a limit on expenses. If there are no restrictions on expenses, some companies abuse this and exaggerate expenses.

Gross Profit - Profit before expenses are deducted.

Royalty - Your share of profits from distribution after (usually) deducting expenses. The royalty can be defined as a percentage of net profits or a percentage of gross profits. Obviously if it's defined with gross profits the computation of the royalty is straightforward and less subject to fraud. Sadly though, a royalty based on gross profits is hardly ever offered to independent filmmakers.

Negative Pickup - A rarely used kind of distribution deal, although one that is very advantageous to the filmmaker, where the distributor pays you your production costs up front plus a royalty and takes worldwide rights.

Guarantee - A nice arrangement where the distributor guarantees to pay you a minimum royalty, but not necessarily up front, or else they lose the distribution rights after a year or two.

Performance - A minimum for gross sales (rather than a minimum royalty) which the distributor must meet or exceed, or else they lose the distribution rights after a year or two.

Copyright - The right granted to you by the government to claim ownership of your film and prevent others from copying it without your permission. You must apply for a copyright when you finish your film (see www.loc.gov).

Title search - A search performed by a professional title search company (like www.thomson-thomson.com) to make sure the title of your film has not been used for another book or film. If you have the money (about \$800) to do this before you start shooting, it might save you some trouble later on. If not you can also do your own, free title search on the Internet Movie Database (www.imdb.com) and get an official search done when it comes time to sign a distribution deal.

Cast and Crew Contracts - The written agreements you hopefully arranged with each of your cast members, crew, post-production people and anyone who is credited with working on the film. Distributors like to see these to make sure they're not going get sued because you didn't have permission to use someone's name or likeness. My advice is make sure you have a piece of paper for every person that worked on the film, every identifiable location you used, and every bit of music or stock footage. I've included some sample contracts in Appendix D.

Deliverables - The things you have to give the distributor in order to distribute your film. They usually include the 35mm negatives

which were created in your video-to-film transfer and a Digibeta master tape. Often they need a foreign version as well as an English version. The foreign version is used to dub the film into another language. To prepare this version, you have to create a music-and-effects track, which is a version of the soundtrack with music and sound effects only, in other words, with no dialog present. The music and effects track is then recorded onto Digibeta tape synchronized with the picture. Other deliverables may include stills from the making of the movie, copies of your contracts with actors and crew, copyright and title search information.

How to Find an Entertainment Lawyer

There are entertainment lawyers in every large city. Entertainment law includes music and other creative endeavors and you don't have to go to New York or Los Angeles to find a competent attorney. For example my own legal needs for the last fifteen years have been handled by an Austin-based attorney named Mike Tolleson (www.miketolleson.com) who has handled contracts between myself and producers, actors, composers, and film distributors. An example of the more expensive and perhaps more connected lawyer is Mark Litwak (www.marklitwak.com) based in Beverly Hills, whom I met with on one occasion-- although he was not interested in helping me. However he has a great website, has authored books on distribution, and has steered many a filmmaker's career. Somewhere between your hometown and Hollywood you can find someone similar. If you know a successful filmmaker they might recommend someone. If not then join the IFP (www.ifp.org), or the AIVF (www.aivf.org) and they can provide you some names.

Self-Distribution

The last resort for filmmakers who have been unable to sell their film is self-distribution. In Chapter Twelve I discussed how to book a local theater, and that process can be extended into a self-made theatrical release on a city-by-city basis. If you can get enough play dates it's conceivable that a video store chain would offer to buy a couple thousand tapes from you, and you could also make a sale to cable television. Certain genre films, like erotica, action and horror films, can be sold this way even without a theatrical release because the demand for these types of films is pretty constant. If you're a member of the IFP, the organization that hosts the IFP Market, you can get a list of companies that buy independent films for cable, and then you can simply mail out tapes addressed to the acquisitions executive of each company.

Internet Distribution

The easiest way to sell tapes of your film is to put together a website with MPEG or Quicktime trailers, stills, articles, and reviews of your film and then to entice web surfers to come to your site and hopefully order a tape. There is a filmmaker named Bill Plympton, for example, who has turned this into a successful business for his own films. Plympton has a unique style of bizarre, funny, and original animation that is recognized worldwide, and in addition to selling his movies to television and for theatrical release he sells tapes and other merchandise off his website (www.awn.com/plympton). My first film, *The Texas Comedy Massacre*, is sold this way directly off the Internet (at dvfilm.com/tcm).

There are also websites which show short films on streaming video, such as YouTube (youtube.com) or Vimeo (vimeo.com). They don't pay you to show your film, but you can have a link to your own website and sell stuff there, like a VHS tape of a feature-

length version of the short film that is showing on their site. Some film websites even offer prizes and movie deals to the best films they get.

Chapter Fifteen: A Test Case — REDBOY 13

I suppose a lot of filmmakers would like to know, in advance of actually making a film, what their chances are of getting a fat distribution deal and becoming enormously rich. I think, in fairness, the answer is so close to zero that you might as well consider it to be zero. The odds might be slightly worse than buying a lottery ticket. However, I wouldn't let that discourage you. The only rule is that there are no rules, and what the public wants is something they've never seen before—and only a new filmmaker coming totally out of the blue is going to provide that to them. You could be that person.

The last feature film I made was REDBOY 13. Part of the film was shot on 35mm and part of it was created digitally, and it was the technology that I developed for the movie that led me into the business of making digital to film transfers. So even though REDBOY is not a typical case, I thought I would use it as an example of how to put together a low-budget film and take it all the way through distribution.

How the Script Was Written

The idea for REDBOY came after watching the movie RAMBO III and observing the fall of the Berlin Wall way back in 1989. The Rambo movies were becoming more and more absurd, and with the fall of communism I thought it was time to poke a little fun at the world of spies and mercenaries and how those people were going to change after the end of the Cold War.

Here is the interview I wrote myself for the REDBOY 13 Press kit:

Q: So what's a REDBOY 13?

A: It's a code name for this spy, a kid who is hired and trained by a half-crazed Air Force Colonel and inducted into a secret branch of the military called the "CYA." The kid's an assassin and a counter-terrorist agent, kind of a mix of James Bond and Rambo, but carries a Teddy Bear. Unfortunately for the CYA, it's the end of the Cold War and the dirty tricks budget has been slashed. So they are forced to operate illegally, fighting bad guys and the FBI at the same time. In addition, little Redboy has his own problems-- his family is breaking up, he's not doing well in school... and he's tired of being a killer and wants to return to normal life.

Q: Where'd you get the idea for this film? Did you write the script?

A: Yes, I wrote it in 1990. It was sort of inspired by the fall of the Berlin Wall and a trip I made to Germany in '87, and also by the "Rambo" movies and all the wide-screen adventures that I grew up with, in the 60's.

Q: For a low-budget film, it has an interesting look, kind of an epic feeling, in some scenes. How did you achieve that?

A: Choice of music, maybe, the 35mm CinemaScope format, and the 30-ft camera boom that we used for some of the scenes, especially when Redboy is running to school. I like the sweeping movements and the over-dramatic score... kind of gives it a Lawrence of Arabia feel. Also, the presence of the Mt. Rushmore-esque Robert Logan, veteran of epics like

"Bridge at Remagen" and other pictures. The style of photography, which is deliberately static for dialog, then mobile for action sequences... is a throwback, really, to when sound cameras were heavy, bulky. A lot of REDBOY was shot with a Mitchell camera, practically an antique I suppose, but it has a certain quality you don't get nowadays.

Q: Why CinemaScope? Isn't that an obsolete process?

A: Not really, it's the same squeeze as Panavision, 2 to 1, used for blockbusters like "Independence Day". The Bausch and Lomb CinemaScope lenses are hard to find these days, though... I bought 'em from a crazy guy who lived behind Grumman's Chinese theater, selling off his collection to pay the rent.

Q: Didn't those lenses have a problem with close-ups... make people look fat?

A: I built a close-up lens from a Nikon zoom and an Eiki adapter to get around that problem. The B&L's were used for wide shots.

Q: There's a lot of planes, helicopters, and tanks in the movie. Some of it's pretty impressive. How did you do it?

A: Couldn't afford the real thing, of course-- I think a C5A costs ten grand an hour to fly, just in kerosene. Those shots are a mix of miniatures and computer animation. My profession, my "day job" is software engineering, and I've been messing around with 3D animation since I was a kid. For REDBOY, I ported over an old animation and rendering program of mine, originally written in FORTRAN, to the SGI Indigo Elan. Back then, in 1994, film animation packages like "Maya" were going for \$100K plus, and I couldn't afford

that. So I rolled my own, using the built-in libraries of the Indigo, and put together a film recorder from a high-res monitor and an animation camera.

Q: How did you learn to do all that stuff? Your degree is in...

A: Electrical Engineering, not film production. I took film as an elective.

Q: Seems like it came in handy. How did you get interested in film?

A: I guess it was from writing, which I did a lot of in high school. I wrote a lot of science fiction stories, comic plays, little radio programs...

Q: Any of the stories published?

A: No, they were pretty bad. Then in college I did a lot of stand-up comedy. I would do impressions, like Jimmy Carter, or characters from Star Trek. My first film, THE TEXAS COMEDY MASSACRE, is sort of taken from my stand-up days.

Q: I haven't seen that.

A: No, no one has!

Q: It's a lot of skits and stuff--?

A: Like KENTUCKY FRIED MOVIE, or THE GROOVE TUBE.

Q: Was it shown theatrically?

A: No, only at film festivals. I was hoping for a videocassette release but it didn't happen, because of liability problems. For example, one segment was "Paramutual of Omaha's Mild Kingdom." None of the distribs wanted to go toe-to-toe with this insurance company, with their giant spigots of hot and cold running lawyers. However, parts of the Star Trek parody were shown on that ABC series, "America's Funniest People," and for that, the network gave me ten thousand dollars. I invested it in REDBOY.

Q: So not a total loss.

A: I guess not!

Q: Where did you meet Robert Logan, who plays Colonel Calcan?

A: At a film festival in Florence, Italy. I recognized him from "The Wilderness Family." Then I found out he'd been in dozens of films, and old television shows like "77 Sunset Strip" and "Daniel Boone." We stayed in touch. I sent him the script for REDBOY. I think he was amused by the smart aleck dialog. Also probably liked the idea of playing a tough guy, a military man, which he'd never done before. Bob's never been in the military, so we worked together on the cadence, the deadpan delivery. I guess I picked that up from working for Tracor Aerospace, a defense contractor here in Austin.

Q: Logan's pretty great in the movie-- an aging, weather-beaten Cold Warrior. What about Devon Roy-Brown, who plays Redboy, and some of the other actors?

A: Devon is the stepson of an old friend of mine from high school, Bill Gelber, who teaches drama, and his wife who is also into acting and is a choreographer. She plays the teacher in the film. Devon auditioned for the part along with three other kids. He was the only one that could enunciate "terminate with extreme prejudice," so my choice was easy. Charlie Schmidt, who plays Sgt. Hurter, I met at the IFFM in '87. He was the star of a movie called ONLY A BUCK, which I thought was pretty amusing. Tito Moreno, who plays Commander Paisano, is a music conductor and composer, lives in San Antonio.

Q: He's really funny... really looks the part of a "jungle general."

A: Yes he does. And then there's David Boone, another old friend, who plays Dave, the other helicopter pilot. David is a great filmmaker, he made a Super-8 classic called INVASION OF THE ALUMINUM PEOPLE. He also co-produced REDBOY with me and supervised the sound recording.

Q: Sounds like you have a big circle of friends in Austin to draw upon.

A: Yeah, there were other filmmakers involved, friends of mine, like Jim Crosby, Kirk Hunter, Earl Saathoff, and Robert Burns, who was the lead production designer... he's famous for building the sets for the original "Chainsaw Massacre" and cult films like REANIMATOR and THE HOWLING. The camera crew were all graduate students from UT Austin, including Brian O'Kelley, the cinematographer. They were really patient with the postwar equipment and worked horrible, horrible hours. I'm gratified to say, though, that most of those film students that worked

on REDBOY have since directed, shot, or produced their own feature films.

Q: Were there a lot of sets built for REDBOY?

A: Yes, a ton of them. Almost all the interiors were shot on sets. That's the only way to do it, if you ask me. I built a huge soundstage in Bastrop for REDBOY, a geodesic dome, seventy feet across in the center, thirty feet high--

Q: Why a geodesic dome?

A: It's the lightest, cheapest structure that has no supporting columns. Columns get in the way if you're doing large sets, or front-screen projection. Nine sets were built for principal photography, and then these were dismantled for another group of sets, the dungeon, the jungle camp scenes and the helicopter interiors for the second round of shooting.

Q: How did you finance the film? What was the budget?

A: I raised a small amount to start the film, all from private investors. Mostly people who knew me pretty well, probably felt sorry for me... never underestimate the sympathy factor. But that was only enough to shoot the dialog scenes. To finish the film, I had to spend many, many times the original investment. The completion money came from a variety of sources. One guy, Ed Toutant, put up his winnings from "Jeopardy." I put in money I got from ABC... so in a small way, REDBOY was financed from trash TV! As to the total dollar amount-- I'm holding my cards closely, I guess. I know that many people are intensely curious about that sort of thing... maybe I can be more open about it after the film is sold. It was a "medium" budget film... somewhere between EL MARIACHI and WATERWORLD.

Q: Oh boy, that narrows it down. C'mon, you can tell us.

A: You'll have to buy the book.

Some More Thoughts

Something a lot of people overlook— and I've been guilty of it myself— is the important relationship between successful films and the actors that are in it. Hardly any independent films do well merely because of their cinematography, sound, or production. It's always the script and the actors that make a good script believable and compelling. Or in the case of a documentary, it's the subject that makes it compelling. Consequently, for dramatic filmmakers, it's important to find and befriend excellent actors and give them what they want in a script: namely, good characters. And it's those actors which have established careers, in other words, stars, who will attract distributors and the public to your film.

You might think stars will only work for megabucks, but the truth is if you know them personally they will consider any project that is compelling, interesting, and meets the requirements of the Screen Actor's Guild for an experimental film (see www.sag.org) assuming they are in the Guild.

Of course that begs the question of where to meet people in the film industry, like established actors, that will help you. I think the best way is to make a really outstanding short film. You will get into a zillion festivals and meet all kinds of people, including talent agents and producers who might be willing to use their connections to help you. Talent attracts talent, and everyone likes to be associated with a new and gifted filmmaker.

Appendix A: Specifications for Transfer

Include 30 seconds of color bars at the head of the tape if possible.

All reels can be on a single tape.

NTSC projects:

Each reel must be preceded by a head leader:

- 30 seconds of black
- a .05 sec, 1KHz head beep (www.dvfilm.com/beep.wav) , accompanied by one video frame of the number 2 in sync with the beep
- 59 video frames of black

Following the reel, which must be no longer than 21 minutes 0 seconds in duration, (not counting the leaders) there must be an audio "pull-up":

- 50 video frames of black with a copy of the audio from the first 50 frames of the next reel
- Followed by a tail leader as follows:
- 58 video frames of black
- a .05 sec, 1KHz tail beep, (www.dvfilm.com/beep.wav) , accompanied by two consecutive video frames of the word "FINISH"
- 10 seconds of black

PAL and 24P projects:

Each reel must be preceded by a head leader:

- 30 seconds of black
- a .05 sec, 1KHz head beep (www.dvfilm.com/beep.wav), accompanied by one video frame of the number 2 in sync with the beep
- 47 video frames of black

Following the reel, which must be no longer than 20 minutes 0 seconds in duration, (not counting the leaders) there must be an audio "pull-up":

- 40 video frames of black with a copy of the audio from the first 40 frames of the next reel
- Followed by a tail leader as follows:
- 47 video frames of black
- a .05 sec, 1KHz tail beep, (www.dvfilm.com/beep.wav), accompanied by one video frame of the word "FINISH"
- 10 seconds of black

Appendix B: Budget for Redboy 13

This budget was originally prepared in 1989, but I have updated it with new figures for today's film and processing rates. You will notice that there are no camera and editing equipment rental costs, since I bought second-hand 35mm camera and editing equipment (for about \$20,000) and donated it to the production of the film.

This budget can be downloaded in Excel spreadsheet format at www.dvfilm.com/budget.xls

TITLE: REDBOY 13 PICTURE NO. 1
 SHOOT IN: 35mm DATE PREPARED: 02/15/89

ACCOUNT NUMBER	DESCRIPTION	TOTAL	TOTALS
100	Story	0	
200	Continuity and Treatment	200	
300	Producer	0	
400	Director	0	
500	Cast	13600	
600	Bits	0	
700	Extras	0	
	Above line	Sub Total	13800
<hr/>			
800	Production Staff Salaries	2900	
900	Production Operating Staff	12800	
1000	Set & Prop Construction	14850	
1100	Production Equipment	2600	
1200	Production Supplies	4200	
1300	Cutting - Film - Laboratory	58720	
1400	Music	10500	
1500	Sound	900	
1600	Transportation and Location	4800	
1700	Studio Rental	0	
1800	Tests and Retakes	0	
1900	Publicity	0	
2000	Miscellaneous	500	
2100	Insurance - Taxes - Licenses and Fee	8500	
2200	General Overhead	500	
	Below line	Sub Total	121770
		Grand Total	135570

Approved _____ Producer
 Prepared from _____ master scene script

28 Day shooting schedule at Dominion Pictures Studios
 and on location in Texas

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS
100	STORY				
101	STORY PURCHASE				0
102	TITLE PURCHASE				0
	TOTAL STORY				0

200	CONTINUITY AND TREATMENT				
201	WRITERS		Marcus van Bavel et al.		0
202	STENOGRAPHER				0
203	MIMEOGRAPH EXPENSE		20 copies	10	200
204	RESEARCH EXPENSE				0
	TOTAL CONTINUITY AND TREATMENT				200

300	PRODUCER				
301	PRODUCER		Marcus van Bavel		0
302	ASST. PRODUCER		none		0
303	SECRETARIES		none		0
	TOTAL PRODUCER				0

400	DIRECTOR				
401	DIRECTOR		Marcus van Bavel		0
402	SECRETARIES		none		0
403	PENSION		none		0
	TOTAL DIRECTOR				0

ACCOUNT NUMBER	DESCRIPTION	QTY UNITS	RATE	TOTALS
500	CAST (assume all non-SAG)			
501	Marcus van Bavel	1 weeks	0	0
502	Robert Logan	1 weeks		
503	David Boone	2 weeks	400	800
504	Devon Roy-Brown	4 weeks	500	2000
505	Charlie Schmidt	1 weeks	600	600
506	Wendy Blech	1 weeks	400	400
507	Tito Moreno	1 weeks	500	500
508	Diane Perella	1 weeks	400	400
509		0 weeks	400	0
510		0 weeks	400	0
511	Bill Johnson	1 days	300	300
512	Ev Lunning, Jr.	1 days	200	200
513		0 days	80	0
514		0 days	80	0
515		0 days	80	0
516		0 days	80	0
517		0 days	80	0
518		0 days	80	0
519		0 days	80	0
520		0 days	80	0
521		0 days	80	0
522		0 days	80	0
523		0 days	80	0
524		0 days	80	0
525		0 days	80	0
526		0 days	80	0

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS
500	CAST, CONT'D				
550	OT/NIGHT WORK				
551	ADR				
552	REHEARSAL		days		
553	FITTING CHARGES				
554	MEAL PENALTIES/FORCED CALLS				
555	AGENT FEES				
556	TRAVEL FOR GUEST STARS			allow	2000
557	LODGING FOR GUEST STARS	7	days	200	1400
558	PER DIEM				
559	FICA TAX				
560	UNEMPLOYMENT TAX				
561	PENSION & WELFARE				
	CAST SUB TOTAL				13600

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS
600	BIT PARTS				
601		0	days	80	0
602		0	days	80	0
603		0	days	80	0
604		0	days	80	0
605		0	days	80	0
606		0	days	80	0
607		0	days	80	0
608		0	days	80	0
609		0	days	80	0
610		0	days	80	0
611		0	days	80	0
612		0	days	80	0
613		0	days	80	0
614		0	days	80	0
615		0	days	80	0
616		0	days	80	0
617		0	days	80	0
618		0	days	80	0
619		0	days	80	0
620		0	days	80	0
621		0	days	80	0
622		0	days	80	0

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS
600	BIT PARTS, CONT'D				
650	OT/NIGHT WORK				
651	ADR				
652	REHEARSAL				
653	FITTING CHARGES				
654	MEAL PENALTIES/FORCED CALLS				
558	PER DIEM				
559	FICA TAX				
560	UNEMPLOYMENT TAX				
561	PENSION & WELFARE				

BIT PARTS SUB TOTAL 0

700	EXTRAS (assume non-SEG)				
701		0	4 days	20	0
702		0	0 days	20	0
703		0	0 days	20	0
704		0	0 days	20	0
705		0	0 days	20	0
707		0	0 days	20	0
708		0	0 days	20	0
709		0	0 days	20	0
710		0	0 days	20	0

EXTRAS SUB TOTAL 0

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS
800	PRODUCTION STAFF SALARIES				
801	PRODUCTION MANAGER		D. Mayer-Oakes	contract	1200
802	1ST ASST. DIRECT.		J. Crosby	contract	500
803	SECRETARY		0 weeks	200	0
805	PROD. ASST.	2	3 weeks	200	1200
	PRODUCTION STAFF SUB TOTAL				2900

900	PRODUCTION OPERATING STAFF				
	A. CAMERA DEPT.				
901	D.P.		B. O'Kelley	contract	1200
902	1ST. ASST. CAM.		D. Lewis	contract	800
903	OPERATOR		4 weeks	250	1000
904					0

	B. GRIP DEPT.				
910	KEY GRIP			contract	1000
911	GRIP		0 weeks	200	0

	C. ELECTRICAL DEPT.				
920	GAFFER			contract	0

	D. SOUND DEPT.				
930	SOUND MAN		D. Boone	contract	1200
931	BOOM MAN		K. Hunter	contract	800

	E. MISCELLANEOUS				
950	MAKE-UP		2 weeks	1500	3000
960	PROPERTY MASTER		1 weeks	800	800

ACCOUNT NUMBER	DESCRIPTION	QTY UNITS	RATE	TOTALS
900	PRODUCTION OPERATING STAFF, CONT'D. E. MISCELLANEOUS, CONT'D.			
970	SPECIAL EFFECTS	1 weeks	500	500
971	ARMORER	1 weeks	500	500
980		0 weeks	200	0
981		0 weeks	200	0
982	CRAFT SERVICE	4 weeks	500	2000
	PRODUCTION OPERATING STAFF SUB TOTAL			12800

1000 SET AND PROP CONSTRUCTION

SETS:	SQ. FOOTAGE
Schoolroom	400
Barracks	400
Oval Office	400
Paisano's tent	200
Dungeon	600
Prison	400
Weapons Lab	200
Redboy's bedroom	100
Huey interior	100
Russian chopper exterior	100
Russian chopper interior	100
Cave	200
Ext prison	200
Dungeon entrance	200
Total	3600

14 SETS, TOTAL SQUARE FOOTAGE = 3600

MINIATURES:

Jungle camp

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS
1000	SET AND PROP CONSTRUCTION, CONT'D.				
	A. LABOR				
1001	PROD. DESIGNER R. Burns			contract	3000
1002	ART DIRECTOR E. Saathoff			contract	1500
1003	SET PAINTERS	2	2 weeks	200	800
1004	CARPENTERS	2	2 weeks	200	800
1005	MACHINIST	1	1 weeks	800	800
1006	SCULPTOR		1 weeks	250	250
	B. MATERIALS AND SUPPLIES				
1010	WOOD			allow	2000
1011	PAINT			allow	500
1012	STYROFOAM			allow	1000
1013	NAILS			allow	500
1014	ADHESIVES			allow	200
1015	FRONT PROJECTION SCREENING			allow	1000
1016	PLASTICS, PLASTER			allow	1500
1020	FURNITURE RENTAL			allow	500
1030	SCAFFOLDING RENTAL			allow	500
	SET & PROP CONSTRUCTION SUB TOTAL				14850

1100	PRODUCTION EQUIPMENT				
	A. CAMERA PACKAGE				
1101	Mitchel NC		4 weeks	0	0
1102	Arri 35-II		4 weeks	0	0
1103			0 weeks	220	0

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS	
1100	PRODUCTION EQUIPMENT, CONT'D					
1110	1000' MAGAZINE	2	4 weeks	0	0	

B. GRIP PACKAGE						
1120	STEADICAM I					
1121	25' REMOTE CRANE		1 weeks	0	0	
1122	TRACK DOLLY AND TRACK		1 weeks	0	0	

C. LIGHTING						
1130	LOCATION LIGHTING KIT		1 weeks	500	500	
1131	HMI's	0	0 weeks	400	0	
1132	GLOBE USAGE			allow	200	
1133	2K SET LIGHTS	20	1 weeks	40	800	
1134	TAPE, GELS, MISC EXPEND.			allow	300	

D. SOUND						
1140	SOUND PACKAGE		Nagra IV	allow	800	
					PRODUCTION EQUIPMENT SUB TOTAL	2600

1200	PRODUCTION SUPPLIES					
1201	PROP PURCHASES			allow	2000	
1202	WARDROBE PURCHASES			allow	1000	
1203	EXPLOSIVES			allow	400	
1204	AMMUNITION			allow	400	
1205	PICT. VEHICLE RENT	0	0 weeks	300	0	
1204	HELICOPTOR RENTAL		0 hours	250	0	
1205	POLAROID/STILL FILM/LAB			allow	200	
1206	MISC RENTALS/PURCHASES			allow	200	
					PRODUCTION SUPPLIES SUB TOTAL	4200

ACCOUNT NUMBER	DESCRIPTION	QTY UNITS	RATE	TOTALS
1300	CUTTING - FILM - LABORATORY			
	A. PICTURE LAB/ 35mm			
1301	PICTURE NEGATIVE STOCK	50000 feet	0.36	18000
1303	DEVELOP NEGATIVE	50000 feet	0.12	6000
1304	WORKPRINT	50000 feet	0.25	12500
1305				
1306		hours		0
1307	ANSWER PRINT	9000 feet	1.2	10800
1308	OPTICAL SOUND	9000 feet	0.38	3420
1309	TITLES AND ANIMATION		allow	2000
1310	VID TRANS ANSWER PRINT	4 hours	300	1200
	B. EDITING (OFFLINE 1/2" w/TIMECODE)			
1320	EDITOR		contract	
1321	ASST. EDITOR	12 weeks	400	4800
1322	CUTTING ROOM RENTAL	0 weeks	300	0
1323	EDITING TABLE (N/C)	0 weeks	400	0
1324	EDGE CODER RENTAL	0 months	500	0
	CUTTING - FILM - LABORATORY SUB TOTAL			58720

1400	MUSIC			
1401	COMPOSER		contract	10000
1402	MIXING STUDIO	1 days	500	500
	MUSIC SUB TOTAL			10500

1500	SOUND			
	A. PRODUCTION SOUND			
1501	TRANSFER AND SYNC	10 hours	30	300

ACCOUNT NUMBER	DESCRIPTION	QTY	UNITS	RATE	TOTALS	
1500	SOUND, CONT'D					
	B. POST-PRODUCTION SOUND					
1510	SOUND EDITOR/ FX CUTTER			contract	0	
1511						
1520	MIXING		hours		0	
1530	LEADER, TAPE, ETC.			allow	600	
	SOUND SUB TOTAL				900	

1600	TRANSPORTATION AND LOCATION					
	A. VEHICLES					
1601	GRIP/CAMERA TRUCK	0	weeks	300	0	
1602	MOTOR HOMES	0	weeks	350	0	
1603	PRODUCTION CARS	0	weeks	350	0	
1604	CATERING TRUCK	4	weeks	350	1400	
1605	GASOLINE			allow	0	
	B. FOOD					
1610	MEALS/LOC	5	20	21 meals/wk	1	2100
1611	MEALS/STU	5	20	12 meals/wk	1	1200
1620	COFFEE, SNACKS, ICE		1 weeks	100	100	
	C. LOCATION SITE RENTALS					
1630			0 weeks	100	0	
1631			0 days	200	0	
1632			0 days	200	0	
	TRANSPORTATION AND LOCATION SUB TOTAL				4800	

ACCOUNT NUMBER	DESCRIPTION	QTY UNITS	RATE	TOTALS
1700	STUDIO RENTAL (WAREHOUSE)	0 months	500	0

1800	TESTS AND RETAKES			0

1900	PUBLICITY			0

2000	MISCELLANEOUS			500

2100	INSURANCE			
2101	EQUIPMENT INSURANCE		allow	500
2101	ERRORS AND OMMISIONS INSURANCE		allow	8000
			INSURANCE SUB TOTAL	8500

2200	GENERAL OVERHEAD			
2201	TELEPHONE		allow	100
2202	FACSCIMILE		allow	200
2203	PHOTOCOPYING		allow	200
			GENERAL OVERHEAD SUB TOTAL	500

Appendix C: Sample Script from REDBOY 13

The following is a sample of the screenplay for REDBOY 13, which might be useful to someone who has never written one. You will notice that the format is extremely spare, pretty much the very minimum required to describe the scenes and dialog. Two common abbreviations in the screenplay are:

INT. Interior location or set

EXT. Exterior location

Each scene was numbered and the scene number appeared on the camera slate as the film was shot. The shots that made up scene 19 were designated 19A, 19B, etc. where 19A might be a wide shot of the hallway and 19B a close-up of one of the characters, etc. In the computer all the shots for scene 19 were grouped together in one file.

19 INT. SCHOOL HALLWAY - DAY

Meanwhile, the mysterious man in the gray suit comes walking down the mall, still wearing his dark sunglasses. He passes the lockers. At one of the lockers, a truant kid is trying to light a cigarette. The kid looks up nervously as the stranger approaches.

KID #4

Who are you?

The man stops. He speaks in a hoarse, Clint-Eastwood whisper.

MYSTERIOUS MAN

I'm your new PE coach.

KID #4

You are??

MYSTERIOUS MAN

That's right-- and if you don't get to class... I'm going to kick your butt.

The kid slams the locker closed and runs off. The man waits for him to disappear. He walks through the back door of the classroom.

20 INT. GEOGRAPHY ROOM - DAY

Mrs. Lockwood is in the middle of listing the principle exports of Antarctica (snow, ice...) when she notices the mysterious man standing at the rear of the classroom. She stops writing on the chalkboard.

MRS LOCKWOOD

Can I help you?

The children in the class turn in their seats to look at the stranger.

When Sean hears the man, he is surprised, then angry.

MYSTERIOUS MAN

There's a gas leak in the basement.
Everyone's gotta clear the building.

The children let out a whoop and rush for the door. Mrs. Lockwood runs after them, yelling.

MRS. LOCKWOOD

Children! Don't run! Form a line,
single file!

Within seconds the classroom is cleared, except for Sean, who remains at his desk. Sean does not even look at the stranger. He stares straight ahead.

The stranger walks around to the front of the room.

Sean glances at him.

SEAN

That wasn't very bright, Colonel
Calcan.

The stranger, COLONEL "DIRTY" LARRY CALCAN, paces behind the teacher's desk.

CALCAN

Chopper'll be here in a few
minutes.

Sean's eyes are burning.

SEAN

No way, Colonel. I've got a math test on Thursday.

CALCAN

I think the National Security Council can take care of that.

SEAN

I've got band practice after school.

CALCAN

I'll mention it to the President.

SEAN

A lot homework due tomorrow!

CALCAN

The Joint Chiefs of Staff have authorized me--

SEAN

There's this girl in English class who kind of likes me.

Pause. The Colonel is taken aback.

CALCAN

Is it serious?

Appendix D: Contracts

Sample contract for actors and crew:

TALENT RELEASE

PERFORMER

MAILING ADDRESS

For consideration of _____ and one videocassette of

the film, _____, I hereby grant to [YOUR NAME HERE], his/her successors or assigns, and those acting under his/her permission, or upon his/her authority:

1. The unqualified right and permission to reproduce, copyright, publish, circulate and otherwise use photographs and/or motion pictures of me, and voice reproduction, whether taken in a studio or elsewhere, in black and white or in colors, alone or in conjunction with other persons or characters, real or imaginary, in any part of the world. I hereby waive the opportunity or right to inspect or approve the finished photographs, films or tapes or the use to which it may be put or the copy or illustrations used in connection therewith. This authorization covers composite, or any unusual photograph and/or motion picture, or voice reproduction, caused by optical illusion, distortion, alteration or made by retouching or by using parts of several images or by any other method.

2. All my right, title and interest in and to all negatives, prints, tapes and reproductions thereof, and I do hereby release the aforesaid parties and their successors and assigns, if any, from any and all rights, claims, demands,

actions or suits which I may or can have against them on account of the use or publication of said photographs and/or motion pictures or tapes.

I have read and understood the release stated above and do hereby agree to its terms and conditions.

Signed _____

Date _____ SS# _____

[YOUR NAME HERE]
Producer

SAMPLE COMPOSER AGREEMENT

This Composer Agreement is made and entered into by and between _____ ("Composer") and _____ ("Producer"), this ____ day of _____, Year _____.

WHEREAS, Producer is a motion picture production company engaged in the making of a motion picture titled _____ ("Picture"); and

WHEREAS, Composer is hereby engaged to arrange, conduct, and perform an original piece of musical material ("Music") as a "work for hire", the Picture's music, specifically arranged for use in said Picture;

NOW, THEREFORE, in consideration of the mutual covenants contained herein, the parties agree as follows:

1. Engagement: Producer hereby engages Composer to compose and deliver to Producer the Music for use in said Picture. All work will be subject to the direction and approval of Producer.
2. Term: The term of this engagement shall commence on the date set forth above and shall continue for the period necessary for the completion of all services required of Composer by Producer hereunder, including without limitation the music editing for and dubbing of the Picture.
3. Delivery: Composer will conduct the music to be recorded by the Producer in the Producer's recording facility and at _____. Composer will conduct the musicians and singers required for the recording as required.
4. Compensation: Provided Composer fully, promptly and completely performs all of Composer's obligations under this Agreement, Producer shall pay to Composer as compensation for Composer's services hereunder and all rights herein granted and agreed to be granted, \$_____.
5. Rights in Music:

a. Except as otherwise provided herein, Producer shall be the exclusive, absolute and unqualified owner throughout the universe in perpetuity of all music and recordings written and made by Composer hereunder, all rights and interests thereto, all elements thereof, and all results and proceeds of Composer's services including without limitation, the title thereof and the copyright therein, it being understood that Composer acts hereunder entirely as Producer's "employee for hire" and that the music shall be a "work for hire" within the meaning of the Copyright Act, Article 17 of the United States Code. Without limiting the generality of the foregoing, Producer shall be entitled to all worldwide copyrights in said music, including statutory copyright and all renewals and extensions thereof, as copyright proprietor, it being agreed that Producer is the author-at-law of all such music hereunder. Producer shall similarly be the unrestricted owner in perpetuity of all rights of every kind or nature, now or hereafter known, in and to all physical material created, furnished, made, copied, manufactured or delivered by Composer hereunder, including, without limitation any and all arrangement, orchestrations, copies, parts, recordings and tapes, and the copyright therein from their inception.

b. Without in any way limiting the generality of the foregoing, Producer shall have the exclusive right to use, and to license others to use, the Music and recordings of the Music in and in connection with the Picture and the advertising and publicity therefor, including without limitation in the exploitation thereof in any and all media and by any and all methods or devices, in perpetuity throughout the world without limitation or restriction, without payment by Producer or any other distributor of the Picture of any compensation therefore except as set forth in paragraph 4, including, without limitation, the following rights:

i. the right to use the Music in synchronization with the Picture and parts thereof (including trailers and teasers), and all sequels, remakes and other derivative works of any kind, and to transmit, perform, broadcast, telecast, and/or otherwise communicate the music in and in connection with the Picture and the advertising and publicity therefor by any means whether now known or hereafter devised, publicly for profit or otherwise, throughout the world in perpetuity; and

ii. the right to record, manufacture, release, distribute, advertise, exploit and perform recordings (on or by means of phonograph records, tapes or other methods or devices) of music from the soundtrack of the Picture or otherwise.

6. Warranty: Composer hereby warrants that Composer is free and able to enter into and fully perform this Agreement and to grant all rights herein granted. Further, Composer warrants that the music, in the form in which it is delivered, shall be wholly original with Composer or adapted from material in the public domain and shall not be copied from any other work other than works in the public domain and shall not, nor shall the use thereof, infringe or violate the copyright or any common law right or any personal, proprietary, or other right of any kind whatsoever of any person, firm, corporation, or association.
7. Indemnification: Composer shall indemnify and hold Producer, its successors, assigns and licensees, any stations over which the music shall be broadcast, the sponsors (if any) and any other parties who shall utilize the music or any part thereof in any way with Producer's permission, and the directors, officers, agents and employees of the foregoing free and harmless from any and all claims, damages, liabilities, costs and expenses, including reasonable counsel fees, arising out of any use of the Music or any part thereof, or arising out of any breach by Composer of any warranty or agreement made by Composer herein.
8. Credit: Provided Composer fully, promptly, and completely performs all of Composer's obligations under this Agreement, Producer agrees to accord Composer screen credit on each positive print of the Picture in which the music is contained. All other matters not expressly set forth in this agreement relating to credit shall be determined at Producer's sole discretion. No casual or inadvertent failure by Producer and no failure by or of any third party to accord the requisite credit herein shall be deemed a breach of this Agreement.
9. No Obligation to Use Music: Nothing contained herein shall obligate Producer to actually use the Music in the soundtrack of the Picture or in connection with the exploitation of Producer's rights in the Picture.
10. Assignment: Producer shall have the power and authority to assign its rights and obligations under this Agreement to any party whatsoever

without Composer's consent. This Agreement is binding upon and shall inure to the benefit of the respective successors and/or assigns of the parties hereto. Furthermore, this Agreement shall inure also to the benefit of all persons who may hereafter acquire the right to distribute, exhibit, advertise and/or exploit the Picture or any of the results and proceeds of Composers' services hereunder.

11. Breach: In the event of any breach of any provision of this Agreement by Producer, Composer's sole remedy will be an action at law for damages, if any, and in no event will Composers be entitled to seek to enjoin, interfere with or inhibit the distribution, exhibition or exploitation of the Picture.
12. Entire Agreement: This Agreement constitutes the entire agreement between the parties and cannot be modified except by a written instrument signed by the parties hereto.
13. Applicable Law and Jurisdiction: This Agreement shall be governed by and interpreted in accordance with the laws of the State of _____ applicable to agreements made and fully to be performed therein, and Composers consents to the jurisdiction of the courts of the State of _____ and the federal courts located in _____.

IN WITNESS WHEREOF, the parties have caused the foregoing to be executed as of _____, year _____.

COMPOSER:

PRODUCER:

Appendix E: Resources

The latest links are collected on this page:

<http://www.dvfilm.com/links.htm>

Anamorphic Lenses

Optex website

<http://www.optexint.com>

Century website

<http://www.centuryoptics.com>

Cameras

Canon

<http://www.canondv.com/>

Sony

<http://www.sonystyle.com/>

JVC PRO

<http://www.jvcpro.com/>

Panasonic

<http://www.panasonic.com>

DV Editing Software

Final Cut Pro

<http://www.apple.com>

Premiere

<http://www.adobe.com>

Vegas Video
<http://www.sonicfoundry.com>

DV Film Maker
<http://www.dvfilm.com/maker>

DV Information Sites

R. Zane Rutledge's DV FAQ
<http://www.rzanerutledge.com/dv/dv.html>

Zero Cut
<http://www.zerocut.com/>

Adam Wilt's DV Site
<http://www.adamwilt.com/DV.html>

Frank's Homepage (auf Deutsch)
<http://www.fml-home.de/videoamateur/>

About.com's DV page
<http://desktopvideo.about.com/compute/desktopvideo/>

Widescreen Information Site
<http://members.macconnect.com/users/b/ben/widescreen/index.html>

Unhollywood
<http://unhollywood.com/>

Film Festivals

Ann Arbor Film Festival
<http://aafilmfest.org/>

Austin Film Festival
<http://www.austinfilmfestival.org/>

Berlin Film Festival
<http://www.berlinale.de/>

Cannes Film Festival
<http://www.festival-cannes.fr/>

Chicago International Film Festival
<http://www.chicago.ddbn.com/filmfest>

Chicago Underground Film Festival
<http://www.cuff.org/>

Cinequest - San Jose
<http://www.cinequest.org/>

Florida Film Festival
<http://www.floridafilmfestival.com/>

Hollywood Film Festival
<http://hollywoodawards.com/>

LAIFF
<http://www.laiff.com/>

London Film Festival
<http://www.lff.org.uk/>

Nantucket Film Festival
<http://www.nantucketfilmfestival.org/>

New York Film Festival
<http://www.filmlinc.com/>

Palm Springs Film Festival
<http://www.psfilmfest.org/>

ResFest Digital Film Festival
<http://www.resfest.com/>

Slamdance
<http://www.slamdance.com/>

Sundance
<http://www.sundancechannel.com/festival00/>

SXSW
<http://www.sxsw.com/>

Taos Talking Picture Festival
<http://www.ttpix.org/>

Telluride Film Festival
<http://www.telluridefilmfestival.com/>

Toronto International Film Festival
<http://www.bell.ca/filmfest/>

Digital Distribution

IFILM
<http://www.ifilm.com/>

Reelmind
<http://www.reelmind.com/>

Video to Film Transfers

DVFilm

<http://dvmfilm.com>

Swiss Effects

<http://www.swisseeffects.ch>

4MC

<http://www.4mc.com>

Efilm

<http://www.efilm.com>

Digital Film Group

<http://www.digitalfilmgroup.com>

Filmout Express

<http://www.filmout.com>

Legal Resources

Mark Litwak's Site

<http://www.marklitwak.com>

Mike Tolleson's Site

<http://www.miketolleson.com>

More links at <http://www.dvmfilm.com/links.htm>

Appendix F: Video to Film Transfer Methods

There are three different methods of transferring video to film: kinescope, EBR, and film recorder.

Kinescope

Kinescope is the original technology developed for transferring video to film. It was designed in the 1950's to record live broadcast television shows so they could be copyrighted and archived by the television company. At that time, videotape did not exist and 35mm film was the only way to make a permanent record of a moving image. Kinescope works by taking the 60 fields per second in an NTSC video, and dropping 36 of those fields to convert it to 24. The remaining fields are then displayed on a television screen and exposed onto film. Kinescope typically records directly to 35mm print film (or reversal stock) and the sound track is recorded simultaneously.

Kinescope transfers are the least expensive transfers because the process occurs in real time, and no extra film printing is required. A typical rate for kinescope is \$90 to \$150 per minute. The disadvantages of kinescope are that it looks even worse than projected video. There are motion artifacts due to the simple frame rate conversion method, and often scan lines are visible in the print.

EBR

EBR, or Electron Beam Recording, is a step up from kinescope. The videotape is captured real-time and converted with electronic circuitry into a 24 frames-per-second progressive scan video signal. Unfortunately, although this conversion is more sophisticated than kinescope, some EBR conversions use a 3:2

pull-down method which exhibits motion artifacts in camera movement.

The 24 fps video signal is separated into red, green, and blue components, and the resulting signals drive an electron beam which exposes black-and-white film stock, exposing three successive frames of red, green, and blue. The black-and-white film is then printed with an optical printer through colored filters onto color film.

There were two practitioners of EBR: 4MC and Sony.

4MC (The Four Media Company, also known as Image Transform) uses an EBR machine that was built by NASA to record space mission videos to film. They always record to 16mm black and white film first, and then optically print to either 16mm or 35mm color negative. 4MC also does film-recorder transfers (see below).

Sony used a 35mm EBR machine which was developed for HDTV to 35mm film transfers. It recorded to black-and-white 35mm film which was then optically printed to 35mm color film. If you gave them an NTSC or PAL videotape, they had to convert it to HDTV first before the transfer. In 2002, Sony closed the High-Definition Center where these transfers were made.

The advantages of EBR are improved resolution (no scan lines are visible) and improved smoothness. The cost of an EBR transfer varies from \$450/minute to \$600/minute including the soundtrack and print.

Film Recorder

The highest quality method to record video to film is with a film recorder. It is also the slowest method, far slower than EBR or kinescope. The video is captured into a computer system, and then

by means of computer software is converted to a 24 fps still-image sequence. Because the conversion is software-based, this method provides the greatest degree of adaptability in the conversion. The still-image sequence is then recorded to 35mm color negative with a film recorder. A film recorder is a device which was invented in the 1980's for recording visual effects and computer animation to film. Film recorders can operate at almost any resolution, up to 4000 lines if required. Some of them use monochrome cathode-ray tubes (CRTs) and color filters, some use color CRT's, and others use multi-spectral laser beams to expose the film with colored light. The film recorder exposes color negative film, which is then contact-printed to print film. The soundtrack is recorded separately and combined with the image during the process of making the print.

The cost of a film recorder transfer varies widely. It can be less expensive than EBR, or more expensive, depending on which company is doing the transfer. DVFilm charges \$350/minute, Swiss Effects around \$500/minute, and Efilm about \$800/minute. The rate may also be lower for longer projects.

The rates I give here are based on each company's public information as of March 2000, and may change. You should use this information as a rough guide only, and get a quote from each company when you're ready to transfer your film. DVFilm's current rates are available on-line at www.dvfilm.com/specials.htm, and you can estimate the total cost of your transfer with the interactive rate calculator on that page.

The following table summarizes the methods, quality, and cost of each method:

Method	Motion Artifacts	Visible Scan Lines	Approx cost \$/min for DV to 35mm
Kinescope	•	•	90-150
16mm EBR	•		450
Film Recorder			325-800

Laser vs. CRT Film Recorder

The laser recorders were introduced around 1999 to speed up the film recorder method. Laser recorders are faster, and also have the advantage of being able to place a precise amount of color on each point of the screen, whereas CRT film recorders sometimes suffer color variations from one part of the screen to another. Some companies, like DVFilm, continue to use the CRT recorder but have corrected out these errors using software calibration. The CRT recorder method, once corrected, is comparable to the laser recorder in quality.

The filmmaker should always send a short sample to each company and compare results before ordering a long transfer. Most transfer companies will do a 1-minute test for about \$250.00 if you have a completed film.

Appendix G: Making a Film with a 24P DV Camera

The introduction by Panasonic of the DVX100 and later, the DVX100A and Canon XL-2, has changed the scene dramatically for filmmakers wanting to shoot on DV. For the first time, it's now possible to acquire your image at 24 frames per second, in widescreen, just like it is meant to be presented on 35mm film and on DVD. Why edit at 24P? Because then you are creating the movie as it will be seen on film. Plus it will be easier to make slow- and fast-motion effects that look good on film, and it will be easier to apply digital effects or combine computer animation with live action. Also it is easy to convert it to PAL for European distribution.

Here are my recommendations for using the DVX100, DVX100A, and Canon XL-2.

Needed Accessories

Other than the camera you will need a good shotgun microphone (as described in Chapter 7). There is one other thing you are going to need for the DVX100, and that is an optical 16:9 anamorphic adapter. It's true that when using these adapters your zoom range is limited. You cannot zoom all the way in to very distant objects, because the adapter will not focus sharply on distant objects. However for 99% of all shots you will find in a typical movie, the adapter is fine. For those other shots you can shoot with the camera's built-in 16:9 letterboxed mode (DVX100) or electronically squeezed 16:9 mode (DVX100A only). Fortunately the extra sharpness in the DVX100 progressive-scan modes allows that to be done. But you will still get better sharpness and a smoother look by using the adapter lens for the majority of your shooting.

The Canon XL-2 can shoot native 16:9 and does not require an adapter.

In addition to your camera's manual you might wish to get Steve Mullen's guide to using the DVX100/100A. It is emailed to you as a PDF document and you use Adobe Acrobat to print it out. See www.mindspring.com/~d-v-c for details on ordering. Also Barry Green's guide for the DVX100 is really good, and comes with a sample DVD. See dvxuser.com

No guide is presently available for the XL-2, but DVFilm has suggested settings for the XL-2 at dvfilm.com/xl2 and they are also printed here later in this chapter.

Suggested Camera Settings for the DVX100

The suggested settings, and discussion of each, for the DVX100 are as follows (the latest version of this can be found at dvfilm.com/dvx100):

SHUTTER = OFF (1/50th).

1/50th is a close match to many film cameras. 1/60th sec may be used to reduce flicker with florescent or arc lighting in 60Hz countries (like the USA). Some filmmakers may also want to try 1/48th sec by using the syncro scan feature. There is very little difference between 1/48th and 1/50th. Regarding 1/24th sec, which is possible with this camera, this setting will create an excessive amount of motion blur. However it may be interesting as an effect for flashback scenes, montage or music video sequences or the like. Higher shutter speeds are possible as well. Unlike regular NTSC cameras, there is no technical reason why high shutter speeds cannot be used, except that it will look somewhat strange. High shutter speeds are rarely used in movie making. It was used for effect recently in "Gladiator" "Three Kings" and "Saving

Private Ryan." If you rent these on DVD you can see the effect. For most shots, though, it's better to use ND filters in high-brightness situations.

ATW (Auto Tracking White Balance) = OFF

This setting turns off the auto tracking white balance, which continuously adjusts the white balance. This would be inappropriate for controlled film lighting situations.

SCENE FILE SETTINGS:

DETAIL LEVEL = -3

Detail level controls the amount of sharpening of the image performed by the camera. A setting of -3 will counteract some of the natural amount of smearing that the CCD sensor produces. Settings higher than -2 however may result in too much sharpening and will result in a "video" look where bright edges have a dark outline around them, or dark lines have a bright ring. This sharpening might look good on a cheap TV but is not good for transfer to film.

If you have a monitor with >500 lines resolution you can pick your own setting for DETAIL LEVEL, paying attention to the appearance of vertical edges. Capturing frames and looking at them with Photoshop at 600% enlargement is also a good idea.

CHROMA LEVEL = 0

CHROMA PHASE = 0

COLOR TEMP = 0

These settings control the color saturation, hue, and balance of the camera. These adjustments are probably better done in post-

production, if they are necessary at all. A value of 0 (zero) for each will leave the color untouched.

MASTER PED = -6

Master pedestal controls the black level of the camera. -6 gives you a standard level that will transfer well to film. More negative values push the black levels down ("crushing the blacks") but may cause you to lose shadow detail in the data that is recorded to tape.

A. IRIS LEVEL = -3

Panasonic recommends an auto iris level of -3 for Cine-gamma (see following). However this may result in insufficient exposure for typical scenes. The iris should really be in manual control (where this setting has no effect), and set by the cinematographer based on viewing a studio monitor.

GAMMA = CINE-LIKE (or CINE-LIKE-V for the DVX100A)

Cine-like gamma results in the least amount of contrast enhancement performed by the in-camera circuitry, which is generally good for capturing accurate color in very bright areas.

SKIN TONE DTL = OFF

This feature is best turned off unless you have specific need for it. It selectively blurs areas of the screen with skin color (presumably Caucasian skin). I think this is an effect best done in post-production, if ever.

MATRIX = NORMAL

The Cine-like color matrix present warmer, more film-like tones, but adds processing to the color signal which is probably better done in post-production. So use the NORMAL matrix setting.

V DETAIL FREQ = THIN

This setting is very important for transfer to film. It turns off the vertical blurring which is intended to reduce flicker on NTSC monitors. Flicker reduction is best done in post-production using DVFilm Maker's deflicker feature, after the transfer to film.

PROGRESSIVE = 24P(ADV)

This setting is also very important, and allows DVFilm Maker to convert the NTSC capture files to 24P Quicktime without degradation of the image. *Always shoot in 24P Advanced Mode.*

CAMERA SETUP:

ASPECT CONV = NORM (4:3)

This setting turns off the 16:9 letterboxing. The only reason to use 16:9 letterboxing is if you are shooting widescreen and you have to take the 16:9 anamorphic adapter off of the camera for some reason (like to shoot an extreme telephoto shot).

The DVX100A also has electronic 16:9. Use this only if you cannot get the shot with the optical 16:9 adapter.

SETUP = 0%

This sets the camera to standard levels for a black picture. Your NTSC monitor must be set to the same value if possible.

SW MODE:

(SW when it appears in the DVX100 camera manual, means "Switch" and refers to a switch, button, or control on the camera).

ATW = OFF

This turns off the Auto Tracking White balance as discussed before.

RECORDING SETUP:

REC SPEED = SP

You must record at standard playback speed for adequate quality and minimal dropouts on the tape.

AUDIO REC = 16BIT

16-bit audio quality must be used for theatrical-quality recording.

DISPLAY SETUP:

ZEBRA DETECT 1 = 95%

ZEBRA DETECT 2 = 100%

These zebra settings will alert you when light levels exceed the range of the CCD sensor. Generally speaking, large areas of the screen should not be allowed to go into white clipping (but it's OK for point-like highlights here and there). If you do have large areas in white clip, the solution must be to either stop down the iris, change the lighting, use neutral density filters on interior windows, or UV and polarizing filters for outdoor sky.

Lower zebra settings are unnecessary because the camera, in cine-gamma mode, will not lose color information until the brightness level is over 100%.

However ZEBRA DETECT 1 = 80% can be used as a quick spot-meter function (as suggested in Steve Mullen's book on the DVX100) to set Caucasian skin tones just below 80%.

OTHER SETTINGS

The DVX100A has many other settings but these are a matter of personal taste and will not affect the transfer to film in any bad way. But be sure to check the results of the settings on a high-quality studio monitor with at least 500 lines resolution (700 lines or more is ideal).

Differences between the DVX100 and DVX100A

There are no significant differences between the DVX100 and DVX100A that affect the shooting or editing process, or a transfer to film. The DVX100A has improved, 12-bit accuracy and performance when using the in-camera settings that change color balance, gamma, and saturation, but I recommend these features be set to zero because these are better adjusted in post-production (unless a drastic effect is desired). The DVX100A has built-in 16:9 anamorphic mode, but this mode is not recommended over the optical 16:9 adapter. The DVX100A has fixed the audio delay problem discussed later in this Appendix. Also the DVX100A allows you to use auto-focus, high gain, and slow shutter speed settings that did not work or were not provided in the DVX100 in 24P mode. However none of these features are recommended for film production.

Camera settings for the Canon XL-2 (latest version at dvwfilm.com/xl2)

FRAME RATE = 24P

Never shoot 30P with this camera, it cannot be converted to 24.

SHUTTER = 1/48TH. 1/60th sec may also be used, but only to reduce flicker with florescent or arc lighting in 60Hz countries (like the USA). Use 1/50th sec for florescent/arc lights in 50Hz countries (Europe).

PROGRAM AE (Auto Exposure) = OFF

This setting must be used to prevent the camera from using high shutter speeds.

ASPECT RATIO = 16:9 (for transfer to 35mm)

2:3:3:2 PULLDOWN

2:3:3:2 pulldown is similar to the 24PA mode in the DVX100. Never use 3:2 pulldown.

GAMMA = CINE

Cine Gamma yields the lowest contrast image which is better for transfer to film.

COLOR MATRIX = Normal

Color matrix setting is a matter of taste, change this if you want.

KNEE = Medium

BLACK = Normal

Knee and black levels are important to get a low-contrast image that will transfer well to film.

VERTICAL DETAIL = Norm

This setting is very important for transfer to film. It turns off the vertical blurring which is intended to reduce flicker on NTSC monitors. Flicker reduction is best done in post-production using DVFilm Maker's deflicker feature, after the transfer to film.

CORING = 0

Coring is a noise reduction method, but the bluriness it may add to images is not worth it.

SHARPNESS = 0

Do not use high levels of sharpness even though it may look better on some televisions.

NOISE REDUCTION = OFF

Noise reduction may reduce resolution, so leave it off.

COLOR GAIN = 0

Color gain might be turned up since the Canon XL-2 has a less saturated look. This is a matter of taste, though.

COLOR PHASE = 0

Color phase is used mainly to balance color between cameras. If you are using only one camera, leave this off.

FILM GRAIN = OFF

The FILM GRAIN feature was removed for later versions of the XL-2. Do not use it, it's better to add film grain effects in post, if necessary.

TOTAL IMAGE CONTROL = 0,0,0

Total image control is also used mainly to balance color between cameras. If you are using only one camera, leave this off.

SETUP LEVEL = 0

Setup level is important to get the right black levels for a good transfer to film.

SKIN TONE DETAIL = 0

Skin tone detail is used to blur out skin on Caucasian faces. Do not use it. If you need to make faces look younger, use diffusion on your light sources.

AE SHIFT = N/A

AE LOCK = N/A

These are auto exposure functions and you should not use them, always use manual exposure.

ZEBRA PATTERN = 100%

See discussion on zebra patterns for the DVX100.

AUDIO = 2-channel (16-bit).

Always record 16-bit audio for best quality.

24P Editing for the DVX100/A and XL-2

The NTSC version of the DVX100 was marketed with the idea that you can shoot 24P but capture, edit, and master your final product all in the NTSC format. Same goes for the XL-2. This is true, but it does not take full advantage of the fact that the cameras acquire images at 24 frames/sec. If you do edit at 24P, you will be creating the movie as it is going to be seen on film, and on a 24 fps progressive-scan DVD. Adding visual effects will be much easier, creating motion effects (fast and slow motion) and integrating with computer animation will be much easier and hassle-free. The transfer to film will be easier, less expensive, and higher quality. There are only two things you will need to edit at 24P, and that is DVFilm Maker and an editing program that works at 24 fps. Most full-featured editors (the ones costing more than \$200) can edit at 24P. Also you have to make sure you shoot in the 24P Advanced mode, as described previously in the camera settings discussion. Also instead of using Maker to convert clips to 24P, the latest versions of Final Cut Pro (4 or HD), Avid Express Pro, Vegas Video (5), and Premiere Pro (1.5) will capture DVX100 footage and allow you to edit at 24 fps. If you have these programs Maker is only useful for converting regular interlaced video to 24P (to incorporate footage from non-24P cameras) or to convert your final cut to NTSC.

How to Use DVFilm Maker with the NTSC DVX100 and XL-2

In the case of footage shot in 24P Advanced mode or 2:3:3:2 pulldown on the XL-2, here is how you use DVFilm Maker: The shots you need are captured with your regular video capture/editing software, in its NTSC-DV editing mode. Then the video clip is opened with DVFilm Maker. Select Process->View Options, 24P Options. You select remove 2:3:3:2 pulldown and can select either a 24P conversion or a 23.976P conversion. Since the source material is 29.97 fps (the standard frame rate for NTSC) and Maker removes exactly 1 out of 5 frames, the output frame rate is going to be 4/5 times 29.97, or 23.976. Some video editors work at 23.976 and some must be used at 24.000. For the ones that only do 24.000, Maker provides the alternative choice of converting to exactly 24.000 fps (.1% faster) and speeding up the audio by .1% to match. In this case it means the audio must play back at 48048 Hz instead of 48000 Hz. (or 48KHz). The choice you make on which mode to use depends on the editing software you are going to use. Here is a brief discussion of each one:

Mac Platform

Final Cut Pro - FCP 4 has been tested to work at 23.976P/48Khz so that is the best option to use.

Final Cut Express - FCE will not edit at 24 fps or 23.976 fps. You have to upgrade to FCP.

iMovie - iMovie has the same problem, you cannot set the timeline to 23.976 or 24 fps. iMovie can be used to capture or playback your NTSC clips, but some other program (like QT Pro) must be used to edit at 24.

Mac or Windows Platforms

Versions of Premiere 5.1 through 6.5- Use 24P. The Premiere 6 timeline can be set up for 23.976, but due to a bug in the program it will only export at 23.98 exactly. This causes movies more than 4 minutes long to go out of sync. So you have to use 24.000 fps. The thing to remember when using 24.000 fps is the audio must then be 48048, and some Mac hardware will not play back audio at this special rate. Most Windows computers will play back 48048 Hz audio with no problem.

Quicktime Pro - QT Pro has very basic editing functions and it can work with 23.976 video. But it can only export video at 24.000 fps, so 24.000P is the best method to use with QT Pro.

Avid - Avid Express Pro will edit at 23.976P but not Express DV or Free DV. Also you have to use Avid Mojo, their hardware playback device, to convert 24P to NTSC in real time.

Windows Platform Only

Vegas Video - Use 23.976P. Vegas Video works well at any progressive-scan rate.

Editing at 24P

To start editing at 24P, you have to setup a 24P or 23.976P timeline in your editor. Each editor has different ways to do this, but the important thing is to set the timecode or timescale to 24 frames/sec, the playback rate to 23.976 (or 24.000 if it does not support 23.976) and the field order to "none" or "no fields". Also

when it comes time to export an edited scene, the export settings will have to be set exactly the same.

Premiere 5.1 through 6.5 using 24P

These older versions of Premiere cannot edit 24P in the "DV Playback" mode or the Windows Media mode. You have to use the Quicktime editing mode. The same is true of other Windows-based editors. The original version of Premiere Pro (1.0) cannot edit 24P Quicktime. You have to use Premiere Pro 1.5 (which supports the DVX100 and XL-2 directly) or the older versions of Premiere.

Aspect ratio

Some editors require you to specify the pixel aspect ratio. 4:3 (standard) NTSC has a .9091 pixel aspect ratio. 16:9 (widescreen) NTSC will have a 1.2121 pixel aspect ratio. When you set the pixel aspect ratio correctly, the editor will show you the frames in their correct proportions.

24P Quicktime clips

Your Quicktime clips generated by DVFilm Maker are brought into the timeline and edited normally. In some cases the editor may not know the pixel aspect ratio of the clip and sometime you may have to set that before dragging the clip into the timeline (Vegas Video is that way).

48048 Audio

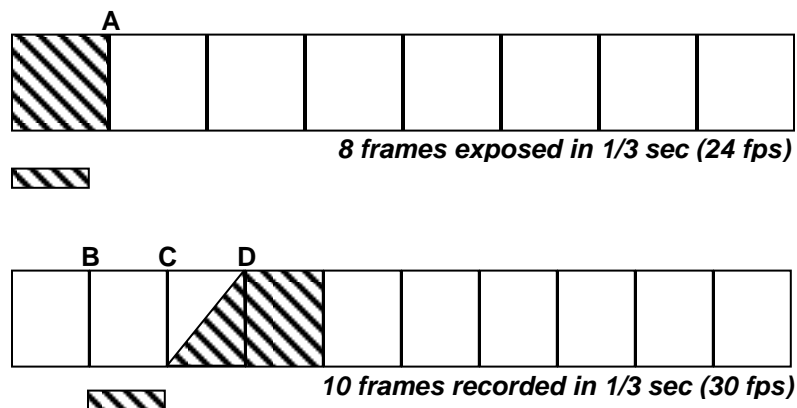
If you're using Premiere and 24.000 frames/sec playback rate, the project settings for audio playback rate must be set to 48048 Hz (select "Other" and type in 48048) for the audio to playback in sync on long clips (more than 30 seconds).

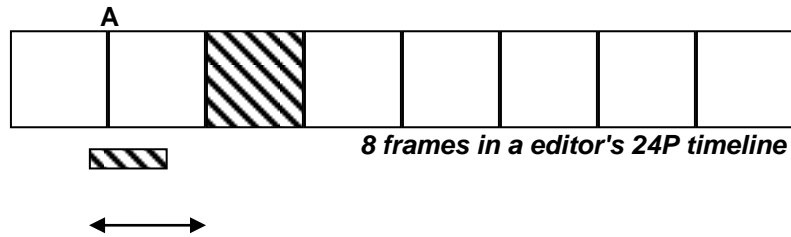
DV Film Maker automatically sets the audio playback rate of a clip to 48048 when the 24.000 fps option is chosen. If you bring audio sources from CD's, MP3's and the like, you must first resample these audio tracks from 44.1KHz to 48048 Hz before bringing them into the Premiere timeline. This resampling is best done with Sound Forge (www.sonicfoundry.com). If the clip is already at 48 KHz, the audio rate can be changed to 48048 without resampling (this is an option in Sound Forge). Using 48048 means that your audio is playing back .1% faster than normal, which is not noticeable. But when the final cut is converted back to NTSC, the playback rate is converted back to 48000 Hz by DV Film Maker (see following step).

Audio Delay

As of this date all Panasonic DVX100's record the audio slightly out of sync in the 24P Advanced mode. DV Film Maker corrects for this problem automatically when converting from NTSC capture files to 24P Quicktime. Use the default setting unless you have done exact tests on what to set the audio delay factor. The DVX100A fixes this problem and the delay is zero. For the XL-2 the delay is also zero.

An explanation of why the audio is recorded out of sync on the DVX100 is illustrated here:





The cross-hatched frame is exposed in 1/24th of a second. The exposure ends at "A", and it is too late to record it at "B" because the NTSC frames are shorter in duration than a 24P frame (only 1/30th of a second vs 1/24th). It is too late at "B" so the next opportunity to record the cross-hatched frame is at "C". That frame is a split field frame (see explanation in Chapter 5 on split-field frames) and it is recorded in one field there and again at "D". The audio, in the meantime, is recorded as soon as the audio frame buffer is full, at "B".

When the NTSC tape is captured and converted back to 24P, the split-field frames are dropped. So the cross-hatched frame becomes the third frame in the sequence. But the audio for that frame still starts at "B" so it is off by about 1-2 frames. DVFilm Maker corrects for this error, so if you use Maker to convert your footage you will never actually see this offset.

Getting Your Final Cut to Film

The best way to deliver a 24P/25P final cut to the film transfer company is to export a 24P/25P Quicktime and save it on a Firewire drive. Check with the company to make sure they can handle it (DVFilm can). The exact rate of the Quicktime can either be 23.976 fps with 48000 Hz audio, or 24.000 fps with 48048 Hz audio, whichever matches the setting on your timeline. In either case the final frame rate on film will be 24.000 fps. For 25P it will be 25.000 fps and 48000 Hz audio.

Choosing Compression Method

When you deliver your film on a hard drive, you must choose which compression method to use, if any, to encode the video. The compression method is chosen when you select the Quicktime file format in your editor's export settings.

If the digital-to-film transfer house is going to be doing your scene-to-scene color correction, and either none or very few of your scenes have any color correction in them yet, then the DV-NTSC compression can be used, which will result in no recompression of your data.

Another option is to use uncompressed component video (YUV) format Quicktime for the final output. This will take up a lot of hard drive space, about 700MB per minute. A third option is to use M-JPEG compression at 100% quality level. This takes up less space than component video format, but the quality is nearly equal to uncompressed video.

Getting Your 24P Final Cut to NTSC Video

You have to convert your 24P final cut back to NTSC for broadcast or presentation on video. DVFilm Maker can be used to convert 24P Quicktimes back to NTSC DV-AVI's (for the Windows platform) or NTSC Quicktime (for the Mac platform) for mastering back to video tape. The option you would normally use in the 24P Options popup is 3:2 pulldown with a deflicker setting of 2. A deflicker value of 2 does a little bit of blurring in the vertical direction only, to make sure that horizontal lines do not flicker on an NTSC interlaced monitor. What is flicker? Flicker happens when a horizontal line is so thin that it appears in one field only and will disappear entirely when the other field is being scanned out to the television. The solution is to blur the frame so that a little bit of light leaks into the other field, reducing the effect.

DVFilm has deflicker settings from 0 through 4. The settings might be characterized as follows:

Deflicker Settings

- 0 = no deflicker
- 1 = minimal deflicker, usually not enough
- 2 = medium deflicker
- 3 = more deflicker, might result in some visible softening
- 4 = visible softening of the image on a high-quality monitor

Converting 24P to PAL

PAL video is required for broadcast in Europe and most parts of the world outside the Americas. Eventually DVFilm Maker will have the capability to convert 24P Quicktime to PAL (25 fps). At the time of this writing it does not. However it can be done with most editing programs using this procedure:

1. Split up your film into 20-min "reels" or segments. Put head and tail sync marks with beeps on each reel. These will be taken out later before you record to tape.
2. Export from the timeline a BMP, TIFF or JPEG image file sequence for one reel. The frame size should be set to 720 x 576 instead of 720 x 480, and if there is an option to use high-quality rendering (in Premiere called "better resize") then use it. Note that even though the frame size is different, both PAL and NTSC have the same aspect ratio once viewed on an NTSC monitor.
3. Export from the timeline 3 different 48000 (or 48048) Hz WAV or AIFF files each containing the 1)music, 2)dialog and 3)sound effects.

4. Time-reduce each of the sound files by the ratio 24/25 (96.0%) using Sound Forge (Windows), ProTools (Mac) or similar program. The new audio track will be 96% of its original size and running length. If the sample rate is 48048, change the sample rate at this time to 48000 without resampling.
5. Open an empty PAL DV project and import the image file sequence into it at 25 fps. Bring in the time-reduced audio tracks which should all be at 48000 Hz. Check the time-reduced tracks against the head and tail beeps to make sure they're in sync. Export the movie into a DV-PAL 25 fps Quicktime or DV-AVI. Bring all your PAL exported reels into another timeline, cutting them back together and removing the sync pops, then record to tape using a PAL MiniDV Camera or a dual-format DVCAM deck such as the Sony DSR-11.

More Information on Time Reduction used to convert 24 to 25 fps

Time reduction speeds up your sound track without changing the pitch of the audio, which would make male voices sound like female voices and make female voices sound like chipmunks. How does time reduction work? It breaks up your audio into chunks, puts a little fade at the beginning and end of each chunk, and then cross-dissolves the chunks back together again. This usually works great, except in the following circumstances: a short but critical sound like a "t" sound in dialog gets dropped out between the chunks; the cross-dissolve distorts an "s" sound; the cross-dissolve changes the phase of a pure note of music or creates a warble in the note. For this reason, you should always time-reduce your tracks separately, check them for quality, and then mix the results together, rather than trying to time-reduce your entire mixed track in one step. Sometimes it's better to speed up music rather than time-reduce it, and accept the change in pitch. If it's original music most people will not notice the change in pitch or tempo. Voice-over narration and occasional sound effects do not need to be time-

reduced, either, just re-edit the tracks in the PAL timeline to decrease the amount of silence between each "cut".

Speeding Up a Track Instead of Time-Reducing It

To speed up a track rather than time-reduce it, which may be more appropriate for music and sound effects, use the following method in Sound Forge: Choose Process->Resample and change the sample rate from 48000 (or 48048) to 46080 with re-sampling. Select the anti-aliasing filter. After the resample is done, choose Process->Resample again and change the rate to 48000 **without** re-sampling. The new file should be about 96% the size of the old file, and will be slightly higher in pitch and tempo.

A similar procedure would be used in ProTools.

Using the PAL DVX100 and PAL XL-2

The PAL version of the DVX100 and Canon XL-2 are used in a different way to create an output to film. The settings described for the NTSC camera are all valid except the setting for 24P Advanced. The mode should be set to 25P instead, or progressive.

The 25P video is captured in the PAL editing mode and put together very much like a regular PAL video project, except that the field dominance setting of the editing program should be set up for "none" (no fields) instead of upper field first.

For transfer to film, the project can be submitted to the transfer company on PAL MiniDV tape, or as a PAL Quicktime on Firewire hard drive. The film transfer company handles the time-expansion of the soundtrack from 25 to 24 frames/sec. Very likely they will request separate tracks of audio for music, dialog and sound effects, so it's best to prepare them in advance and provide the tracks on CDROM or on the hard drive. You can also attempt

your own time-expansion using a process that is the opposite of the time-reduction process described in the previous paragraphs.

Converting 25P PAL to NTSC

The PAL final cut can be easily converted to NTSC using DVFilm Atlantis (dvwfilm.com/atlantis). You take the 20-min "reels" from your PAL final cut, open them with DVFilm Atlantis, uncheck the Deinterlace feature (the PAL frames do not need deinterlacing since it is progressive-scan to begin with) and start processing. The resulting NTSC movie is then saved to a file and recorded to tape using an NTSC camera or NTSC tape deck.

Appendix H: Making a Film with an HDV Camera

Sony introduced the HDR-FX1 in late 2004, and the "pro" version HDR-Z1U in early 2005. The FX1 is the first affordable HD camera that can be used to make a transfer to film.

The FX1 has the potential to create a much sharper image for transfer to film than any DV camera. The frame size is 1440 by 1080, over four times the number of pixels as an NTSC camera. The camera does not have a high-quality 24P or 25P shooting mode, however interlaced video can be converted to 24P or 25P using DVFilm Maker, with excellent results.

The converted 24P/25P footage can be created with any suitable Quicktime codec/format, including MJPEG, YUV, and uncompressed (RGB) format, and then edited with any quicktime-capable editing system such as Premiere Pro, Vegas, Avid or Final Cut Pro. The frame size remains 1440 x 1080 all the way through the final cut and transfer to film.

There is a great advantage to converting the footage to true 24P/25P Quicktime before editing. The conversion to 24 fps is cleaner and higher quality, especially if slow- or fast motion effects will be applied in editing, vs. doing the conversion afterwards. 24P progressive-scan frames are easier to work with when applying motion graphics, composites, or other visual effects. Also the data size and performance requirements for playback are 20% less.

DVFilm will also transfer 1440 x 1080 frames to 35mm for the same rate as a PAL or NTSC transfer to film, provided the footage is supplied to them as 24P Quicktime on hard drive, and DVFilm Maker is used to do the conversion before editing. This results in a cost savings of about \$10,000 for a feature-length film.

I urge anyone making a feature film with this camera to send to DVFilm a 1 minute of test video before starting your project. The cost of the test on 35mm (silent) is \$250.00.

Suggested camera settings for the HDR-FX1 and Z1U:

Euro model: Shoot HDV-mode 50i (interlaced) 1/50th sec shutter speed.

US Model: Shoot HDV-mode 60i (interlaced) 1/60th sec shutter speed.

It's very important that you use the recommended shutter speeds for a successful conversion to 24 or 25 fps. Do not use Auto Exposure where the camera sets the shutter speed. Do not use CF25, CF30 or CF24 modes. These modes result in reduced vertical sharpness vs. the interlaced modes. Also CF30 cannot be converted to 24 fps.

Record dialog audio on the camera using a boom mike. The camera uses Mpeg audio compression, but it is high quality compression and more than adequate for spoken dialog. However music and sound effects for the film should be recorded on DAT or MiniDV (i.e. uncompressed) for highest quality.

Suggested Post production - Windows

Capture clips through Firewire with CapDVHS (a free program for Windows) download here: <http://home.earthlink.net/~weathersix>

Convert clips from 50i to 25P or 60i to 24P Quicktime with DVFilm Maker 2.1. Edit at 25P or 24P with a Quicktime-capable editing program such as Vegas, Avid or Premiere

Export 25P or 24P quicktime with no compression, or MJPEG compression at 100% quality, and provide to DVFilm on Firewire drive for transfer to film. The frame size throughout this process should be 1440 x 1080 anamorphic (widescreen).

Suggested Post production - Macintosh

Capture clips through Firewire with iMovie HD. Convert clips to Quicktime.

Convert clips from 50i to 25P Quicktime or from 60i to 24P Quicktime with DVFilm Maker 2.1 for Mac. (This software will be available in 31 Jan 2005).

Then edit at 25P or 24P with Final Cut Pro HD. Export 25P or 24P quicktime with no compression, or MJPEG compression at 100% quality, and provide to DVFilm on a Firewire drive for transfer to film. The frame size throughout this process should be 1440 x 1080 anamorphic (widescreen).

Real-time Playback Problems

The large frame size of the HDV cameras can make real-time playback of the video slow or jerky during the editing process. Editors can prepare in advance by putting together a faster computer if they know they are going to editing HD. For example, disk arrays, combined with fast 64-bit bus motherboards and fast, dual CPUs can make playback smoother and faster. There are also fast HD codecs like the Cineform codec (cineform.com). However until the technical issues settle out, you may be stuck with intermittent playback if you have an older computer. This does not mean you cannot edit accurately, it just means that rendering to a low-resolution format (like 24P NTSC 720 x 480) must be done to check the cutting of a scene in real time. Full resolution rendering is then used only to check individual frames or to transfer to film.

Since the cameras are new there may be changes and additional information on the best way to use them. The latest info on using the HDR-FX1 and HDR-Z1U can be found at dvfilm.com/fx1

Biography

Marcus van Bavel was born in Tempe, Arizona in 1960 and has lived in Texas for 45 years. He graduated from the University of Texas at Austin with a Bachelor's degree in Electrical Engineering, with additional studies in film production. He worked on several low-budget action pictures as a cameraman, and his first film as writer and director, **THE TEXAS COMEDY MASSACRE**, was selected by the Internationale Hofer Filmtage (Germany) and the Florence Film Festival in 1987. Parts of it also appeared on ABC Television's "America's Funniest People" in 1992.

REDBOY 13, his second film, was selected by the South by Southwest Film Festival in 1997 as the opening night film, and by the Film Society of Lincoln Center for Independent's Night, 1997. **REDBOY** was released on home video by Vanguard Cinema and is available on DVD and VHS from many on-line retailers (see redboy13.com).

Van Bavel built for his own use a geodesic-domed, 3600 sq-ft soundstage near Bastrop, Texas, for the production of **REDBOY 13**, and he lives in Austin with his wife Angélique and daughter Morgan Claire.

He is the owner and chief engineer of DVFilm Digital Transfers, a company which provides digital video to film transfers and software for independent filmmakers.

Some recent movies featuring his 35mm film transfer work include **SEQUESTRO EXPRESS**, **KUNGPOW: ENTER THE FIST** and **GUARD DOG** (Academy Award Nominee, Best Short Film).