INTRODUCTION

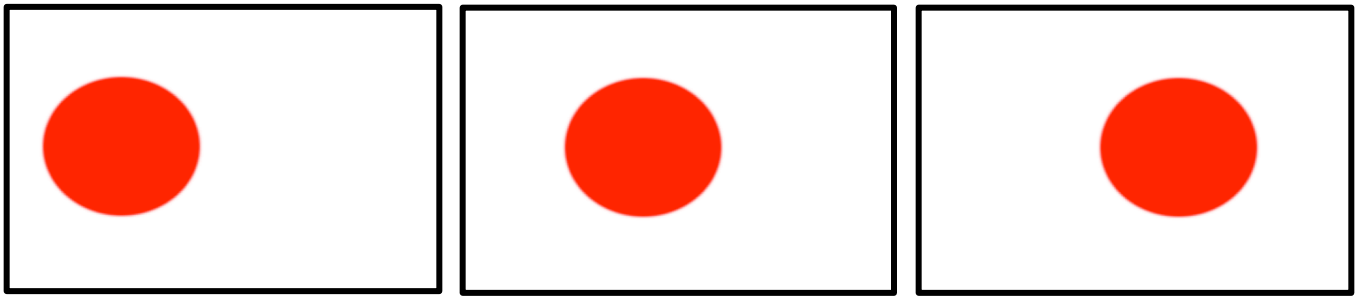
Since the beginning of film in the late eighteen hundreds there has been considerable confusion about how moving images work. Even today with the advent of high definition television a standard has yet to be set and confusion reigns supreme. With the advent of non-linear editing systems, personal digital cameras, and DVD burners, people can more easily create their own movies. However, with all this technology and the user-friendly functions the technology provides, a lot of users don't really know technically why things are the way they are. This lack of knowledge isn't too severe of a problem, but if something does go wrong the users have no idea how to fix the problem. They also don't know how to get the most out of the equipment they have.

Throughout this article I will focus on the different video standards—what they are and what they mean. I will also give a brief history of why video is the way it is and what I expect to see in the future. Great depth is not my objective here so if the reader wants to learn more I recommend an Internet search on the topic of interest. A lot has been written about video—it's just a matter of finding the information and verifying that whoever is providing the information knows what they are talking about.

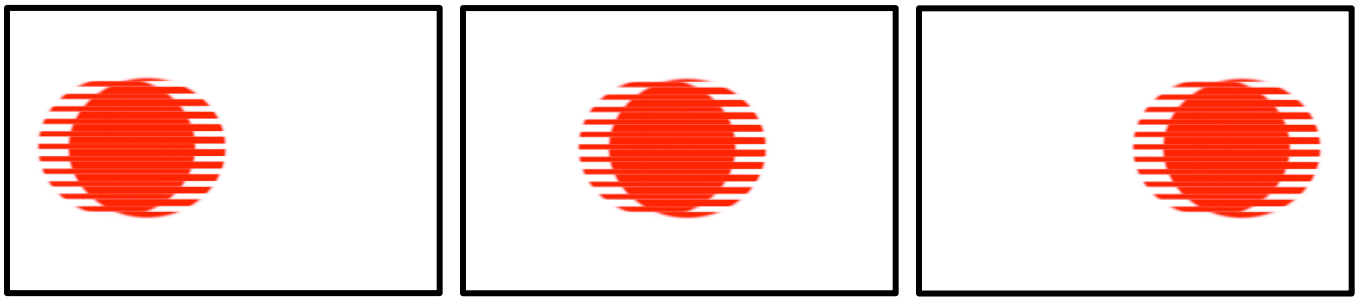
Film as a form of mass entertainment wasn't brought about until the Lumiere brothers entered the scene at the end of the 19th century and the beginning of the 20th. The Lumieres invented a camera that was loaded with a form of film and then hand cranked—exposing the film to the light. This procedure created a sequence of images that when played back created the illusion of movement. Because the speed of the images depended on the speed of the person cranking the handle, no standard was set for frame rates. Subsequently the Lumieres started having a lot of fun with variable frame rates. They learned that if they cranked slower when filming and then faster when playing the film back, they were able to make people and objects move faster. The reverse was also true so they would crank very fast and then play it back slowly to make things look slower. Interestingly enough, this technique is still used today. If a person wants something to look especially nice in slow motion, they need to increase their frame rate as high as they can and then play it back at normal speeds. By doing this, slow motion shots don't look as choppy.

STANDARDS TODAY

Today in America and other parts of the world, film is run at 24 frames a second. This means that 24 images are projected every second. Our brain interprets these images and creates motion. In America and some parts of the world, film runs at 24 frames a second; however in other parts of the world (mainly Europe), film runs at 25 frames a second. So that seems pretty simple, but the tricky matter is when we get into television. Televisions don't run at 24 frames a second—televisions don't even work with frames but work instead with what we call "fields." Televisions run at 29.97 frames per second, but really the rate is 59.94 fields a second. So what is the difference between fields and frames? To keep this simple, let me introduce another term known as "progressive." Progressive means that there are no fields. If a camera supports 24P or in other words 24 progressive frames a second that means the image basically looks like film. Progressive frames by definition don't have fields. Fields are horizontal lines that go across a television screen. When television was invented in the 1950's technology wasn't far enough along to project 30 progressive frames a second. Televisions draw the image out from top to bottom, filling in the lines as they go. But since television couldn't do 30 progressive frames a second, the inventors decided to do every other line. The mechanics were fast enough to draw in every other line, then go to the top and draw in the lines that the television missed the first time in a thirtieth of a second. This same technology has been going strong for almost 50 years. So there are really 60 images per second on a television screen—showing every other line 60 times. But when these images are looked at on a computer screen, the viewer sees both lines at the same time so it looks as if the images have jagged edges. The images below are an example of this phenomenon. The top line of images shows what film frames look like on a computer monitor, while the images below show what television frames look like on the same computer monitor. **Notice how these balls look nice and clean. This would look good in the theater, but on a television screen they would appear to look a little more choppy.**



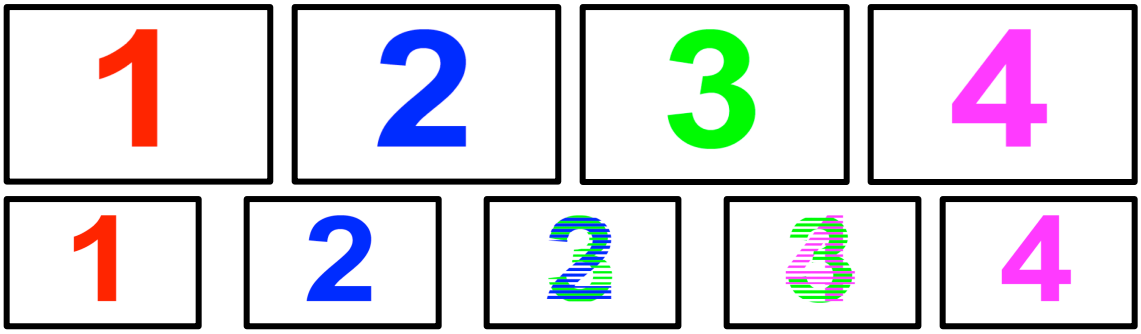
Notice on these balls how the edges are jagged. This looks flawed now but on a television would appear to have smoother motion than the other balls.



Just recently with the advent of HDTV the public is starting to see televisions that are capable of doing progressive frames. It's not that the technology wasn't there previously—computer screens project progressive images for example—it's just that switching an entire medium takes time and is a long hard process.

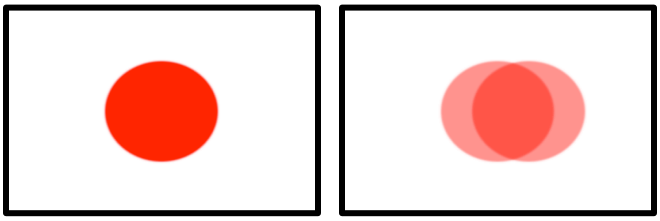
HOW DOES SOMEONE GO FROM 24P TO 29.97?

So the question arises, how does one go from 24P or film to television? The answer lies in the fact that if a person takes 24 over 30 and reduces it they get 4 over 5, so for every 4 frames of film we need to see 5 frames of television. The easiest way to do this is to just double the fourth frame. So the frames would go 1 2 3 4 4 1 2 3 4 4 and so on. This process works and is sometimes used today, but there is a better way that looks even cleaner on a television screen. This better process is called 3:2 pull down. Because there are really 10 fields in every television frame inventors decided to make it so that some of the frames were on for 3 fields and some on for 2 fields.



This example shows how this process works. The top four frames are what were originally shot. The five frames below show what is done so that the images look right on a television screen. Notice that the image of the number 3 on the second line is hard to read, but if that image were shown on a television it would look just fine because a

television shows the fields in a sequential order. The television would be leaving the image of the number 2 on for three fields and the image of the number 4 on for three fields. This way of going from 24 frames to 30 frames is the most common. So the inevitable question remains: Why do we need to know this? This knowledge is important because if the process is wrong the image looks really faulty. The interesting thing is that even today among professionals it can be done wrong. A good example of this is *The Incredibles*' DVD. "they may have fixed this, but the version I have" When watching the special features a person can see where someone screwed it up. Whenever the director moves fast his hands become lines, which means one of two things: they either got the 3:2 pull down wrong or had the wrong fields. Most systems today are what are known as "lower fields first." This means that the footage is expected to play with the lower field first. The example of the ball in fields is a good example. If the ball image were made lower fields first then brought into an editing program like final cut, when previewed on a television the ball's movement would be smooth. But if the ball was rendered upper fields first then brought into final cut it would appear as if two balls were there when previewed.



Lower Fields First **Upper Fields First**

If the ball was stationary no one would know the difference but because it is moving the motion gives away the problem. This is the same reason *The Incredibles* DVD looks fine when the director isn't moving, but when he waves his arms the viewer can tell something isn't right. If I had to guess, however, I would say *The Incredibles* problem is a 3:2 pull down problem. Some of the newer and nicer cameras have 24P, which is great if you know how to use it. The frame rate makes things look more filmic. However the mini-DV versions of these cameras are writing to a mini-DV tape which holds to the standard 29.97 frame rate. So to write to these tapes the camera

automatically does a 3:2 pull down on the fly. When a person captures from that camera you can tell the editing software to remove the 3:2 pull down, which basically tells the software to turn the film back into 24P. So a person can edit the footage in true 24P. The problem arises when the conversion back to 24P isn't done right. If you look at the 3:2 pull down image you will notice that the frames go whole, whole, slice, slice, whole. For simplicity, let's refer to that as WWSSW. However, what if someone were to cut the sequence right between the first W and S? Then the sequence would go SSWWW. But if the computer was trying to use the WWSSW formula on the SSWWW the result would just get ugly—and it does. Most of the time the computer is pretty good at guessing the pull down for the editor, but if the computer gets the frame rate wrong the editor would need to fix it by going in and telling the software what the correct pull down is.

The reason the editor needs to go back to 24P on the editing system is to keep the film consistent when doing titles, credits, or animations. They all need to be done the same way the footage was shot so the project all looks the same. Actually if a project is done in 24P when making a DVD, the creator can just leave the sequence in 24P because DVD players can play 24P movies—DVD players just do the pull down on the fly so that the movie looks good on the television.

THE FUTURE

If I had been asked a couple of years ago about the future, I would have said that when high definition comes around the industry will get rid of fields all together and just go to progressive frames. However, that is not the case. Two HD formats have arisen—actually more formats than that have been developed. One format is lower resolution that works with progressive frames and the other format is higher resolution that has fields. More recently the higher resolution has had a progressive option. This is 1080p. HD is here to stay. The question arises: Which of the two formats stick? The answer is: I don't know. Why film and television decided to run at different rates remains a question, but we have to know how to work with the standards we have. If a person doesn't know if they got the fields and the pull down right they should render it out to DVD and play it.

If it looks right it was done right; if it doesn't look right it needs to be gone through again. This process can seem overwhelming but after a person has worked with the process a while, it becomes second nature so they should continue to learn.

By Chris Wells

Update:

the HD formats are
720P which is 1280X720 progressive frames
1080i which is 1920X1080 interlaced
1080p which is 1920X1080 progressive

Now there are HDV cameras that shoot all kinds of crazy variations of this. Using square and mostly non square pixels. What do I mean non square. Well a TV/DVD resolution is 720X480 but it's pixels are taller than they are wide. If you used a square to measure it would be one high and .9 wide. So a perfect circle would look fat on a computer screen but round on the tv. That's DVD's

In HDV land. you have 1440X1080 so the pixels are 1.33 wide and 1 high. Even high end cameras do this. Like the Sony F900, when it puts it on tape it does this. There's also 960X720. Again non-square pixels. Anyway This is enough for this article. My hope is with new cameras, The Red being my current favorite. we won't have to worry about crappy compression. color spaces, "a topic for another day" or non square pixels. Hopefully we can just work with progressive frames in a 12 bit color space. We can dream can't we.