A PRODUCTION GUIDE TO DTV

Snell & Wilcox offers plain language advice to Producers, Broadcasters and Videographers for "future proofing" today's video programs for tomorrow's digital broadcasting.

With the pace accelerating towards the introduction of DTV in the United States, producers must not only create compelling programs for today's analog broadcasting systems, but make certain those shows deliver acceptable technical quality on widescreen digital systems in the years ahead. "Future proofing" today's video for tomorrow's DTV broadcasting is not complex, but does require an understanding of a few basic issues in planning the way new programs are made.

Peter Wilson, manager of HDTV for Snell & Wilcox, is one of the most knowledgeable people in the world on issues confronting producers in the DTV transition. The following Q&A was prompted by questions from working producers seeking real-world strategies for dealing with the transition.

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1. Peter, television program producers today face a maze of choices as they prepare for the transition to digital television. Can you offer some advice to producers who want to ensure that their programs have adequate production value in the DTV era?

Wilson: My general advice is go to the highest possible spatial resolution that your budget allows. That's either 35mm film or high definition video for origination. There's a lot of discussion about the cost of moving to HDTV and, yes, it's going to be a bit more expensive to re-equip. But the cost of key items such as cameras and recorders is coming down very sharply. So I'd advise producers to acquire the highest quality mastering format they can get as soon as they can get it.

2. So 1080i is the best production video format available today?

Wilson: 1080i currently offers the highest spatial resolution. You can derive all of the ATSC (Advanced Television Systems Committee) transmission formats from 1080i. And you will get the best conversions to high definition progressive formats in the future.

3. When we consider the benefits of the 1080i format, we often hear that it offers the best spatio-temporal capture parameters of all the video formats. Would you explain what that means?

Wilson: Spatial resolution is basically how much horizontal and vertical resolution you get. In number terms, for example, 1920 (horizontal pixels) by 1080 (vertical lines) has got more spatial resolution than, for example, 1280 by 720. There's more data there. Temporal resolution is how many frames per second you capture.

4. How does that combination of parameters affect the choice a producer might make in deciding a production strategy for digital television?

Wilson: If you are a producer doing primetime TV programs that have an archival life and you want the highest quality, you probably would shoot today on 35mm film. It's not inconceivable that the networks will also master some of their dramas in HD video. If they use video, they ought to go for a video format with a spatial resolution that closely matches 35mm film. The 1080i format - at 1920 by 1080 - is very similar in spatial resolution to 35mm film.

The difference between 1080i video and 35mm film is in temporal resolution. The 1080i system is 60 fields, 30 frames a second. That will always be much better for sports than 35mm film at 24 frames per second. The producer has a choice of production formats, depending on the content. Whereas you might use film for the production of primetime dramatic programming, you'd probably choose video for the coverage of sporting events.

5. 1080i may be the preferred video production format, but it's also the most expensive and requires a major upgrade of the production infrastructure. What about the producers using current production formats such as Betacam? For example, Snell and Wilcox has demonstrated some very respectable looking upconversions to 1080i from the analog Betacam SP format.

Wilson: Betacam SP is quite a good format. It's analog, of course, but analog formats don't have to be bad. The advantage of Betacam SP in a camcorder is that you make a component recording. It has quite a reasonable bandwidth, has low noise and it doesn't suffer from composite encoding or decoding artifacts.

One thing most people don't realize is that when you use a standard 525 camera, the interlaced scanning actually captures 40 percent more vertical resolution than we can see. This additional resolution cannot be seen on a standard interlaced monitor. When you upconvert, you release that 40 percent of vertical information. Because you are upconverting into an oversampling domain, you perceive all of that extra 40 percent of resolution. That's why when you do a direct one-to-one upconversion, e.g. 525 16-9 to 1080 16-9, the 525 picture looks a lot better than you would expect. If you are using standard 525 in the composite domain, you need to be quite careful about how you decode the signal. You need to use a very good quality decoder in order to minimise the artifacts of NTSC decoding and to keep as high a resolution as you can.

A high quality multidimensional decoder is needed because you want to extract all that is available in the signal. To get the maximum luminance and chrominance resolution you must have a 3D filter in the decoder. You want to minimise some of the regular decoding artifacts that result from less sophisticated decoders. It's as simple as that.

On the cost of 1080i production equipment - yes, there is a price premium now, but that will disappear over time as 525 equipment diminishes and 1080i catches on. It will not be long before price ceases to be an issue.

6. The new generation of very low-cost DV format camcorders is being used extensively by broadcasters and independents for news and documentary applications. How do images from these devices look when upconverted?

Wilson: We have looked at some 4:3 DV and it looks OK. That's as long as the image is exposed correctly, and the camera is not over-enhanced and has a good resolution CCD sensor.

The problem with some current low end camera systems is too much enhancement. What's not proven with DV is how it behaves in a multigeneration environment. For example, if you do a lot of heavy post-production it may fall apart. In a news situation, as long as you have a good recording made at the highest resolution, you should be in pretty good shape.

7. Would you advise producers to reduce the enhancement in the 525 video cameras that they use?

Wilson: Ideally. But it depends on the camera. Quite a few of the very low-cost cameras don't have any enhancement settings. The enhancement levels are fixed and can't be adjusted.

8. Can you compensate for too much enhancement after the recording has been made?

Wilson: In fact, we have a de-enhance function in our upconvertor. It takes out some of the worse artifacts of over-enhanced cameras but there is a limit to how much you can do. Very often when you over-enhance you clip the signal. Once it's clipped,the data is gone. You cannot reconstitute it.

9. Can you offer some general advice on determining and setting enhancement levels?

Wilson: Look at the camera very closely on a 525 monitor. Look for vertical aliasing. That is when the camera sees fine vertical detail which is occurring at a frequency beyond the capture range of the 525 video system.This gives you alias artifacts which often look like jagged edges around objects. When you

upconvert , those jagged edges look rather bad because you are magnifying them. Because the 525 picture has not got much vertical resolution, there's a tendency to turn the vertical aperture corrector up too far to make the picture look sharper. The problem with that is if you are capturing a scene that has too much vertical detail for the camera, the enhancer grabs that vertical detail and enhances it to the point where it's objectionable.

Normally, enhancement levels are set with an internal adjustment on the CCU. You put up a test chart and look at the resolution on a wave form monitor and generally you set it according to the manufacturer's instructions. But there's a tendency to tweak a little bit extra to make the picture a little bit punchier. That's what you want to avoid. It's better to err on the low rather than the high side.

10. Other than reducing enhancement in video cameras, what rules of thumb would you offer program producers who want to protect their 525 productions for DTV transmission?

Wilson: Some low-cost cameras don't have good manual control of the exposure. It's important to get a good quality image from a photographic point of view. Remember, with DTV the viewing screens are going to get bigger while the room size stays the same.When you view video on a bigger screen, all the differences in exposure between shots - discontinuity of levels or sharpness, for example - become very apparent. You may not notice these differences in the 525 image but when you display the program on a larger screen these things can be very noticeable. A big screen is like a magnifying glass.

Also, in many situations the viewing room will have lower ambient illumination. Wider screen displays give the viewer a cinema feel and it's quite likely people will lower the lights while watching programs. In that case, the eye becomes more sensitive to changes in pictures scene-to-scene.

For successful DTV video production, consistent exposure is essential.Good photographic techniques are very important - more important than with 525. Turn off the auto iris. As with most things involving HDTV, you take a step back ten years and come forward again.

11. Some of the inexpensive DV cameras with 4:3 CCD sensors have pseudo 16:9 modes that are primarily intended for display on widescreen monitors. Should videographers use this widescreen mode on a DV camcorder if they intend to upconvert the recording for 16:9 display on DTV?

Wilson: I have seen some pretty bad results with these internal camera processors. These are small cameras with very little in the way of internal electronics.The 16:9 mode is not very good. You are better off shooting 4:3, protecting the safe area and doing a high quality upconversion later.

12. Tighter shots look better than wide shots when upconverted. Why is that?

Wilson: That's true. It's because of the resolution capability of the camera.A closeup generally doesn't have much resolution in it. For that reason, you don't see a very big difference between standard and high definition closeups. But when you do a really wide shot of an external scene, there's a huge amount of data to capture. You just can't capture it all in a 525 camera.

13. You have warned videographers to use care with the latest generation of 525 CCD cameras. These cameras, you said, tend to have excessive vertical resolution that when combined with inappropriate shutter speeds can burn both alias and strobe effects into the 525 signal. Would you elaborate on that?

Wilson: The drive in the marketplace has been for widescreen cameras with better pictures. The result is the camera manufacturers have made their cameras much sharper. Because we use an interlaced chain, you don't always see all the artifacts on a 525 monitor that are created by these very sharp cameras. But once you put the programs through an upconverter, you magnify any of the artifacts that you have captured. As I said earlier, many of the problems come from the enhancer, which is used to make the 525 pictures really stunning. In reality however, you are much better off with 525 pictures that don't look so stunning. You then work with the enhancer in the HD domain. It's a better way to do it.

The shutter issue is a general comment that quite often camera operators choose inappropriate shutter speeds. There's really no rule on this.The choice of shutter speeds varies depending on the material. But basically you are working with a temporal strobe.

Perhaps a bit more instruction might be useful on what the implications are of using the wrong shutter speeds. For example, if you are shooting fast moving sports, you tend to use a higher shutter speed because you want to minimize the blur and capture sharp images. In some cases there's a cogging effect,where the subject looks like a series of still frames. As you turn up the shutter speed, you end up with more dead time because the shutter is waiting for the next field and the next to capture again.When the motion is fast, you get a very sharp image when the shutter opens and closes but there's a judder effect brought into the picture. This is because the camera is alternately capturing, moving, capturing, moving, capturing, moving. When this video is upconverted, it looks strange. Of course if the shutter speed is too slow, it can look very, very blurry and unnatural. Some blur looks more natural than excess judder.

The correct choice of shutter speed must come from the experience of the camera operator. If you use shutter speeds correctly in NTSC, it should be fine when upconverted. This applies to both electronic and mechanical shutters.

14. Snell and Wilcox upconverters not only convert the video format but change the aspect ratio of the image. What are the considerations a producer should have in shooting 4:3 aspect ratio images that will later be conve rted to the wider 16:9 aspect ratio?

Wilson: If you are going to convert a 4:3 image to a 16:9 image, then you'll probably crop the top and bottom. So you need to be careful of framing and make sure you are in the safe area. Important information should be kept well within the frame. Some new cameras and most studios have shoot-and-protect lines. But it's important to calculate in advance what will happen in the letterbox format. The aspect ratio converter function can take the full width 4:3 signal and crop the top/bottom or whatever part you want. But it's got to crop something and the creative team on a production should be aware of what will be cropped. The only problem with cropping is that 4:3 program material might not look as tight in the future. We may have a few years ahead of very loosely shot 525. There are some compromises with this, but there's no other way out. Aspect ratio conversion is basically a zoom and crop.

15. If you know your show will be broadcast in 16:9, are you better off originating the production in 16:9 and then converting to 4:3 for conventional broadcast?

Wilson: Yes. This is because when you convert 4:3 to 16:9 you lose vertical resolution.Your 483 lines is reduced to a little over 300 lines. We can do that conversion at the highest possible quality, but it still takes a hit.

16. Are any abnormal artifacts introduced when you convert aspect ratio?

Wilson: It's important not to capture alias in the original program material. That means if the 483 lines are not enough to capture the vertical detail within the scene, you get foldover alias artifacts, which appear as "jaggies".You have to be careful not to shoot scenes that cause the camera to "zing." This is tricky because it's not always apparent on the 525 monitor when you've done that.

17. We're warned that noise is the enemy of compression. When are problems with excessive noise most likely to occur?

Wilson: Noise is mostly related to older archives. It's not really a problem with modern cameras and recorders.

18. In many situations today archival footage originally recorded on 3/4-inch or even VHS is inserted into a broadcast program. Can these older formats be used in the same way in a DTV env i ronment as we use them today? Or will we get some nasty surprises during the upconversion process?

Wilson: It's really just an issue of comparison. One thing that's very apparent when you are looking at a big picture is the change between scenes. In upconversion, you automatically timebase correct the recording, so you make it stable. You clip out the noise bar from the bottom of the picture.You can tidy it up a bit. But there is only so much resolution in there. Formats like U-Matic and VHS use special signal processing that makes them look better than they should. Upconversion is like putting the original signal under a magnifying glass.

Often in a multigeneration environment you end up with unnatural effects. For example, the skin on the face may be blocky because you have lost all the chrominance resolution.When you upconvert and put that kind of image into a standard HD stream, you'll notice it. You may get a subjectively OK picture but you won't escape the noticable difference in quality.

It also depends on the program. If the program is about someone who is long dead and all you've got is U-Matic, then it's perfectly valid to put the U-Matic material into the program because that's how it is.

19. Will archival footage require some kind of noise reduction before upconversion?

Wilson: I think nearly all archives will need some form of noise reduction. However, it's not that simple an issue.You need to preserve as much of the original resolution as possible in the archived program. If you overdo the noise reduction, you reduce the resolution. For a really important piece of material you might actually tolerate the noise because you need the resolution for the impact of the scene. So the operators of the noise reduction system need some skill at this.You might get a reasonable result if you just put the noise reducer in the circuit and leave it on. But you'll get a better result if you have an operator that understands what he's trying to achieve.

20. Will noise reduction become the next "black art" of video?

Wilson: The optimum will become a black art. There will be guys just like the compressionists in Hollywood who are experts at archive restoration.

21. Is noise reduction done by eye?

Wilson: Yes, you do noise reduction by eye. But it takes skill. There's a tendency to reduce the resolution to lower the noise. This can make flesh tones go blotchy.You've probably seen it with the old 3/4-inch system, where they had coring to reduce the noise. It looked good on the first few generations, but if you went five generations you had completely flat cheeks and faces. That's the problem if you have too much recursive noise reduction.

22. Since many viewers will be watching DTV on large screens, should creative decisions such as noise reduction be made on large screens in the production facility?

Wilson: Yes. I'm suggesting you do it for ordinary drama, but it's important for feature releases. Also, in multicamera shoots, using a bank of small monitors can sometimes result in the director seeing the images as television and cutting too fast for display on larger screens. For HDTV viewed on large screens, it will be very beneficial to slow the pace of shot selection. You can linger much longer on an interesting shot on large-screen HDTV than you would on a smaller TV.

In a broadcast environment, I recommend using a 28-inch professional monitor or larger. Don't use smaller sizes. Also be aware that the HD system is able to capture quite a wide contrast ratio, so you need professional-quality monitors for any checking. For example, in its Pro monitors Sony uses a very high resolution Trinitron tube. Between each colour there is a jet black stripe. This, combined with an anti-flare coating, gives a very high contrast ratio. Other tube manufacturers use similar techniques. When you

use a high quality, professional monitor that's set up correctly, you can trust your eyes on issues such as aliasing, enhancement and noise reduction. It's also good to locally upconvert for testing. We have in our range some low-cost upconverters for that kind of operation.

23. In the early years of the transition we are likely to have a combination of video resolutions on DTV. Will the viewer be able to assimilate these varying resolutions easily or do you think it will have a jarring effect?

Wilson: That depends entirely on how the Producer does it. If it's an HD movie - a drama where you are really engrossed in the program - changes in resolution or black or white level on a scene-by-scene basis can be jarring. However, if the content is documentary or news programming and you have many different kinds of scenes, the effect won't be as severe. So the impact on the viewer really depends on the style of programming.

24. How might upconverters be used in the real world? Will we have situations where upconverters are just placed in a rack, left on all the time and used to automatically process the entire program stream, and will we have other situations where more sophisticated and exacting upconversion will be done on specific programs in post-production facilities?

Wilson: We'll have both. Upconverters will be used unattended in preset modes in broadcast environments. In these situations, they will give very reasonable results. In post-production, upconverters will be used for scene-by-scene processing of more critical programs.

25. In a scene-by-scene upconversion session,what kind of things could be done to improve a production?

Wilson: One may want to adjust vertical and horizontal enhancement. Or marginally change the framing. There are choices in how to convert 4:3 to 16:9. You might want to change the vertical or horizontal sizing, zoom in or out slightly. I see this happening for the most valuable material where the extra time can be justified.

26. We've seen demonstrations proving that video material originated in 1080i and then downconverted to 525 actually looks far better than original 525 when upconverted back to 1080i. Why is this?

Wilson: It goes back to what I said earlier. In the interlaced domain you have 40 percent more vertical resolution than you can see. So if you take an oversampled picture in 1080i and then you downconvert it through a precision digital filter, the filter allows you to push in as much energy as is physically possible. So basically you squeeze all that information in but you squeeze it in a legal form. When you upconvert it again, it comes back out quite near to the original conversion. Obviously it will lose some sharpness because you have downconverted it. But the results are quite remarkable in practical terms.

27. Let's say one day in the future broadcast systems migrate to 1080 progressive.Will this extra vertical resolution allow us better conversions from 1080i to 1080p?

Wilson: If we convert from 1080i to 1080p, we will get that 40 percent benefit in vertical resolution. So there's a big benefit when you convert to progressive. The data is there already.

28. Some people are pushing the idea of 480p as a mastering format. Would shooting 480p give you any benefits in an upconversion to either 1080i or 1080p?

Wilson: It is still prone to vertical alias and is not HDTV. It won't give you the benefits of the extra resolution. Using 480p is not just a matter of buying a camera and a recorder. It requires upgrading the entire plant. If you are going to buy an entire new plant, you may as well future proof your program output and buy high definition equipment. It doesn't make musch sense. There's no benefit to going 480p.

29. Turning to film for DTV production. Obviously 35mm is considered the optimum film format for HDTV. But there's been some debate over whether 16mm and Super 16mm film offers sufficient resolution for the acquisition of HD programming. What's your opinion on this issue?

Wilson: It's possible, with careful shooting, to get an acceptable result with 16mm. But for mainstream production you are not going to get that. Super 16 is the minimum you should go for. Super 16, shot with care, is acceptable. It is not pushing the limits of the system, but the results should be OK. Of course, 35mm is much closer in performance to HDTV.

30. How then would Super 16 compare with standard definition video as an acquisition format for HDTV?

Wilson: Super 16 would be better than standard video. It is, of course, normally 24fps though.

31. On downconversion... Let's say you're originating a live sports event using HD cameras in the 16:9 aspect ratio. A downconverted 4:3 feed of this event will also be broadcast simultaneously. The producer wants both the widescreen HD and the conventional 4:3 feeds to look good. What are the critical issues here?

Wilson: It's mainly an issue of framing.It's a bit like broadcasting a widescreen movie in 4:3. If the action is at both sides of the frame, you have problems. You can only have a segment from the frame. That segment can be from the left or the right or anywhere in between, but if you've got action on both sides of the frame you are going to lose one of them. This is why when you do pan and scan on Cinemascope movies you often do cuts even from one wide shot in the original. You cut from left to right according to dialog. This is more of an aesthetic problem than a technical one.

32. What are the implications for set design and lighting when studio programs are broadcast simultaneously in 16:9 and 4:3?

Wilson: In practical terms, widescreen means that care has to be taken with the outer edges of the set - something that was of little concern before. The viewer may be seeing parts of the set that are not normally exposed. Not only does this require more painting, detail work and attention to flaws, but it requires lighting parts of the set that were not important before.

33. Do you have any final words of advice for Producers moving into the DTV era?

Wilson: Ultimately, the Producer needs to determine what the production is to achieve. As we discuss all these new standards, it's very easy to bring all of it down to the lowest common denominator. It really depends on how much effort a Producer wants to put into achieving quality.

All of the high definition cameras made in recent years have a much higher contrast ratio than the 525 cameras they replace. Today, there are far fewer compromises in professional camera design. Advanced signal processing allows a tremendous dynamic range in video.You can shoot and light with far greater freedom and flexibility than ever before. The end result of this DTV transition now really depends on the creativity and desire of producers and their creative teams to expand the boundaries of television. As it was in the earliest days of the medium half a century ago, we have again entered a period of extensive experimentation. There's the opportunity to really push the limits of the new technology.The Producers can take it as far as they want to go.
