# Image Quality From A Non-Engineering Viewpoint

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When asked to do this paper, I tried to decide whether the title suggested that I confine my remarks to non-engineering issues or simply limit my remarks to a non-engineering point of view on engineering issues. I also thought, given the title of this paper, that everyone who was involved in the very complex engineering problems of the new video imaging technology would think "I can relax and tune this paper out, he is just talking about non-engineering considerations." Meaning, I suppose, what color a high definition camera should be painted, or should a large screen display be done in a high tech or traditional walnut motif to blend in with a modern living room. While these are, of course, all weighty questions we shall not, however, consider them here.

If we assume everyone on the engineering end of the new imaging technologies executes designs with the same brilliance and imagination as has been used in proposing new system configurations and in attacking problems of noise, compatibility, and band-width thus far. I for one feel confident that although all of these problems are not yet solved, they soon will be. When we are to the point of producing a practical, well engineered, advanced video production system or more likely several advanced video production systems in an "A","B", and "C" format, which will slug it out in the marketplace, (until everyone forgets that the original intention was to drain the swamp of alligators and not introduce new ones into it).

But, anyway, if all this comes about then the resulting enhanced or high definition systems will live or die on the basis of non-engineering considerations. Or, to put it another way, when all the engineering obstacles have been met, we will not, as a production industry, have a useable, advanced video production system until the non-engineering obstacles are overcome.

The non-engineering difficulties that a new technology faces are generally the final obstacles which it must overcome before being accepted and put into practical use. Unlike the engineering obstacles, however, the non-engineering ones are rarely planned for in advance, rarely even researched until they are encountered. Problems of application and acceptance of a new technology catch everyone by surprise even though they could have been foreseen with a little advance research or even a conversation or two with the people who will apply the production technology that will result from all of the careful study and thoughtful discussion that we are participating in here today.

Any new production technology redefines the production process, and it has always been a mystery to me that designers of production equipment spend so little time studying the production process before designing and producing equipment which will impact and change that process. It almost seems as if practitioners of film and video production are constantly attempting to understand the impact of new technology on their art and craft while the makers of this technology do not seem to understand the art and craft which the products of their technology are impacting.

All film and video productions regardless of budget and regardless of production quality consist of creative work and decision making under moderate to severe time and budget pressures. Equipment designed for this industry, format, and image quality decisions made for this industry, must be undertaken in such a way as to alleviate this time and budget pressure rather than intensify it. Practicality and flexibility are the cornerstones of our non-engineering considerations.

We were, of course, asked to discuss image quality from a non-engineering point of view. While image quality is certainly of paramount importance, in the minds of the production industry practicality, flexibility, and usefulness are frequently traded for considerations of image quality. One need only look at the evening news for occasionally overwhelming examples of this trade.

So now that we have come this far in our discussion, and in the true high definition study group tradition, let's redefine this paper's title. We will change it to "If It Works, Why Fix It". Because, seriously, that is the question most often being asked these days by film producers, studios, directors, and cinematographers, even television network executives. In short, the customers whose equipment purchases will ultimately pay for all the research and development which is now going into advanced television imaging systems.

As we continue this discussion on image quality, I suggest all of you bear in mind the question "if it works, why fix it"? In other words, NOT will this or that proposed standard or encoding method do the job of encoding, producing, and editing quality images, but will it do the job SO MUCH BETTER than what is currently being used as a production standard so as to justify the change. Will the improvement convince a pragmatic, deliver-the-goods-on-a-budget-type producer at 2:00 A.M. standing out on a New York street in the rain when the director just told him that the next set up will be down a sewer manhole cover that the new technology will be worth the additional problems that new technologies always create.

Or will the subtle improvement in image artifacts that some of the extended or enhanced definition systems promise be of importance only to an engineer in a control room studying a high resolution test monitor. Because if that is the case, if we toss

out the technology we have, in favor of some barely noticeable measure of image improvement for the sake of bandwidth conservation and compatability, then we may never get another chance to toss that system out in favor of REAL image improvement.

Let's consider first the most volatile proving ground of new technology. Namely dramatic, feature length production for big screen display. If you're concerned about the proposed advanced imaging systems' appropriateness for large screen display, if you are a member of the "we can produce quality pictures, but we can't put them on a theatre screen" society, then stay with us through this discussion, but omit the large screen display. The problems are really the same in all areas of consideration except resolution, whether the end product is displayed on a theatre screen or a quality television screen.

Despite its tinsel-town, fantasy land image, motion picture production is very much the art of the possible, the art of the practical. Although the motion picture industry has the reputation in the popular media of being financially irresponsible, it is actually fiscally and technologically conservative.

The upright moviola in the editing room, for example, is a classic mechanical contraption existing almost unchanged in style or function from the 1930's version though today's. It is a fixture in the Hollywood editing suites. Although it is known to consume film and tear sprocket holes with alarming regularity, and although the improved horizontal flatbed-type editors have existed since the mid 1960's, the changeover is slow and my prediction is that at least in the Hollywood area, upright moviola editing machines will exist and be used daily to edit film until the turn of the century.

This conservative streak is not to say that the motion picture industry is not without its pioneers. There are certainly those within the feature production community with a considerable taste and daring to innovate. However, in an industry where computers are being used to keep track of pages shot per day and set ups completed per hour with daily reports sent to accountants and producers; and, when a director's job security is based on a computer projection of the completion date of the project based on an extrapolation of current page counts, directors in this climate are understandably leery of technological innovations on the set.

The rewards for being the first director or producer to utilize new technology are media attention and notoriety for the innovators. The penalty for experimenting with new technology on a production can be set delays and the most expensive kind of research and development. The type which goes on while the cast and crew stand around waiting. It is the fear that any form of innovation applied to a production will interfere with the creative process or such intangibles as pace, working rhythms,

or production styles that has tended to keep production innovations from being applied in the production industry thus far.

Any casual observer within or outside the production community is certainly well aware how difficult it is to predict the success of a script, a production concept, a production style, or even the blending of selected artists and technicians into a working community. Since no one can guarantee the success of a production approach, no one can guarantee with certainty which aspects of the production process can be successfully modified.

The reason I feel it is so essential to concentrate on the applicability of new imaging technology to the theatrical production field is that by studying the most demanding application we can learn a great deal about the other applications of this technology. There is an analogy here in the way the automobile industry has utilized the sport of racing to test, modify, and refine their car designs. The motion picture industry has always been used in much the same way by the television production community. Motion pictures set the standard in the areas of photographic effects, visual moods, and image styles, not to mention photographic quality.

So what then are the design priorities for a high definition video system to possess in order to successfully compete with motion picture film in the production of feature length dramatic films. These priorities listed in order of importance to the production community are:

1. Practicality, flexibility, and ruggedness.
2. Aspect ratio.
3. Sensitivity.
4. Gamma or Transfer characteristics.
5. Resolution. I don't believe resolution is number 1 in priority although resolution has figured heavily into the debates on system configurations.
6. Standards acceptance.

Or, failing to find a consensus for one standard, then the second choice for our number 6 priority would be standards conversion.

The ranking of these priorities may seem odd and indefensible to you, but this list is prioritized according to the "if it works, why fix it" imperative. In other words, these priorities meet the needs of box office, common sense, and bottom line--the three golden yardsticks against which all production decisions are measured. This is a list of the priorities of the producer, of the director, and cinematographer. This is not necessarily the way a distributor or broadcasting network would prioritize its needs. But we are assuming that if production priorities are met, standards conversion could be used to alter these priorities for

distributors, or television networks' use. Let's discuss these system considerations one a a time.

PRACTICALITY would seem to be obvious, but is probably the consideration that merits the most discussion precisely because it is the one which is least often discussed in any debate of new technology. We must not fall into the trap of thinking that the dramatic production industry has problems that need to be solved simply because those who advocate new technology have an idea that they want to try out on this industry.

The benefit most often promised to dramatic producers by advocators of new production technology is cost savings. The minute one mentions cost savings to a producer one immediately has his undivided attention. The argument that video technology will save a producer money would be more convincing if experiments with single camera video use in the production of a traditionally film-type dramatic show had ever resulted insignificant cost savings.

It would even be more convincing if a cost-effective, single camera production had received critical, in addition to fiscal, rave reviews. But, dating back from Universal's experiments with single camera video on "Harper Valley", where a projected $17,000 budget savings turned out to be only $3,000 because of post production overruns; to Universal's experience with "Invisible Woman" which resulted in only a $4,000 difference between the video and the film budget, this has not been the case. Matt Herman, of Comworld, remarked after producing three feature length television movies on video tape exclusively, that "video tape technology results in little cost savings if the same time and quality is spent on the video, as would be on a film production."

There is certainly a more important consideration than the cost saving aspects of dramatic production on video. It's quite reasonable to argue that any new technology in its infancy may not be cost effective, and possibly not even artistically effective and that with practice greater success in both areas will be possible. The truth is, that the motion picture production community already possesses a flexible, versatile, adaptable production method, one in which changes come slowly through a process of evolution over a period of years.

Take, for example, a piece of production equipment called an "apple box." Apple boxes are frequently used for raising people and production equipment to desired heights, sort of like large building blocks. Several years ago, for example, a grip discovered that by cutting the handles of an apple box in an off-center, rather than a centered position, they could be carried two at a time with one hand, instead of one at a time as was previously done.

This idea was debated for a while and is slowly coming into acceptance, but the moving of handles on apple boxes from the

traditional position was not a change accepted lightly. The film industry unlike the video or computer industry does not possess a "Gee Whiz" attitude towards new technology, but more of a "give me one good reason to change" attitude. When you pick up apple boxes a thousand times a day during the long working conditions of a dramatic production, you want to know that the movement of a handle from its traditional position is not going to create more problems than it will solve.

Likewise, when Universal decided to produce a televison pilot and six episodes for a series called "Fitz and Bones," in which video would be used in addition to film, they were reluctant to undertake the experiment. The story of "Fitz and Bones" concerned a news ENG camera crew and the concept was that, while the show would be shot on 35mm film, the video news cameramen's pictures would be shot with an ENG camera modified for 24-frame recording and screened on 24-frame 3/4 inch video tape playback. The working method used is that after a motion picture sequence was shot in which the actor was video taping a scene, a video crew separate from the film crew would step in, video tape that sequence, and that video tape would later be played on monitors in editing room sets and control room sets of the dramatic show.

The shooting progressed smoothly enough and the video experienced no technical difficulties or performance problems, but the video crew experienced a great deal of difficulty fitting into the working rhythms and pacing of the show's film crew. The result was that after a sequence was filmed and it was time to video tape the additional sequences, the film crew frequently experienced delays and breaks in its working rhythm while the video crew shot its sequences. These problems were not technical, they were more procedural and interpersonal. The result is that at the end of the first week, Universal determined that the video production crew had resulted in a $20,000 cost in terms of crew and cast delays and the video crew was simply replaced with a film crew and the inserts that were intended to be video taped, were filmed and transferred to video tape.

This story illustrates, in some small measure, how despite the successful solution of technical problems, the failure to be equally successful at solving practical problems can be terminal for any new production system. The use of video tape on the Universal show "Invisible Woman," for example, was considered by all measures of performance, to be successful, but, apparently not sufficiently successful, not overwhelming successful enough, for Universal to plan at this time, other single camera television episodic shows. It seems for a new production system to gain industry acceptance, it must not only be practical and cost effective, it must also be connected with the production of an artistically and financially successful project.

Image vision, the Image Transform system of producing video tape for transfer to 35mm motion picture film, for example, is

an artistically and cost effectively viable production system. Many observers in the industry have not been able to understand why it has not found greater industry-wide acceptance, and the only conclusion that many of us who have looked with sympathy at the development of Image Vision, have come to, is that it has been Image Vision's misfortune to never have been identified with a film which was succcessful artistically and in the box office. It seems as you discuss Image Vision with the motion picture production industry that everyone wants to be the second person to produce a successful Image Vision feature; nobody wants to be the first.

What then is the relationship between design considerations and box office success? Well this is certainly a tenuous connection to be made, but two factors can be discussed:

1. If a production system advocates itself and promotes its use as a means of saving money, then it certainly increases its chances of being identified with quick and dirty exploitive production where quality and artistic effectiveness are not a primary concern.

2. If a new production technology is awkward to use or inflexible, it interferes with artistic options. By being limited in lens selection or photographic options, it threatens to disrupt working methods and such intangibles as artistic pace and mood. These limitations will make the production of an artistically successful project more difficult. If one advocates a production system solely on the basis of cost savings, then one is condemned to constantly justify the money saving aspects of its use. In the case of video, this is frequently done through the use of smaller crews, lower lighting budgets, and the use of a more hectic shooting schedule. None of which are conducive to quality production.

Current video production equipment is designed for three camera, live-switched shows or news. Although recent modifications to camera designs have been made for field production, none of these go far enough to produce a full-featured location production camera for quality imaging, with the possible exceptions of the Panacam and Ikegami EC-35. It remains to be seen whether any of the cameras developed for high definition, will even go this far towards meeting the needs of the production community.

Our second priority, ASPECT RATIO, has certainly been greatly debated, and everyone with even a casual interest in high definition systems, is aware of the bandwidth dilemma. The bandwidth required for wide aspect ratio has argued persuasively in favor of moderate aspect ratio systems. Five to three is often discussed, and a ratio of 1.85 to 1, or 2.35 to 1, quite common in the motion picture industry, is considered wasteful or even radical as a proposal to make for high definition broadcast systems.

This may be true, but as Kerns owers once pointed out, the history of the motion picture industry shows, that when given a choice between wide aspect ratio and resolution, the industry has chosen wide screen and wide aspect ratios on every occasion. The motion picture industry has done this based on the most conclusive, most immediate, type of audience preference poll--that of whether or not they will pay at the box office. It seems a shame when we are on the verge of new imaging technologies, we would consider taking a step backwards in terms of aspect ratio, especially since our entire motion picture heritage exists on films predominantly shot on a 2 to 1 or wider image format.

One possible alternative to the bandwidth conservation issue which, in my opinion, has not been adequately explored is the application of anamorphic lens systems in the original photography of high definition video pictures. The subsequent de-anamorphosing could be accomplished through the use of frame store technology at the receiver or projection end. This could also be accomplished, in an even simpler fashion, by modifying the receivers' vertical height with a switch and fixed resister to change the vertical size for de-anamorphosing.

This system has been used in motion picture production video monitors for some time. While this may produce the dreaded, underscanned screen that the FCC, at least in the U.S., has such a phobia towards, there are precedents of, for example, the feature "Manhattan" being shown in the New York area with black bands top and bottom in the original wide screen format. Certainly, with all the discussion of wide screen display systems, it is probable that display systems of the future will have sufficient area that the shrinking of vertical height will not pose an image size problem. The advantages of this system should be obvious in terms of increased vertical resolution at no additional cost in terms of transmission broadcast bandwidth usage.

Our third priority is SENSITIVITY. Some of you may have been puzzled that I placed sensitivity above resolution as a priority. I felt justified in doing this because camera sensitivity translates directly into production costs, whereas resolution does not. To realize the impact of increased sensitivity on a production one must study what has occurred in film production with the advent of 5293, 5294, and other high speed motion picture stocks. To be responsible about this investigation, one must realize that high speed motion picture stocks did not begin with 5293, and that even 5247, which is now considered to be a normal speed motion picture stock, was once itself considered a high speed motion picture stock.

Sensitivity in a motion picture stock, or indeed in a video production camera, directly translates into man-power hours required to light a set. Other hidden costs of low sensitivity are: electrical power consumption, caused by increased lighting and air conditioning needs on the stage, fatigue factor on the part of actors, expensive production delays caused by the need

to reapply make-up that has faded from heat and perspiration, as well as the length of time required to set up and strike a location of heavyweight compared to lightweight lighting instruments.

It has certainly not been lost on the advocates of motion picture technology that high sensitivity in relation to signal-to-noise ratio figures is currently a major advantage of motion picture stock over video technology. This advantage will increase, rather than decrease as video technology progresses farther in the direction of high definition video systems.

Number 4, GAMMA. The ability to reproduce extremes of contrast is a critical requirement for any film or video camera. It is a difficult variable to quantify. In practical terms, a camera's ability to reproduce images of wide scene brightness range often is of primary importance to its photographic usefulness. Since lighting contrast ranges occurring in nature exceed the ability of both film and video to reproduce adequately, in professional photographic situations it is usually necessary to reduce the existing contrast range through the use of fill lighting. Put simplistically, the narrower the dynamic range which can be safely reproduced by a camera the more fill lighting is required to reproduce a scene.

Dynamic range limitations have always occurred in video cameras that do not occur in film cameras. In current state of the art equipment, the video camera is at a disadvantage over a corresponding film camera only to the extent of a stop and three quarters in latitude. This generally translates as a seven stop range from opaque blacks to transparent whites in film and a five and a quarter stop range for the equivalent exposure levels in video.

While gamma compression devices on current electronic cinematography cameras are incapable of increasing the camera's actual photographic latitude, they nevertheless, simulate a filmic appearance in the reproduction of high-key contrasty scenes. The current contrast reproduction differences between film and video are certainly workable, if somewhat problematic, but if the dynamic range of a high definition camera tube were to prove limited, even by today's standards, this would definitely be a very serious problem.

The ideal, of course, would be a high definition production camera with dynamic range beyond what is currently available approximating or surpassing that of film. It is conceivable that CCD technology may make this possible although it would, of course, be necessary to overcome first some of the CCD's other technical limitations.

Our fifth item on our priority list is RESOLUTION. This may surprise some, because resolution is the first item on most engineering lists of priorities where HDTV or other advanced imaging systems are concerned. I think this is partially the

case, because when designing a video system to compete with film, many engineers are perhaps overly defensive about matters of resolution. Many cinematographers feel it is not the superiority of film over video, in terms of absolute sharpness, which is the problem. A relatively small area of the picture, in any given frame, is critically sharp. The resolution characteristic of film, which is most difficult to imitate with electronic cameras, is the gradual transition from sharp areas of the image to soft-focus areas of the image.

Due to the optical nature of this transition in film, it seems natural to our eyes, compared to the aperture-corrected, electronic appearance of video contours. This same transition in video, from an in focus enhanced portion of the image to an out of focus and thus unenhanced portion, is most objectionable.

Mr. Dee Pourciau's paper called "High Resolution TV for the Production of Motion Pictures", which was given at the fall 83' SMPTE conference, was a very interesting comparison between the resolution of film systems and video systems. While Mr. Pourciau is the first to say that he is still in the process of verifying his work, the paper strongly suggested that the resolution of theoretically possible high definition systems were competitive with currently available film resolution figures.

When discussing resolution in motion picture film, two very important practical considerations must be kept in mind:

1. That the motion picture industry has never proven a correlation between image sharpness and box office success, or even between image sharpness and artistic success. "The Concert for Bangladesh," for example, utilized 16mm film blown up to 70mm and whatever measure of success that production met with was not limited by its lack of sharpness. A feature film called "Signal Seven," directed by Rob Neilson, was shot on three-quarter inch video cassette. Photographed entirely under low light conditions, in car interiors, and on city streets at night. It was blown up to 35mm by Image Transform, and met with critical acclaim at the Telluride Film Festival.

No one is suggesting, of course, that the resolution limits, inherent in three-quarter inch video tape, are adequate for large screen projection, but the point must nevertheless be taken that the audience did not throw tomatoes at the screen and run out of the film festival shouting. As a matter of fact, it seems quite clear from all accounts that a large percentage of the audience did not know they were viewing a film that was originally shot on video tape.

The second practical consideration of resolution is that sufficient motion picture sharpness for professional theatrical applications can be defined as follows: that amount of resolution which allows the cinematographer to put diffusion or nets in front of the lens, and deliberately toss away a large portion of the available resolution. That also allows the

assistant, working with high speed lenses, to miss his critical focus once in while and still provide a result that can be screened to a large audience, on a projection system that is rarely in focus, without that audience stamping its feet and complaining. If this seems to imply that motion picture resolution requires a reserve of sharpness to handle a certain amount of accidental or intentional abuse in the hands of cinematographers, then that was my point exactly.

As a cinematographer, I have learned that discussions of resolution cannot be separated from discussions of lens design and quality. The selection or design of a high resolution camera tube is something that generally takes time and careful attention. But, the design of a lens appropriate for use with that tube is an equally difficult, if not more difficult, undertaking.

A specific high definition camera needs only three quality pick up tubes at any given time, but it may require dozens of lenses of resolution equal to that pick up tube throughout its production life. Too frequently in the design of video production equipment are lens specifications given to lens designers too late in the design process. Too frequently are video lenses hastily produced and with too limited a focal length diversity for professional production applications. Many video cameras that theoretically promise great resolution, actually deliver poor resolution, because of the limitations of the corresponding lenses which were produced for that camera.

This takes us back to our central theme of the high priority of flexibility and practicality in a dramatic production camera. It's worth touching on at least the subject of registration in a high definition camera. Obviously, any situation but perfect registration would produce major resolution limitations in the final high definition picture, but it should be remembered that a high definition video camera must be more than capable of superior registration, it must capable of achieving that registration in a short time period, consistently, and hold it under adverse conditions, and extremes of temperature and vibration.

Our sixth point on our list of priorities is STANDARDS ACCEPTANCE. Certainly the dramatic production industry can be counted among the supporters of one worldwide standard at least for production if not for distribution. Producers who invest a great deal of money in a dramatic production want to know that the standard in which it was photographed will continue, and be universally accepted for some time to come. That the production standard of a given project is so superior to distribution standards that if need be it can be standards converted without a great deal of loss in image quality.

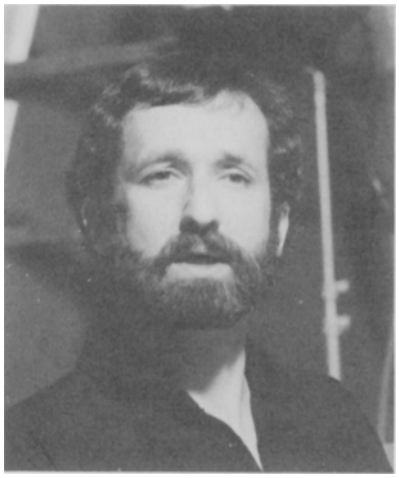
It's interesting to note, however, that while broadcasters are interested in standards compatibility and/or simplicity of standards conversion, producers as a group, are more interested

in standards complexity and less interested in convenient standards conversion. The primary reason for this is that piracy or unauthorized duplication of motion picture products, according to Variety, is an industry whose profits reached one billion dollars last year. Complex encoding schemes and the use of encription devices promise to make motion picture piracy a more difficult undertaking.

This has great appeal for producers and certainly is a tangible argument for high definition video production of dramatic subjects. Simultaneous worldwide distribution via direct broadcast satellite also promises the producer a sizeable immediate income from his product. More importantly, it is a profit that can be realized before motion picture piracy can significantly errode into the box office earnings of his production. This short turn around between completion of a production and the box office return on its investment, promises to stimulate production in a era of high interest rates, and in some small measure stem the tide of rising production costs. And don't think the promise of a world-wide release before the reviews can come out, is lost on the production community, either.

Can all of these design requirements and goals be met in the production of an advanced video imaging system. I think they can be. Will they be? I'm not sure. Remember as the debate goes on during these sessions that we are not simply designing hardware, we are designing a creative tool to be used in the production of art and communication.

The answer to the question we posed at the beginning of this paper "if it works, why fix it," is that you fix something to improve it, but any attempt to improve an existing system must start with an understanding of the methods currently used to produce dramatic production and a realistic assessment of actual needs, not imagined needs. We must ask ourselves are we designing equipment to solve problems that don't exist. Equipment to improve production methods must first possess basic system flexibility and image resources that current equipment and methods provide, and build from there.



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