Point of View: Image Quality from a Non-Engineering Viewpoint

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Image Quality from a Non-Engineering Viewpoint

By Harry Mathias

The non-engineering difficulties that a new technology faces are generally the final obstacles that it must overcome before being accepted and put into practical use. Unlike the engineering obstacles, however, the non-engineering difficulties 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 technology.

Any new production technology redefines the production process. It has always been a mystery to me why designers of equipment spend so little time studying the production process before designing and producing equipment that will impact and change that process. 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 the new equipment do not seem to understand the art and craft that the products of their technology impact.

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

Although image quality is of paramount importance, in the minds of those in 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-off.

Now, in the true high-definition study group tradition, let’s change this article’s title to “If It Works, Why Fix It?” because 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 now going into advanced television imaging systems.

As we continue this discussion on image quality, I suggest 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 that it will justify the change.

Will the improvement convince a pragmatic, deliver-the-goods-on-a-budget-type producer standing out on a New York street at 2 a.m. in the rain, after the director has just told him that the next setup will be down a sewer manhole, 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 compatibility, 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 — dramatic, feature-length production for large-screen display. If you are 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 theater 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 theater 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 through today’s. It is a fixture in Hollywood editing suites. Although it is known to consume film and tear sprocket holes with alarming regularity, and al-
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though improved horizontal flatbed-type editors have existed since the mid-1960’s, the changeover has been slow, and I predict that, at least in the Hollywood area, upright moviola editing machines will continue to be used daily to edit film until the turn of the century.

This conservative streak does not mean that the motion-picture industry is without its pioneers. There are certainly those within the feature-production community with considerable taste and daring to innovate. However, in an industry where computers are being used to keep track of pages shot per day and setups 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 are understandably leery of technological innovations on the set.

The rewards for being the first director or producer to use a new technology are media attention and notoriety for the innovator. The penalties for experimenting with new technology on a production can be set delays and the most expensive kind of research and development — the type that 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 innovations from being applied in the production industry.

Any casual observer within or outside the production community is well aware of how difficult it is to predict the success of a script, a production concept, a production style, or even the blending of 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. There is an analogy here in the way the automobile industry has used the sport of racing to test, modify, and refine its 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 are the design priorities for a high-definition video system to successfully compete with motion-picture film in the production of feature-length dramatic films? These priorities, in order of importance to the production community, are:

1. Practicality, flexibility, and ruggedness
2. Aspect ratio
3. Sensitivity
4. Dynamic range or transfer characteristics
5. Resolution
6. One world production standard.

Although resolution has figured heavily in the debates on system configurations, I don’t believe it is the first priority. If a consensus for one standard cannot be found, then my second choice for priority 6 would be one that permits “transparent” standards conversion, or as nearly so as possible.

The ranking of these priorities may seem odd and indefensible, but the list is arranged 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. These are the priorities of the producer, the director, and the cinematographer. It is not necessarily the way a distributor or broadcasting network would order its needs. But we are assuming that if production priorities are met, standards conversion could be used to alter the priorities for distributors’ or television networks’ use. Let’s discuss these system considerations one at a time.

Practicality

Practicality would seem to be obvious, but it is probably the consideration that merits the most discussion, precisely because it is the one that 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 they want to try out in the industry.

The benefit most often promised to drama producers by advocates 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 traditional film-type dramatic show had ever resulted in significant 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 from Universal’s experiments with single-camera video on “Harper Valley,” where a projected $17,000 budget savings shrunk to only $3000 because of post-production overruns; to Universal’s experience with “Invisible Woman,” which resulted in only a $4000 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 videotape exclusively, that “videotape 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 a more important consideration than the cost-saving aspect of dramatic production on video. It is reasonable to argue that any new technology in its infancy may not be cost effective, and possibly not even artistically effective, but that with practice, greater success in both areas will be possible. The truth is, the mo-
tion-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, like large building blocks, for raising people and production equipment to desired heights. Several years ago, a grip discovered that by cutting the handles of apple boxes 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 toward 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 hours 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 solves.

When Universal decided to produce a television 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 concerned an ENG camera crew, and the concept was that although 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 1/2-in. videotape playback. The working method was that after a motion-picture sequence was shot in which the actor was videotaping a scene, a separate video crew would step in and videotape the sequence, and the videotape would later be played on monitors in editing room and control room sets of the dramatic show.

The shooting progressed smoothly enough, and the video experienced no technical or performance problems, but the video crew experienced difficulty fitting into the working rhythms and pacing of the show’s film crew. As a result, after a sequence was filmed, when it was time to videotape 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 procedural and interpersonal. At the end of the first week, Universal determined that the video production crew had run up a cost of $20,000 in terms of crew and cast delays, so the video crew was replaced with a film crew, and the inserts that were to be videotaped were filmed and transferred to videotape.

This story illustrates how, despite the successful solution of technical problems, the failure to successfully solve practical problems can be terminal for any new production system. The use of videotape on the Universal show “Invisible Woman,” for example, was considered by all measures of performance to be successful, but it was not overwhelmingly successful enough for Universal to plan other single-camera television episodic shows at this time. It seems that for a new production system to gain industry acceptance, it must not only be practical and cost effective, it must also be connected with an artistically and financially successful project.

Image Vision, the Image Transform system of producing videotape for transfer to 35mm motion-picture film, for example, is an artistically and cost-effectively viable production system. Many observers in the industry have been unable to understand why it has not found greater industry-wide acceptance. 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 never to have been identified with a film that was successful artistically and in the box office. In the motion-picture production industry, 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? This is a tenuous connection, 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 increases its chances of being identified with quick-and-dirty exploitive production where quality and artistic effectiveness are not primary concerns.

2. If a new production technology is awkward to use or inflexible, it interferes with artistic options. If it is 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 go even this far toward meeting the needs of the production community.

 Aspect Ratio

Our second priority, aspect ratio, has 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. Often discussed is 5:3, and ratios of 1.85:1 or 2.35:1, although common in the motion-picture industry, are considered wasteful or even radical as a proposal for high-definition broadcast systems.

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tire motion-picture heritage exists on films predominantly shot in a 2:1 or wider image format.

One possible alternative to the bandwidth/aspect ratio dilemma that, in my opinion, has not been adequately explored is the application of anamorphic lens systems in the original photography of high-definition video pictures. Subsequent deanamorphosing could be accomplished through the use of framestore technology at the receiver or projection end. This could also be accomplished in an even simpler way by modifying the receiver’s vertical height with a switch and fixed resistor to change the vertical size for deanamorphosing.

This system has been used in motion-picture production video monitors for some time. Although it may produce the dreaded underscanned screen that the FCC, at least in the U.S., has such a phobia against, there is a precedent, for example, in the showing of the feature Manhattan in the New York area with black bands top and bottom in the original widescreen format.

With all the discussion of widescreen 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 advantage of this system should be seen in increased vertical resolution at no additional cost in terms of transmission broadcast bandwidth usage.

Sensitivity

The third priority is sensitivity. Some of you may be puzzled that I placed sensitivity above resolution as a priority. I did this because camera sensitivity translates directly into production costs, whereas resolution does not. To realize the impact of increased sensitivity on a production, we must study what has occurred in film production with the advent of 5293, 5294, and other high-speed motion-picture stocks. (To be responsible in this investigation, high-speed motion-picture stocks did not begin with 5293; and even 5247, which is now considered a normal-speed stock, was once considered high-speed.)

Sensitivity in a motion-picture stock or in a video production camera translates directly into man-hours required to light a set. Hidden costs of low sensitivity are increased 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 makeup that has faded from heat and perspiration; and the length of time required to set up and strike a location of heavyweight compared to lightweight lighting instruments.

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

Dynamic Range

Dynamic range, 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 with fill lighting. Put simplistically, the narrower the dynamic range that can be reproduced safely by a camera, the more fill lighting is required to reproduce a scene.

Dynamic range limitations that do not occur in film cameras have always occurred in video 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 1½ stops in latitude. This generally translates to a 7-stop range from opaque blacks to transparent whites in film and a 5½-stop range for the equivalent exposure levels in video.

While gamma compression devices on current electronic cinematography cameras cannot increase 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 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 be a serious problem.

Resolution

The fifth priority is resolution. This may surprise some, because resolution is the first item on most engineers’ lists of priorities where HDTV or other advanced imaging systems are concerned. I think this is partially because when designing a video system to compete with film, many engineers are overly defensive about matters of resolution.

Many cinematographers feel it is not the superiority of film over video, in terms of absolute sharpness, that is the problem. A relatively small area of the picture, in any given frame, is critically sharp. The resolution characteristic of film that is most difficult to imitate with electronic cameras is the gradual transition from sharp to soft-focused 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 enhancned portion, is most objectionable.
Louis Pourciau's paper, "High Resolution TV for the Production of Motion Pictures," which was given at the 125th SMPTE Technical Conference, was an interesting comparison between the resolution of film systems and video systems. Although Pourciau is still in the process of documenting his work, the paper strongly suggested that the resolution of theoretically possible high-definition systems is competitive with currently available film resolution figures.

When discussing resolution in motion-picture film, two practical considerations must be kept in mind. The first is 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 the 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 3/4-in. videocassette. It was photographed entirely under low-light conditions, in car interiors and on city streets at night, and blown up to 35mm by Image Transform. It met with critical acclaim at the Telluride Film Festival. No one is suggesting that the resolution limits inherent in 3/4-in. videotape are adequate for large-screen projection. Nevertheless, the audience at the film festival did not throw tomatoes at the screen or run out shouting. As a matter of fact, from all accounts, a large percentage of those in the audience were unaware that they were viewing a film that was originally shot on videotape.

The second practical consideration is that sufficient motion-picture sharpness for professional theatrical applications can be defined as that amount of resolution which:

1. Allows the cinematographer to put diffusion or nets in front of the lens and deliberately toss away a large portion of the available resolution, and

2. 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 implies 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 is 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 generally takes time and careful attention, but the design of a lens appropriate for use with that tube is an equally, if not more, difficult undertaking.

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

This takes us back to our central theme of the high priority of flexibility and practicality in a dramatic-production camera. It is worth touching on registration in high-definition cameras. Any situation other than perfect registration produces major resolution limitations in the final high-definition picture. However, a high-definition video camera must be capable of more than superior registration, it must be able to achieve that registration consistently, in a short time period, and to hold it under adverse conditions including extremes of temperature and vibration.

Standards Acceptance

The sixth priority is standards acceptance. The dramatic-production industry can certainly 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 to be universally accepted for some time. They also want to know 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 loss in image quality.

Although broadcasters are interested in standards compatibility and simplicity of standards conversion, producers, as a group, are more interested in standards complexity and less in convenient conversion. The primary reason for this is that piracy or unauthorized duplication of motion-picture products is, according to Variety, an industry whose profits reached $1 billion last year. Complex encoding schemes and the use of encryption devices promise to make motion-picture piracy a more difficult undertaking.

This has great appeal for producers and is a tangible argument for high-definition video production of dramatic subjects. Simultaneous worldwide distribution via direct broadcast satellite promises the producer a sizable immediate income from his product. More important, this profit can be realized before motion-picture piracy can significantly erode the box office earnings of his production. The short turnaround between completion of a production and the box office return on investment promises to stimulate production in a era of high interest rates, and in some measure stem the tide of rising production costs. The promise of a worldwide release before the reviews can come out, is not lost on the production community, either.

Conclusion

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, 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 posed earlier — if it works, why fix it? — is that you fix something to improve it. Any attempt to improve an existing system must start with an understanding of the methods currently used to produce a dramatic production and a realistic assessment of actual needs, not imagined needs. We must ask ourselves if we are designing equipment to solve problems that don't exist. Equipment to improve production methods must first possess the basic system flexibility and image resources that current equipment and methods provide. We can then build from there.