

# The New Generation Television Recorder — A Broadcaster's Perspective

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## 1. INTRODUCTION

For the television broadcaster, the recorder plays an essential role, as the majority of television programs that are transmitted today come from recordings. The recorder is used widely in the field and in the studio for production recording, in the studio for post-production editing and program assembly, at the presentation studio for the playback of program segments, commercials, promotional material, and in the network for program delay and regional rescheduling. By the time the sound and pictures reach the viewer, they will have been recorded and reproduced between three and six times on the average, and more recording generations would be useful, particularly in production and post-production, if the resulting quality could be made acceptable.

The broadcaster's equipment is used frequently in a wide variety of operational situations and hence a single recording format for all applications is desirable. The new tape format, which the Broadcaster is seeking, will be common to all applications and hence great care must be taken in its specification. It must meet the current and potential needs, it must be technically and economically realizable and must, where possible, avoid placing hard limits on future improvements.

Although the various configurations of the machine will share a common tape format, and share many common parts, there will doubtless be several versions of the machine, each optimized with features for a particular task—field production, studio post-production, multi-cassette distribution release. There may well be different quality levels. Clearly, this family of machines will be very different to those currently available and the design approach must be significantly different.

## 2. OPERATIONAL ENVIRONMENT

An exhaustive list of all operational applications is essentially impossible, as television production pushes further into new areas, but the following can be identified and categorized as important for the broadcaster.

### 2.1 Field Recording

Production recording in the field, or using similar single-camera techniques in a dry studio, demands a machine that is transportable, rugged, highly reliable, operator friendly and insensitive to temperature, vibration, shock and foreign material of all kinds. Scene lengths tend to be short, production "special effects" are of very limited utility and monitoring/maintenance needs are best automated wherever possible.

Playback performance must be adequate only to establish the quality of its own recording or to make a few "after-hours" work copies in the field. This environment suggests a compact, reliable, recording machine using small sealed cassettes.

## 2.2 Studio Post-Production

If we assume that post-production will remain on tape, then the need is for rapid and precise scene location and editing capability, with highest quality playback and recording quality over several generations and with a wide range of source tapes. While many of the features demanded can be obtained by the use of intelligent processors, the basic reliability, accuracy and tape handling must be designed in, as must audio and video quality and editing accuracy. Size and weight are not major concerns and the studio offers a benign combination of temperature, humidity and cleanliness. Maintainability must be emphasized as downtime may become very expensive.

## 2.3 Distribution Uses

The operation of a television station, network, cable system or broadcast satellite, consists of the threading together in real-time under the viewer's (and sponsor's) scrutiny of numerous recorded segments of various lengths, origins and quality levels. Distribution may also require extensive record/playback operations to maintain time-zone and regional network schedules. Generally, distribution operations are driven by a computer system that ties together the machine control, switching and logging functions with those of traffic and scheduling and hence the recorder operates principally as a computer peripheral in the playback mode. In this application, the tape format selected must be adaptable to cassette operation and cassettes must be capable of reliable and efficient automatic loading from the library, identification and playback, with segment lengths from a few seconds to over an hour. Due to the cost impacts of downtime, the machine must be very reliable, maintainable and self-testing in all areas of its operation. Production features are not a priority need and size/weight concerns are of secondary interest.

## 2.4 Summary

The broadcaster needs then a range of machines which will share a common tape format, many essential modules and will be optimized and economic for the specific tasks of his plant. One single machine design is unlike to meet the needs adequately as the operational constraints vary widely from one use to another.

## 3. SIGNAL FORMS

The new recorder must be far more versatile than its predecessors in the variety of signal forms that it will handle, as the broadcaster is rapidly moving away from simple monophonic audio and NTSC video in the directions of multi-track digital audio and component video in both analog and digital forms, to obtain better quality, more flexibility and to prepare for component broadcasting via DBS. The interfacing needs for analog audio and NTSC video are well known, but in need of the improvements noted in section 4.

The interfacing requirements for digital audio, and component video are currently under close scrutiny in SMPTE, EBU, AES and CCIR and final standards are likely very soon. There remain many questions, however, regarding such things as audio/video synchronization, time-code in video and audio forms, ancillary signal processing, test signals etc which will take some time to solve. Broadcasters are participating in these discussions and generally envisage a recorder with a high quality video track, four audio tracks and a utility data track that are usable through interchangeable interfaces with the various signal forms. The recorder format could be simplified by making a 2:1 track relationship between component signals and composite NTSC signals and simple integer (e.g. 10:12) ratios between the track layout for 525 and 625 signals.

#### 4. TECHNICAL PERFORMANCE

At the present time, video and audio quality at the broadcaster's studio output is set largely by the accumulation of impairments over several generations of recording in production, distribution and presentation, as cameras and terminal equipment are already essentially transparent. In the future, as the plant moves towards higher quality levels in video components, there will be increasing pressure to improve the recorder. As a practical objective, some broadcasters suggest that the majority of the studio output should be CCIR Grade 4.5 or better (on a 5 point quality scale) which must be achieved, in many cases, after six generations of recording currently and potentially ten in the future. While this is a long way from "total transparency", it is still a formidable task for the recorder designer when translated into permissible impairments at each generation. For instance the video signal-to-noise ratio must be at least 55 dB and the luminance K-rating cannot exceed 0.25 percent at each generation. Similarly, the audio signal-to-noise ratio must be at least 75 dB with non-linear distortion below 0.1 percent and very tightly-controlled frequency response.

It seems unlikely that such large performance improvements can be achieved using analog recording techniques at reasonable tape consumptions and costs, while retaining current operational features and adding new ones. It is clear there must be an increasing focus on digital recording techniques which can provide these levels of technical performance and offer also improvements in productivity, reliability and maintainability.

The new recorder must also offer high quality recording of data for time-code, production use, editing control, synchronization etc. While the broadcaster has little direct experience to set the objectives here, it seems likely that a data rate between 38.4 Kb/sec and 57.6 Kb/sec will be required with a corrected error rate less than 1 in  $10^8$ . This again represents a significant design task for the new recorder, and lends further evidence to the need for a digital recorder. SMPTE and EBU have made good progress in the definition of a standard control interface for the VTR and this should also be incorporated into any new machine for the broadcasters plant. The technical performance of the new generation of recorders must be extremely good.

## 5. RECORDING MEDIA

From the broadcaster's viewpoint the choice of the recording media is not of direct concern. However, he will be looking for small size, cassette mounting, low cost, interchangeability, multiple sourcing, long mechanical life, freedom from drop-outs, archival stability, fast shuttling, over-write editing etc, all of which are directly affected by the choice of a tape media, its size, the packing density and record/ playback head selection. The choice of a tape media and the recorded patterns are key decisions in progress towards this new recorder and must be made on the basis of the priorities: - interchangeability, adequate operational margins, operational ease and reliability and good tape life. The broadcaster needs a machine that will do his job without any gambles involved.

### 5.1 Coating Materials

There are three basic contenders for the recorder, which will use a thin tape with long, narrow tracks. A tape thickness near that of Beta/VHS cassettes is foreseen (about 16-20 micro-meter - 0.6-0.8 mil). Based on 25.4 mm (1 in) tape, tracks likely would be 170 mm (6.7 in) long with a pitch of 45 micro-meter (1.8 mil). Coating choices include:

- Cobalt-Doped Gamma-Ferric-Oxide. This is the normal formulation for analog video-tape and hence it is well understood, backed by a great deal of experience and widely distributed. It has good freedom from drop-outs and a coercivity of about 700 Oersted with achievable packing densities of 4-6 Mb/cm<sup>2</sup> (30-40 Mb/in<sup>2</sup>).
- Metal Particle Tape. This technology is now at the early production stage for video applications and there remain concerns regarding head-wear tape wear and drop-outs to overcome. The coercivity is approximately 1400 Oersted and potential packing densities near 16 Mb/cm<sup>2</sup> (100 Mb/in<sup>2</sup>) are reported.
- Evaporated Metal Tape. This technology promises very high packing densities but is essentially at the laboratory level currently. Its long-term performance is not clear.

Taking account of the broadcaster's priorities of reliable interchange, adequate operational margins and good tape life, it is clear that a design based on ferric-oxide tape has advantages and that future developments or the use of new tape formulations could add better margins, longer cassette durations and the like. Strategically, the introduction of a new recorder, bringing together new technologies and new unproven tape formulations seems an unacceptable combination of risks.

### 5.3 Tape Width and Cassette

The broadcaster's needs are for a workable cassette with a length of at least one hour, which is reasonable in size, weight and form while being usable in both automatic and manually loaded machines. In addition, the cassette must have long life, allow high-speed shuttle with the tape threaded and offer good mechanical protection.

Tape widths between 12 mm ( $\frac{1}{2}$  in) and 25.4 mm (1 in) are attractive but the region 19 - 25.4 mm (0.75 - 1 in) gives the best combination of packing density, mechanical complexity and operational convenience, with a small advantage in shuttle-time and tape utilization for the 25.4 mm (1 in) width.

### 5.3 Track Pattern

Selection of a track pattern is a complex issue but the broadcaster's concerns are not the pattern itself but its operational consequences. The designer must consider particularly:

- Worst-Case Interchange. Track-following servos will almost certainly be required for this reason and to perform "stunt" modes such as picture in shuttle and slow-motion. (Stop motion will be from a frame store).
- Editing. Video and audio tracks must be editable independently and under worst case conditions. Track-following servos cannot be used to correct errors in record without some considerable complication.
- Audio. Audio data must be independently editable and will likely be recorded as time-multiplexed blocks at the ends of the video tracks. To provide timed pre-reading (for overlapped splices) the playback head must deflect over a number of tracks.
- Data Dispersion. To minimize the effects of head and tape related errors, spatially adjacent data words from the picture should be scrambled to non-adjacent positions on the tape, while noting the limitations imposed by high-speed playback. Multiple, parallel tracks containing several video blocks offers advantages.

There is a need for the reproduction of video, reference audio and time-code data over the full range of machine speeds. Suitable longitudinal tracks and coding schemes will have to be chosen.

The broadcaster needs a track pattern that meets these current objectives, offers good production flexibility and provides a vehicle for future growth. The choices of media, cassette and track details must be made soon and many broadcasters believe that there now exists enough data on the needs and appropriate technologies that this can now be undertaken.

## 6. PRODUCTION FEATURES

The list of production features to be found on any machine will vary from one version to another, as dictated by application. The essential requirement is that the tape format chosen, in conjunction with appropriate electronic processing should offer the desired range of features while still permitting low-cost small-size machines with minimum features and not unduly limiting innovative developments in the future. The format must then support:

- Basic record and playback of one video channel, four audio channels and a data channel with confidence playback in record mode.
- Independent editing of any combination of channels and editing between channels without timing or performance compromises with overlapped audio edits.
- Usable video and audio reproduction in shuttle mode, perhaps with audio derived from a longitudinal reference track.
- Slow-motion, video-only playback with good picture quality at selected speeds between -1 and +2 times play speed. Some speeds may be economically unfeasible in unsophisticated processors.
- Time-code recoverable in all modes. Editor to be referenced to time-code, data (source time-code), audio time-code or tape frame count (footage).
- Closely related versions of the format for 525 and 625 line standards and at  $\frac{1}{2}$  and twice the 4:2:2 component standard data rate.

Many extra features in processing, editing and control can be obtained by suitable electronics and this is to be encouraged, as it keeps the basic tape format simple, and retains the concepts of compatibility and expandability, which are essential to the development of the new generation of recorders.

## 7. OTHER CONSIDERATIONS

The previous sections of this paper have addressed, from the broadcaster's viewpoint, the major points of the technology, the production requirements and the desired technical performance of the new recorder. It is useful to review some other related concerns that may have a bearing on the design and introduction of the machine, though not of the highest priority.

### 7.1 Human Concerns

There is a continuing need to simplify the operation and maintenance of television equipment so that there can be a greater concentration on the creative use of the medium and as equipment performance becomes better less intrusion by the limitations of the medium into artistic decisions. The current widespread use of  $\frac{1}{2}$  in and  $\frac{1}{4}$  in portable equipment in ENG and in production well illustrates this point. This new generation of recorders must continue and expand this concept. The machines must be completely operable by people skilled in production. Tapes must be in cassette format to avoid handling, threading errors and contamination. The machine itself demands stability, reliability, self-checking, on-line monitoring and diagnostics and user-oriented controls, driven by friendly software. There will exist a need for user-defined controls, readouts etc to customize the controls for the work at hand. The checking system must report in meaningful messages and be programmed to call the operator only when the problem needs a decision, taking internal corrective action when needed. The machine must deliver full performance by design and not substitute operator skills to overcome circuit short-cuts.

## 7.2 Maintainability

There is no doubt that the recorder will be a complex device, though much of this complexity will lie in replicated digital logic elements, and in software. Due to the digital nature of the machine, failures will tend to be catastrophic rather than the gradual impairments in performance encountered in analog machines. It will also be working in an environment where downtime can be very expensive.

There is an obvious need then for inclusion of self-test features in all paths of the machine and for an internal monitoring/diagnostic system to check performance continuously, perform any possible control functions (e.g. Bit-swapping in memory) and to isolate and report fatal faults. The digital nature of most of the recorder, while a bane in complexity, is a blessing in simplifying the inclusion of these features.

## 7.3 Production Methods

It is likely that the introduction of the new recorder will make large changes in production methods, due to its high multi-generation capability and also due to the concurrent conversion of TV studio operations to components, in many cases using digital interconnection. Some significant development in recorder usage will then take place within the short period after its introduction and the designer must set aside some areas into which he can introduce the new features that evolve, without necessitating major redesign of the machine.

## 8. CONCLUSION

The New Generation Television Recorder is needed by the broadcaster soon and is, in fact, not a single machine but a family of machines sharing common tape formats and many components. The machines must offer very high levels of performance in the studio, in post-production and in distribution and be capable of working with the common signal forms of NTSC composite video, 4:2:2 component video and possible 4:1:1 or 4:4:4 component video signals in the future. It is clear that the machine performance, in both technical and production terms, can best be met using digital techniques and that the interchangeability and reliability aspects demand a very conservative approach to tapes and heads where technology changes slowly.

The broadcaster is not seeking video utopia. His needs continue to be high quality, flexibility, reliable tape interchange and predictable, reliable performance over long periods of time. We believe that the conclusions that are suggested in this presentation will be found to be a practical and realizable basis by which to measure the acceptability of the new generation of recorders in broadcasting.



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