

THE TRANSITION FROM ANALOG TO DIGITAL BROADCASTING

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Noting that the title of this conference is: "The Transition from SECAM to Digital Broadcasting", I feel something of an interloper, being ignorant of the problems involved in such a transition. I can, however, speak to the issues involved in the transition from NTSC to digital broadcasting, trusting that some of the matters raised will be common to all analog transmission formats.

The roots of this astonishing change in television are the "ones and zeros" of digital technology. Digital TV and HDTV are sweeping away present analog systems worldwide, launching a digital television future as different from today's analog television as was the introduction of color from the 19th century mechanical scanning experiments of Baird and Campbell-Swinton.

The digital TV and HDTV future began on June 1, 1990, when General Instrument proposed an all-digital high definition television system, and television was forever changed. The digital era had arrived and analog television was doomed worldwide.

As today's analog TV technology slips into oblivion, television will make its most fundamental technological change since its very inception. As digital techniques reinvent television technology over this decade, so will they reinvent broadcasting, cable, direct to home satellite systems, home video, and consumer devices.

Today, therefore, I want to give you a summary of the state of the transition from analog to digital techniques in America, a transition that is occurring at an ever-faster pace. But no new television delivery service can start without programs to support it, and thus the production of HDTV programming has become a major priority.

Almost from the time of the very first HDTV demonstrations in 1981, many in the industry perceived the importance of a single world standard for the production of HDTV programs, especially because the world of telecommunications was becoming ever smaller and more interconnected, becoming indeed a "global village", wherein the ready international interchange of programs would become vital. The leadership of the ITU in pursuing the objective of a single standard is a matter of record, a record for which the ITU should be justly proud, and all program producers and broadcasters very grateful, given the many practical and economic benefits derived from the standard.

One year ago, we celebrated the achievement of the ITU Recommendation ITU-R BT. 709-3, and the Common Image Format which it embodied, making it the world's first and only digital HDTV standard for the production and international exchange of HDTV programs, (Figure 1.). The Common Image Format is defined as having 1920 samples per scanning line, an aspect ratio of 16:9, with 1080 active lines interlaced and progressively scanned at 50 and 60 fields or frames per second, and progressively scanned at 24, 25, and 30 frames per second. There is no doubt that the establishment of this standard has had a galvanizing effect on the implementation of HDTV service in North America, and ultimately, will have such an effect everywhere.

Given the remarkable advances in the performance of HDTV cameras, today programs produced using electronic capture provide superb quality, while offering significant economies in the cost of production. This technique has been used to produce 22 one-hour episodes for TV of "The Secret Tales of Jules Verne", and 22 episodes of each of two other television programs: "100 Center Street" and "Titus". Following the successful use of electronic capture in part of "Star Wars Episode 1" by Lucas Films, "Episode 2", now in production, is using electronic capture only. Further, some nine other full-length feature "movies" are now in production, all shot electronically in High Definition.

Today, almost every major sporting event in tennis, golf, baseball, basketball, football and ice hockey, is produced in HDTV, and broadcast live. Many documentary-type programs, music spectacles and commercial messages are also produced and recorded in the Common Image Format standard.

Producing programs electronically has been shown to provide a technical quality of high definition that is superior to the cinema projection of 35-mm film. This has been demonstrated throughout Europe recently with the release of "Toy Story 2" and the remake of Disney's classic "Fantasia", which could be viewed both as film projection and as all-electronic projection. These last two "movies" are especially important, because it is the beginning of the Digital Cinema, a virtually new industry in which the program is produced in digital HDTV using electronic capture, and recorded at the traditional film rate of 24 frames per second, progressively scanned.

Postproduction is then completed in the 24P format to produce a master digital tape, (Figure 2.). Copies of this master may be made on tape or disc, and delivered to the theaters for exhibition. Beyond this, it is well seen that further economies may be achieved by satellite or fiber optic distribution of the programs to the multiple theaters scheduled to display them. The era of the Digital Cinema has arrived, and its expansion will be propelled by two fundamental economic advantages.

Firstly, it is now recognized that up to a 70 percent saving in production operating cost is achieved by all-electronic production in place of 35mm film cinematography. The principal sources of this saving are:

- Film is 10 times more costly than tape;
- Tape requires no chemical development or processing;
- Electronic production provides instant dailies as part of the production operation - at virtually no cost.
- Post production and non-linear editing of the original master tape recording is quicker and less expensive than film transfer to tape followed by editing.

Second, for a successful movie, the cost of printing many copies of the film and the cost of distributing them to cinemas worldwide, can amount to several million dollars, whereas a tape or disc is inexpensive to replicate for distribution, if it is required at all.

It is becoming clear to program producers, whether in Hollywood or in the television and cable industries, that programs which are expected to have archival and commercial value for the future, must be shot in HDTV. And even where today the program is to be distributed or exported in some lesser format, a down conversion of the HDTV master to, for example, Standard Definition TV (SDTV), provides a significantly better technical quality than if it had been produced in that lesser format originally.

While many studios are preparing to take advantage of all-electronic production, and are making the necessary investments in digital equipment, there presently remains a serious lack of HDTV programming to distribute. Happily, however, in the United States, the great mass of entertainment programming for the commercial and public service television networks is recorded in high definition, namely 35mm film, and it has been thus for fifty years. However, not a single frame of this high definition film has ever found its way into the home.

To acquire this source of HDTV programming for television broadcast, the original film negative is transferred to HD tape, maintaining the native picture-taking rate of the film of 24 frames/second, progressively scanned. All post production operations are conducted in this format, resulting in improved quality and efficiency, in particular through the avoidance of split edits occurring when working in a 3:2 pull down mode at 50 or 60 fields per second.

Once the post production operation is complete, the 24 P master tape may be converted to whatever format is required for the distribution of the program. This technique for HDTV production on film uses the same wide screen format, on the same film, using the same cameras as those used for current analog productions. Using this approach, the CBS Television Network, is, in the present season, broadcasting almost the entire schedule of entertainment programming - 18 hours per week - of prime time evening programs in HDTV.

This formidable schedule of programming contains two movies, six situation comedies, and 11 episodic drama programs, (Figure 3.).

Overall, in the USA today, terrestrial broadcasters, together with cable system operators and direct broadcast by satellite services, are currently transmitting over 150 hours per week of HDTV programming. In sum, the production of digital HDTV programs, whether derived from electronic capture or from the conversion of 35mm film, is growing rapidly, and the digital HDTV Common Image Format used, will become also the standard for the international exchange of programs.

The status of the transition of the TV stations from analog to digital service is essentially on schedule. Almost all the 1619 stations in the United States have filed for permission from the FCC to construct a digital TV transmission facility. 525 stations have been granted construction permits, and 150 stations are already on-air with a digital signal, serving 64 percent of all the TV households in the United States, (Figure 4.).

All stations are required by the FCC to be on air with a digital signal by 2003. The FCC has ruled that the new digital channel that has been allocated to every broadcaster must:

- Provide a free digital broadcast service;
- Simulcast both the digital and analog channel;
- Return the analog channel in 2006, or at the time that NTSC broadcasting is stopped;
- Cause the digital signal to replicate the existing NTSC service area with minimal interference using the 8-VSB transmission system. CBS has conducted field tests to determine if this goal is being achieved.

The tests were conducted in Philadelphia, comparing the digital television coverage to the coverage of a nearby NTSC station with similar propagation characteristics. Both indoor reception at 35 sites and 105 outdoor reception measurements were made at ranges of 5 miles to 60 miles from the transmitters.

Of the 33 indoor sites that had even a marginal NTSC reception, 94 percent had full quality DTV reception. Of 105 outdoor sites that had even a marginal NTSC reception, 99 percent had full quality DTV reception. It was concluded that the 8-VSB system could fully replicate the NTSC analog coverage and meet all FCC requirements.

Since the beginning of television, every major advance in the technology has been dubbed "High Definition", simply because it was of higher definition than the system which it replaced. In 1935, RCA produced a system with 343 scanning lines, which the BBC topped with 405 lines a year later. In 1939 it was 441 and in 1953, color TV in the U.S. had 525 lines, while in Europe, it became 625 lines. Today, HDTV is 1125 total lines and 1080 active scanning lines.

So, how high can HDTV go? Certainly, systems can be built with even higher numbers of lines, but there is a practical limit for television displays intended for the home viewer of television programs, and that limit is the natural acuity of the human eye. It turns out that a viewer positioned 3.2 picture heights from a display that subtends a 32 degree angle of view to the viewer, is able to resolve a maximum of 1920 picture elements in the horizontal plane, and this limit is set by the acuity of the eye.

As it happens, the Common Image Format standard requires that the same number - 1920 pixels per scan line - be sampled. At least under the viewing conditions above, human viewing acuity has set the limit to observed resolution.

At this point, however, the displays now on the market limit the observed resolution of the picture. In fact, the HDTV signal is much better than it looks. The casual observer, viewing HDTV on a presently available display, may conclude that there is little or no difference in resolution between HDTV and any lesser version of HDTV or even SDTV. However, using prototype displays embodying the latest advances in display technology, the differences between 1080/ 1920 HDTV and any other format are both large and evident.

But this temporary limitation in displayed resolution is as it should be. The full potential of any new standard should never be fully encompassed by the existing state-of-the-art, nor should it be so futuristic as to not have its potential achievable in a foreseeable time.

In reviewing the status of this ongoing technical revolution, it is important to recognize that HDTV is not just another minor advance in providing pretty pictures for today's small screen TV sets. Rather, it is a wholly new digital platform that will support the larger and vastly improved displays now coming to market. HDTV viewed on such high quality, wide screen displays, will create an entirely new viewing experience and will finally make the home theater a practical reality.

Digital TV broadcasting with its quality and flexibility will provide a host of new opportunities for more and better services. In addition to the transmission of full HDTV or several multiplexed standard definition programs, the digital system allows the simultaneous transmission of data and what is called "opportunistic data". This "opportunistic data" is available whenever the picture does not require the full channel data capacity. Statistically, this occurs often enough to provide enough data to transmit both program and non-program-related text, data and graphics, simultaneously with the HDTV program. Services such as news, weather and financial data may be multiplexed into the program signal, and transmitted along with the digital program.

The final stage in the transition to the digital age is the acceptance by the viewer. The rate at which DTV and HDTV will penetrate the consumer market will turn upon the consumer's interest, the price of a receiver, and finally upon the availability of HDTV programming. Some eight consumer electronics manufacturers are producing digital receivers for the home, with prices starting as low as \$2,500. It is forecast that 500,000 DTV sets will have been sold by the end of 2000, and that US market penetration of HDTV will be between 30 and 50 percent by 2006.

While digital 525 and 625 line television systems are evolutionary improvements over analog systems, they are not HDTV, and while useful for some purposes today, they are based on 50 year old analog systems, and they may not survive long into the 21st century as HDTV becomes de rigueur. I would then leave you with these suggestions.

1. Participate in the design, development and standardization of the new service. Critical decisions are being made daily by broadcasters, satellite and cable operators, and by the ITU. Participate!
2. Make no further investments in analog equipment. It is fading into obsolescence.
3. Plan now for the digital and HDTV transition, noting that the international program market is moving now towards HDTV to protect archives, future program distribution and international sales.
4. If you have not yet started the transition to digital, I would urge you to make the leap, but leap all the way to HDTV. Do not stop half way at SDTV, because it is not even half as good!

High Definition was a new thought in 1935, when David Sarnoff, President of RCA, reported on the emergence of television, and on the need for the highest quality system. He said:

"Public interest in television continues unabated since RCA stated that it was diligently exploring the development of television. Our laboratory efforts have been guided by the principle that the commercial application of such a service could be achieved only through a system of high definition television."

Twelve years later, in 1947, he issued this warning on the need for planned and considered action:

"I am not here to urge you to enter the field of television beyond the point where you yourselves think it is good business for you to do so, or to propose that you plunge in all at one time. Rather, I would suggest that you reflect carefully and thoughtfully upon the possible ultimate effects of television on your established business if you do nothing, and of the great opportunities for your present and future business if you do the right thing."

Today, it is here, real, growing, and unavoidable. Embrace it!