HDTV Issues: Rallying Cry or Whimper?

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Summary

Far more than most technology-related subjects, finding a direction for U.S. policy toward HDTV has attracted both congressional and industry attention in a textbook example of struggles in an information-age issue area.

The strongest claim being made is that HDTV policy is critical to future U.S. technical and economic health, and that HDTV must serve as a rallying point around which to muster U.S. electronic capabilities. But is this really the case? And, even if so, are the suggested actions adequate to achieve the objective?

The issues. New technical capabilities have made improved video product and service offerings possible, but the way these capabilities are adopted can alter the competitive positions of existing stakeholder groups. Some of these stakeholder groups owe their existence to possession of government licenses, while others are subject to little or no government intervention. The technology, itself, is claimed to be so critical to a variety of applications beyond TV that effective participation in HDTV is viewed by some as pivotal to maintaining both a healthy balance of trade and a position of global technological leadership.

Thus, there are numerous stakeholders, many of them asserting that the stakes are high, not only for themselves but also for the industry, the public, and the nation. Their arguments cover a wide range of subject matters; and corporate and government decision makers, as well as interested citizens, have difficulty differentiating between reality and hype.

Fundamentally, two families of issues tend to be put forth:

- Broadcast issues These center around home TV system standards and spectrum usage, as they influence which program distribution methods can be employed with each proposed improved system; these often are referred to as the "broadcast" issues.

- Chips-plus issues These involve trade and technology leadership matters, as they may be influenced by HDTV standards that are

adopted and the speed with which these standards are put in place. They have sometimes been termed the "chips" issues, although they are far broader than the label implies.

Reality testing. Stakeholders have proposed a number of actions with regard to these issues. So far, however, little consideration has been given to whether the actions being proposed can really produce the desired results, given the technologies involved and current U.S. industry positions and attitudes. Taking the second issue family above as an example:

- There are those who maintain that the HDTV situation offers U.S. industry an opportunity to "catch-up" in TV manufacturing, and that it must use the opportunity to ensure that it retains its strong position in solid state technologies.

- If the U.S. were not experiencing a major weakness in consumer electronics, and the perception of a growing threat of one in advanced solid-state technologies, there probably would be little concern about this subject and related trade issues. Instead, HDTV probably would be viewed as raising only domestic issues concerned with conflicting distribution methods (as was assumed in early discussions of HDTV).

- On the other hand, the perceived U.S. problems in consumer electronics and solid-state technologies may very well be far too fundamental to be altered in a meaningful way by any set of steps that are confined to HDTV issues. If this is the case, the HDTV issues must be related to other, quite major (and as yet unspecified) economic and social measures before the real problems can begin to be diagnosed and treated.

Questions. We have reviewed some major features of the HDTV issue area and believe the following questions are particularly relevant:

Is the broadcast issue more than a temporary one? Assume that it is socially desirable to have quality standards for video displays set to meet broadcast limitations. Is there a feasible and acceptable way to maintain such standards? Won't other forms of TV and video distribution find ways to bypass the standards if they have reasons to do so?

For example, an approach proposed by William Schreiber of MIT uses a flexible signal processor "front end" that would enable a variety of display quality levels to be offered, each of which could be matched to a particular use or distribution technology. This approach extends practices already used in the computer industry, where higher quality displays have been needed (and are available) for some purposes. Because much of what is needed is software embedded in chips, the costs for such flexibility may become quite low. Given this capability, can standards that have been set to match broadcast limitations really be effective in blocking use of higher definition distribution means?

What are the important linkages between HDTV and employment? Between HDTV and the U.S. position in other areas of high technology?

Manufacturing activity is now global; regardless of the size of its market, specific production will not stay in a country if it can be done better elsewhere. Large CRTs (for which better definition is important) tend to be produced close to final assembly points because of their bulk and fragility. But this is not the case for their competitors -- large-screen projection systems and (perhaps eventually) large flat panels. Thus, neither industry participation nor end market size automatically imply local manufacturing jobs.

Linkages appear to be inherently strong and important in two areas: in design, where components such as chips are specified and proprietary elements are incorporated, and in justification of the R&D support that is needed to maintain technical and product development strengths. For participation in both of these activities, and in the associated production of key components, a strong manufacturing position in relevant final product industries is likely to be needed, and HDTV provides one such opportunity.

Can HDTV provide a basis for re-entry by the U.S. into the home TV industry? Into the consumer electronics industry? Is this re-entry possible without the willingness of some strong U.S. companies to commit massive amounts of their own money into the effort? What, if anything, can be done to encourage such commitments?

These last, of course, are the key questions. Unless they can be answered affirmatively, the scope of useful U.S. actions will be quite limited in their impacts and HDTV will not provide the rallying point some are seeking.

Review

Technology-application interfaces. Because technological advances were a major factor in stirring up the HDTV issues, we can examine the situation by looking at the technology-application combinations of concern in the current discussions. These are shown on the attached table, categorized in terms of: (column 1) Display Technical Characteristics; (column 2) Display Applications; and (column 3) Distribution Processes for input materials that can be associated with different groups of applications.

In its original and most narrow definition, HDTV only involved changes in the standards that apply to the combination:

- display characteristics[1] (in the form of changes in existing display shape and increases in definition)
- for the home TV application
- using distribution means associated with Basic Video.

The broader issues of trade and technology leadership began to receive attention more recently, growing rapidly to cover subjects as apparently remote as the influence of HDTV leadership on long-term leadership in personal computer and workstation development.

Display Technical Characteristics	Display Applications	Distribution Processes
Type CRT Flat panel • Liquid crystal • Other **Shape** **Color** **Quality** Definition (pixels) Other features	**Basic Video** Home TV Theater projection video	**Wireless** Traditional broadcasting Satellite broadcasting **Landline** Coaxial, fiber optic cable **Hard copy** Cassette, disk
	Other/More than Basic Video General purpose computers Special purpose workstations (e.g. CAD/CAM) Video games Interactive multimedia Reading device	**All combinations of materials that were:** Generated during local applications Received over telecommunications links of all types Acquired on disks/cassettes
	Instruments/Avionics Simulators C^3I displays Holographic displays (?)	**Above** plus inputs from: remote sensors

HDTV/High Definition Displays:
Technology-Application Interfaces

[1] Originally only CRT displays (for direct viewing or for projection) were considered; more recently, flat-panel systems have begun to receive increasing attention.

The table helps us take a closer look at the underlying technologies and their applications:

Display Technical Characteristics (column 1). Proposed new standards will essentially double the vertical definition (the number of horizontal lines displayed per frame) of current CRTs. With a larger width/height ratio also planned (discussed below), the effective number of pixels presented per frame may be as much as quintupled. At this point, the practical definition limits for small and medium-size color CRTs will have been reached. The reason is that the only way found so far to produce good color CRTs requires a carefully aligned shadow mask, and mask production and operation run into a variety of fairly fundamental difficulties as the mask hole radii and separation are decreased.[2] (Note that the limit would pose no problem if pixel count per frame could increase with display size. While this approach raises complex problems for recreational TV -- especially with broadcast delivery -- these may be manageable. Computer displays already exploit an approach of this type to some extent.)

Liquid crystals will not be subject to the same limitation. Their problem is almost the opposite -- how to produce adequate yields of large displays, for which you have to lay down millions of transistor power and control lines with lengths that may have to be half or more the dimensions of the display. This is a type of engineering problem that the U.S. and the Japanese have been quite successful at solving in the past; if equal success is achieved in this case, the longer-term future probably belongs to liquid crystals![3] However, the large wall-hung displays sometimes described in HDTV discussions still seem a fair way in the future.

The proposed new shape for video TV screens will be closer to that of wide-screen cinema. This change will make it possible to transfer movies to video systems with a better match of picture dimensions. The new shape is fine for entertainment, especially for multi-person viewing. But will it also be a good shape for other display purposes? Consider books, for example; the shape of their pages has never been strongly constrained by materials or process limits, so human factors

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[2] Example: as hole size is decreased, beam strength (current) must be increased to maintain the brightness of the display. This requirement, however, tends to cause both beam defocusing and damage that shortens tube life. Despite major efforts over many years, these types of problems have not been solved effectively, and improvement has been very slow. Monochrome CRTs also have practical limits to their definition, set by beam dot sizes; however, at a price, quite high definition can be achieved.

[3] This point is strengthened by the fact that the panel display is built with solid state technologies for which we have a long history of major reductions in costs as experience is gained and production runs increase. CRTs, on the other hand, employ technologies for which major future cost reductions are very unlikely. Thus, liquid crystals are likely to win the cost battle as well as the definition one.

have been the dominating influence at work. Given their long evolutionary history, the current shapes are apt to be the most natural ones for serious reading and probably for composing text.[4] It is interesting to note that a number of high-quality CRT monitors have adopted a "page" shape (height greater than width) rather than sticking with the TV-derived, standard monitor shape.

All the various display uses have their own use-related needs, and probably have corresponding "natural" display shapes (as well as different size, definition, and quality requirements). Even though the same basic technologies may be employed in their manufacture, these differences potentially can lead to at least some fragmentation in the structure of the display production industry.

If one is interested only in display quality, then high-quality computer monitors (with up to more than 5 million black and white pixels per frame) are already available and in growing use. While special-purpose workstations, such as CAD/CAM, are the major application, high-quality monitors also may appear in top-of-the-line general purpose computer systems. Their quality can be equivalent to or better than that to be offered by HDTV. Thus, the market for computer-related displays already is large enough to make its demand worth the effort of creating new high-end product lines that go far beyond the quality of current, production-type TV tubes.

Display Applications (column 2). The list of display uses constitutes a mix of existing uses and extensions of these uses. In essence, the list ideally should include the visual outputs (including indicators for control operations) for all substance on which electronic reception or processing (including retrieval from electronic storage) has been employed.

For many of the items listed (simulators, C^3I displays, special purpose workstations, some video games, and so on), display costs are a small fraction of the full equipment costs and an even smaller fraction of the economic benefits expected from operation of the systems. For these uses, neither TV display limitations nor TV display advances are apt to have much impact on the specific displays employed. As noted above, this already has been demonstrated in the case of high-end workstation and computer displays. Thus, the displays for these markets can be viewed as largely independent of the production operations used to supply the TV display market.

For home computers and possible future reading devices, display costs can be much more important to purchasers. However, the longer-term future for these devices, and the "future" in which they are most important, is one where they permeate society and form a huge market by themselves. If this large market arises, its size should provide a considerable degree of independence from TV display development as long

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[4] Larger sizes and somewhat different shapes presumably are better when advertising is added to a text presentation, as in newspapers and magazines.

as user needs and preferences offer significant reasons for physical or technical display differences.

If the above views are valid, the synergies between home TV display equipment and that used for other video purposes will be more limited than in the past, but they won't be totally eliminated. Many underlying production technologies, design features, and components will be common to both families of uses, so important scale economies may apply to items such as memory chips. Also, differences in required quality levels for different uses may enable some producers to utilize their total output of components more efficiently than others; memory chips again furnish an example.[5]

Distribution Processes (column 1). Distribution mechanisms differ among types of uses principally based on the extent to which display input is locally generated and/or locally manipulated or controlled at the detailed level. This distinction can be viewed as the contrast between active and passive uses of received materials. Another and more operational view (although one that has some modest exceptions) distinguishes between, first, uses that can survive on, or benefit significantly from, using broadcast inputs; and second, those that cannot.

This distinction has tremendous (and obvious) impacts, because use of broadcast:

- creates a major government role, based on the need to control and allocate spectrum;
- increases the number of attributes and/or range of technical specifications to which standards must apply, if equipment is to be widely usable and stable over time, and thus "safe" for consumers to purchase;
- creates an environment very conducive to large-scale advertising; this can generate large financial support for broadcast operations and thereby provide viewers with "free" programming.

Many of the currently more controversial issues concerning HDTV flow directly from these factors.

At the moment, most proposals for new standards are centered on broadcast technologies and involve technical approaches that incorporate three fundamental ingredients:

- A careful mix of analog and digital techniques, with digital used for sound and for at least some control functions (such as synchronization pulses);

[5] The Japanese reportedly have used the good quality output of (new, higher-capacity) memory chips for computers, and then used the good segments of lower-quality output for TV and other consumer goods that had lesser memory requirements.

- Varying degrees of pre- and post-processing for purposes such as obtaining a high data compression ratio. At one extreme is the MIT proposal (mentioned earlier) for a highly flexible module that, depending on the circuit cards incorporated, could handle a wide variety of types of input signals and formats;

- A requirement in all the significant proposals for at least some increment of broadcast bandwidth to support the full HD version of equipment -- usually for an additional 3 or 6 MHz.

These elements in proposed approaches mostly arise from the simultaneous requirements for compatibility with the present system and minimal addition of broadcast bandwidth.

Being free of both the above requirements (although with some compatibility requirements of their own), the other listed uses have far more flexibility in selecting preferred technologies. Non-broadcast systems are apt to be all digital, rather than hybrid. Bit-mapping may be their preferred display scan, while raster scanning, because of its analog roots, is the traditional approach for TV. For many non-TV systems, technologies can be adapted from non-video sources, such as digital audio disks, rather than requiring (or waiting for) video-capable versions of the techniques. The bandwidth problem still exists in many of these applications, but the options for handling it are far more numerous.

Once again a picture seems to emerge in which some technologies and design elements, a number of common components, and perhaps some common production and/or distribution channels will be shared. But the strongest pattern suggests a potential for independent evolution whenever markets are identified in which different customer needs and interests dictate different display characteristics.

Implications

What general conclusions can be drawn from this discussion? To what extent are the public versions of the issues compatible with the technical capabilities from which, in part, they flow? Some general comments follow.

Benefits. The benefits of high definition are most important for large displays (say, greater than 20" diagonal) of all types (including projection systems), and for smaller displays that have uses involving examination of extensive amounts of text and/or the details of images.

High definition is also useful for medium-size displays (say, 10"-19" diagonals) but it is not needed for small displays of typical current home TV material (such as action type video).

Markets. There appears to be a range of market types for electronic displays:

- A very large existing market for home TV (received via a number of delivery means), much of which can benefit from high definition;

- A potentially large market for portable TV (via broadcast and, perhaps, eventually video disk) that can benefit greatly from lightweight displays but that has no great urgency for higher definition because smaller displays normally will be used;

- A fairly large existing market for computer displays, mostly of medium size, that can benefit from high definition;

- A potentially very large market for "book" or reading type displays that will require both high definition and light weight; and

- A large number of niche markets, many of large monetary value, for specialized computer displays, instruments, avionics, simulators, and the like. Many of these can benefit from high definition, some of them quite importantly. In fact, a number of these application areas may be able to expand in scope and grow in usage, partly because higher definition displays will support increased capabilities.

Diversity. These markets are not tightly linked. Although there is some overlap, the customers and their needs, and therefore the appropriate marketing approaches, now are quite different.

- The current dominant market is for home video/TV. Here, there are strong reasons for standards that will assure future video equipment compatibility with broadcasting in general ("free" programs will not easily be given up, and any growth in the largely broadcast-dependent, portable TV market will reinforce this feeling) and compatibility with current broadcast equipment in particular. Note that this compatibility requirement is a minimal one and not a total constraint on higher quality. As indicated by the MIT approach, equipment can be designed to be compatible with broadcast but to also provide higher definition for use with non-broadcast distribution means, although the extra costs may be significant (especially at the start).

- The remaining markets (for computer displays, etc.) are not broadcast-dependent. However, most of them are either potentially big enough to control their own destinies or are sufficiently high value-added to be relatively insensitive to the costs of their displays (and thus need not depend on the commodity-production displays used in the TV market).

Linkages. Important linkages do arise in the underlying technologies, especially at the component and manufacturing process levels. The broadest links concern:

- Solid state components, in particular memory and special processor chips. These appear in all the equipment types of concern, and their usage probably will grow with the spread of new techniques for signal processing, data compression, screen control and buffering, and equipment/operations diagnostics. Skill in designing, mass producing, and employing these devices to improve equipment quality and functionality is likely to become the key to market leadership.

- The display itself. Large CRTs and projection systems are likely to be the first ones used in HDTV. Because of their bulk and fragility, the large CRTs will tend to be manufactured close to final assembly points. However, projection systems and smaller CRTs can be manufactured anywhere, and special production equipment for all types of displays is apt to originate in the country of the display designer.

  The flat-panel situation could evolve differently. With less bulk and weight, and less fragility than CRTs, even large panels could be manufactured anywhere -- without regard for eventual assembly point. Liquid crystal panels also differ from CRTs in that basically they will be solid state devices, relying on techniques such as TFTs (thin film transistors) for crystal control. This reliance places greater emphasis on the solid-state skills mentioned just above; dominance in flat-panel technologies -- if they are successful in achieving adequate definition-size combinations -- will provide very broad technological advantages.

- Design skills. Many design considerations (such as location and division of "smarts" of different types, special purpose chip designs, and integration techniques) are likely to be of value across application areas to an extent that broadly based companies (or closely cooperating individual companies) will have important potential advantages. At the national level, it is important to note that the designer normally will specify the components to be used. The components he will know best are likely to be local ones, so these will be at an advantage; and there probably will be even stronger reasons to use local sources for high-value components and for those incorporating proprietary features.

- Research and development. R&D budgets obviously will be influenced by the depth of involvement of organizations in the total production process -- design, manufacture, distribution, and marketing. Participation in detailed design of equipment is of critical importance in this regard, because this stage provides the main opportunity for practical use of R&D outputs and, thereby, justification for such activities. Scale economies also are important, since state-of-the-art R&D in current solid state technology is extremely expensive. Finally, there are potential

synergies of R&D applications across product types that can be exploited, if the effort to do so is well managed.

Software/Video Production organizations. These organizations should gain to at least some extent from the improvements in picture quality, but this is likely to be a second-order effect except in the case of successful reading devices, where the impacts could be enormous. Software production equipment presumably will continue the normal improvement pattern -- cheaper, better, etc. -- after an initial period of higher costs to reflect the greater complexity of the new HD systems. Other software costs should not be affected by the change in displays, except to the extent that something new starts to be tried because higher definition displays have become available. Even here, the cost changes seem likely to be small compared to the increases that can result from non-display advances (mainly in computer and memory capabilities) that enable markets to grow for products that employ techniques such as multimedia and hypertext. This, of course, simply amounts to the development of new markets, and these will grow only if new revenues exceed new costs.

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Overall, HDTV is clearly an important area, and one for which the direction of future changes is subject to some control through decisions regarding broadcast standards, spectrum allocations, and other government actions. However, this control may be far from complete. There are also other products and services, and some major areas of technology, that will be influenced by the path of HDTV evolution. Nevertheless, it is far from clear that standards decisions and other government actions, by themselves, can have the dramatic effects on U.S. industry that some stakeholders are implying.

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