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TO: Mr. J.A. Flaherty
Chairman, Planning Subcommittee,
ACATS.

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I attach a copy of the ~~report on~~ the projected penetration of **HDTV** into the universe of television households.

This report is the output document of the Planning Subcommittee's Working Party 5. Amendments suggested by members of WP-5 have been included in this final version of the report.

It is expected that more precise pricing information will become available in the next six months, and the report will then be updated.

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MARKET PENETRATION OF HDTV

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HDTV MARKET PENETRATION

EXECUTIVE SUMMARY

Previous projections of the penetration of HDTV into the consumer market, have been based on a presumed analog with the market penetration of color television and of the VCR. This study builds on the earlier work, but takes account also of recent advances in both digital and display technology, and the recent consumer trends towards larger displays.

The basic premise of the present study is that all the potential high definition delivery media, including terrestrial broadcasting, cable, home video, and DBS will contribute to the growth of HD homes. A High Definition Television Household (HD TVHH) is defined as one having a HD display unit. This display unit will serve for any or all of the delivery devices, much as the VCR today uses the same display unit as is used for terrestrial broadcasting or cable service.

It is projected that, in the early years after the selection of a HD terrestrial broadcasting standard, HD cable and HD home video may begin market penetration before terrestrial broadcasting can be widely implemented.

The overall rate of growth will be constrained by several factors. First, the perceived incremental value of HD service over current service may be equal to that of color TV over Monochrome TV. This condition is defined as "High Perceived Value", and leads to the most optimistic projections of growth.

Equally, the perceived value may be much less, assumedly one third of the High Perceived Value. This condition of "Low Perceived Value" leads to the most pessimistic projections of growth.

Second, the annual discretionary income available for HD equipment purchases is assumed to be that currently applied to the four delivery services. This source of funding would be gradually redirected to the purchase of HD equipment in the condition of "High Perceived Value". For the "Low Perceived Value" condition, the available funding is taken to be one third of that available for the "High Perceived Value" condition.

The quantity of HD equipment acquired will then depend on the price of each unit. Since these prices are as yet ill-defined, each unit is accorded a "High Price" and a "Low Price" at introduction. Both these prices are assumed to fall with improvements in manufacturing design and developing economies of scale.

While other factors affecting penetration are considered herein, they are seen to have little impact on the rate of growth, with the exception that the market penetration developed by HD terrestrial broadcasting will be directly limited by the rate at which local TV stations are able or choose to convert their plant for HDTV terrestrial transmission.

For the purpose of this study, Year 0 is defined as the time at which the FCC selects a transmission standard, issues a Report and Order, and issues a table of spectral allotments, for which TV stations may apply for a specific channel assignment.

On the basis of the above methodology, four curves of market penetration growth are developed, viz.:

- High Perceived Value with High Price.
- High Perceived Value with Low Price.
- Low Perceived Value with High Price, and
- Low Perceived Value with Low price.

The mean values of these projections (shown in Figure 2) suggest a penetration of 6 percent in Year 5, and 37 percent in Year 10.

It is also recognized that discretionary income is an ill-defined fund, and that if the perceived value of HDTV is very high, discretionary income may be redirected not only from that now applied to video services (as assumed in this study), but may be redirected additionally from other areas of consumer expenditure.

The fact that five percent of the present TV set market comprises large screen sets; that this market segment is growing; and that there is confidence in the set manufacturing industry that much of this market segment will readily and quickly convert to High Definition displays, suggests that the rate of penetration growth of HD TVHH may be closer to the more optimistic projection for the condition of High Perceived Value with Low Price.

This projection calls for 8 percent penetration in Year 5, and 56 percent penetration in Year 10.

No specific attention has been given to the probability that manufacturers will introduce forward pricing strategies in the first years in order to seed the market more rapidly, and thus increase the penetration.

MARKET PENETRATION OF HDTV

1. INTRODUCTION

During the last three years, PS WP-5 of ACATS has studied the possible rate of penetration of HDTV receivers in the consumer market.

A series of penetration scenarios has been developed, using a number of assumptions, and based in part on the historic penetration rates of color TV and the VCR.

The published results of this work have been broadly, if somewhat intuitively, criticized as being too conservative. In this discussion paper, the prior assumptions are reviewed, and some new or revised considerations are introduced, based upon more recent technical advances and FCC policy positions. These taken together, form the foundation of a new penetration scenario.

2. FACTORS AFFECTING MARKET PENETRATION

The following factors will have a direct or indirect impact on market penetration:

- The perceived value of HDTV
- Consumer price of equipment
- The availability of HD programming
- Television Station conversion costs
- The cost of HD programming
- The growth of HD Home video
- The growth of HD cable service
- The growth of HD DBS service.

Some of the above factors will be affected by new technologies in the following fields :

- Digital encoding and transmission
- Fiber optics
- Interactive services
- Multi-media terminals
- Solid state displays.

We move now to a consideration of the above factors.

2.1 The Perceived Value of HDTV to the Consumer.

No truly adequate surveys of audience reaction to HDTV have been published, either because the samples were too small or the methodology was suspect. However, from the body of work available, it is at least clear that there exists a general preference for a wide screen display with a 16:9 aspect ratio. Associated with this is the preference of viewers to view the display at a distance of three times the picture height, thereby providing a 30 degree field of view, similar to that already enjoyed in the cinema. To view a display at that distance with the conventional 525 or 625 lines format is generally found to be disagreeable, because the line structure is very obvious. However, with a display of more than 1000 lines, no picture structure is seen, and the definition observed approximates the acuity of the eye.

The subjective merits of HDTV are most evident when viewing a large screen. If the viewer is seated six feet from the screen, then the picture height should be two feet and the diagonal of the display will be 49 inches. This size display is impractical for CRT devices, and therefore a projection system is required or a solid state display. The latter have not yet been developed to the point where they can be mass-produced reliably or economically. Within the time frame of this study it is likely that they will become available, and will compete with the present type of projection systems.

If it is accepted that, for most of the consumer market, a large display is essential to assure that the viewer perceives HDTV as a greatly improved video service, the question arises of the incremental price the consumer is willing to pay for the new service.

The market acceptance of color TV may provide some indication of the market acceptance of HDTV if the assumption is made that the perceived value of HDTV over color is comparable to the perceived value of color TV over monochrome TV. When full primetime programming in color was achieved in 1966, and when market penetration "took off", the retail price of a color TV set represented 14.7 percent of the average per capita income. The equivalent price in 1992 for a similar percentage investment is \$3,700, a figure that is feasible for a HDTV set. It is also noted that in the four years from 1966 to 1970, market penetration rose from 9 percent to 34 percent.

Lacking any valid data on the perceived value of HDTV service, and sensitive to the view that it may be less than the perceived value of color TV, this study considers also that the perceived value of HDTV lies between the value accorded color TV and a lower value projected to be one third that of color TV. These two bounds are referred to as "High Value" and "Low Value" in later sections of this report.

Some support for the "High Value" approach is found in the present trend of the market towards larger projection displays which are also more expensive. In addition, large CRTs of 30 inches and up now constitute 3 percent of the total market. In NTSC, these offer no increase in definition, but evidently meet a consumer demand. It is believed by some manufacturers that this growing market segment may be the first to acquire HDTV equipment as soon as it is available, and currently represents sales of 400,000 projection units annually.

2.2 Consumer Price of Equipment.

When monochrome and later, color TV sets were introduced, they provided the only video channel to the home, and a single "black box" had to make and penetrate a new market. With the advent of cable, and later the VCR, alternative channels to the home appeared, giving the viewer more choice and often better quality. However, the common feature of the home equipment was the display CRT, which received signals from the terrestrial broadcaster, the cable system, and the VCR.

In the era of HDTV, the display will remain the common element for delivering the signal, whether from NTSC broadcast, HD broadcast, cable, satellite, or home video. Later it may be used as a computer terminal, a video phone, or for interactive services. In the light of these developments, it is helpful to view the TV set as consisting of three distinct parts:

The receiver/demodulator,

The interface processor, and

The display.

In this study, the display unit (DU) is considered as a separate cost item because it is common to all the delivery media. Thus today, homes with multiple video services such as terrestrial broadcast, cable, Home Video, and DBS, may all be connected to a single common display unit.

2.2.1 The Display Unit.

In current TV sets, the display and its associated cabinetry represent 75 percent of the manufactured cost of the set. The CRT technology is mature, manufacturing volume is large, and the cost is stable. The cost however, increases exponentially with the size of the display and of the picture resolution, and for the optimum viewing experience for HDTV, the display should be large. The high cost and bulk of large CRTs makes it essential in the future to use solid state flat displays.

However, several years will elapse before they are available in quantity and at an economic price for the consumer market. It follows, that during the introductory period of HDTV service, projection systems will be the first choice for display units, hereinafter referred to generically as a 50" display unit (DU).

For the present owners of TV sets with displays of 25" or smaller, and priced in the \$400 to \$700 range, one may conclude that the investment in equipment at five times the price is not likely, either because of budget constraints, or because the consumer does not judge the benefits of HDTV service to be worth the large incremental investment. However, it is also possible that the consumer's perceived value of HDTV service is such that he will purchase a much smaller HDTV display unit (a 25" 16:9 display has a picture height of 12 "), if the price is correspondingly lower and on the order of \$1,500. Some manufacturers' studies suggest that a market exists for a nominal 25" HD display unit, and that some part of the present TV set market for 25" sets, which is 25 percent of the total market, may gravitate to small HD displays despite the fact that such a size is inadequate for the full appreciation of HDTV. The consumer perception that a wide screen display is HDTV may assist this market. Accordingly, this study projects the development of such a secondary market for HDTV service, and it is detailed in Section 4.

In addition, 30 - 35 inch display units will be used for HDTV service.

2.2.2 Terrestrial broadcast Receiver and Interface Processor.

For terrestrial broadcast, a receiver, demodulator, decoder, and an interface processor are required. The cost of this element of the delivery system is the subject of current study and the cost will be affected partly by the final selection of a transmission standard. In Section 4, a high and low range of prices for this unit is presented, together with the anticipated drop in price as the design is refined, IC technology advances, and manufacturers' economies of scale take effect.

2.2.3 Cable Service

The genesis of cable television service was to provide an alternative route for the delivery of broadcast programs which could not be received with an antenna because of the local topography.

From this beginning, cable systems today commonly offer 35 channels of programming for the viewer's choice, while still delivering all the local television broadcasts. Developments in technology indicate that 150 channels will soon be commonplace, with even further advances in prospect. Pay-per-view services are growing and will later offer nearly on-demand viewing of programs.

These advances have been made possible in part by the technology of digital compression and the application of fiber optic trunking to cable systems. The digital transmission of HD signals on cable systems is believed feasible, and field tests are under way.

Indeed it is possible that the inauguration of HD cable service in some major metropolitan areas will take place shortly after the time of the selection of a terrestrial transmission standard by the FCC. , and when display units are available.

It is likely that HD cable service will be implemented on a pay-per-view basis. The consumer must purchase a HD display unit and must acquire a device for the demodulation and decoding of the incoming cable signal, together with an interface processor. These units will be similar to those required for terrestrial reception, especially if the cable transmission format is the same as that employed for broadcast.

The cost to the consumer will comprise a display unit, a payment to the cable system on a monthly basis to cover the cost of the receiving unit, and a payment, also on a monthly basis, for the delivery of premium HD programs. The receiving unit could as now, be incorporated physically in the display unit. These costs are developed in Section 4.

It is noted that if the consumer already has HD terrestrial broadcast service, it will not be necessary to purchase a display unit.

It is further recognized that the HD programs produced and delivered by the networks and syndicators to the local TV stations, can in fact be delivered to the home by cable, even when the local broadcaster has not yet installed the HD terrestrial transmission equipment. This possibility is important for many small market stations, and could ease the financial burden of conversion. However, it is doubtful that such an arrangement would be acceptable to broadcasters.

One constraint on the contribution which cable can make to the more rapid penetration of HD service is that only 60 percent of TV households are connected to cable nation-wide, although the penetration of cable continues to grow. A further constraint in the early years could be a shortage of cable channels.

2.2.4 Home Video.

When color TV was introduced, there was but a single video service to the home, namely monochrome TV, and market penetration developed in an environment of a small number of program channel options for the viewer - typically four.

Today, the situation has changed radically with the rapid growth of home video and cable services. The program choices available from home video are legion, and include both mass market entertainment and special interest programs. The viewer expects that this large range of choice will be maintained in the HD environment.

Six companies have prototype models of home video devices. It is possible that a consumer product could enter the consumer market one year after the FCC selection of a transmission standard, always assuming the availability of a HD display unit. The central point of this development is that while the home video playback machine will not impact the terrestrial transmission system, it will employ the same 16:9 wide screen display unit to be used by all the potential delivery media.

For the consumer purchasing a HD home video system, the display unit will, as noted above, be a large component of the total cost. Once this common component is purchased, the incremental cost to acquire other delivery services will be lower. The cost of the HD Video Player will depend on the quality provided, and it is anticipated that low-end models may be introduced at less than \$1,000. It is therefore possible that the initial penetration of HD home video will pave the way for the more rapid acceptance of the terrestrial broadcast equipment in the consumer market. The incremental investment will be lower, and the perceived value of HD will be well established before HD terrestrial broadcasting service can be implemented on a substantial scale.

The historic growth in penetration of home video gives an indication of what may be expected for the HD format. The VCR made its debut in 1975, but for three years its use was limited to time-shift viewing of television broadcast programs, pre-recorded programs being

scarce and expensive. In 1978, an ever-increasing inventory of pre-recorded programs available for low cost rental, sparked a new business, and in about one year, the 1 percent penetration point was passed.

It is likely that video rental service will again provide the basis for HD home video growth. Time-shifted viewing of broadcast HD programs may have a limited appeal, but the main growth will be in the rental of pre-recorded programs.

The rate of growth will depend on the willingness of the video rental industry to invest in a large and attractive inventory of HD programming.

Given the availability of adequate programming, the growth rate of HD home video could be similar to that achieved by the HD terrestrial broadcast receiver.

High and low ranges of HD Home Video equipment costs are detailed in Section 4, together with the anticipated drop in prices with developing economies of scale.

2.2.5 DBS Service

A viable commercial DBS service has not yet been established in the U.S. However, in the context of advances in digital compression, it is now apparent that four NTSC channels may be delivered on a single transponder, or at least two HD channels, depending on the quality of signal required.

This development will radically change the economics of the business. High definition DBS service is likely to be, at least for the early years, a premium service, perhaps on a pay-per-view basis. With 3.5 million home earth stations now installed, the acceptance and growth of HD service is likely. Support for this thesis is that 95 percent of DBS homes already have home video equipment, and thus have a double incentive to convert to HD service through the acquisition of a wide screen HD display unit .

The DBS consumer must bear the cost of new demodulator and decoder circuits and an interface processor. The cost of these units may be on the order of \$700, and over \$1000 initially, but this is not likely to be a major disincentive to the videophiles who comprise much of the DBS universe.

Projections of HD DBS costs are presented in Section 4.

2.3 Availability of HD Programming

A major factor impacting the penetration of the HDTV market is the availability of programming for the new service. Its importance is evident from the experience gained from the introduction of color. When color service was first introduced, some six years elapsed with a very low rate of market penetration, even though the consumer price of color sets fell by a factor of 2.5 during this period. Only when full primetime color programming was provided by the three networks did sales of color sets make significant and rapid advances.

For HDTV service today, the situation is quite different, and much HD programming can be made available at the introduction of service. First, 70 percent of all primetime programming is produced on 35 mm. film, which is a high definition medium, and intrinsically has a wide screen aspect ratio. Such high definition programming can be readily transferred to videotape for broadcast, or for delivery by the other distribution media of cable, DBS, or home video.

However, while archival 35mm. film programming will be available, TV stations will need to acquire HD video playback equipment when the programs are played back by the station rather than passed through in real time from a network delivered signal.

The remaining 30 percent of primetime programming consists of live programming such as sports and news, or programs produced electronically in the NTSC 4:3 format. While the production of these programs will be gradually converted to HD, in the interim the programs may be "upconverted" to the high definition transmission format. This technique has the merit that the programs are perceived by the viewer as subjectively superior to the present NTSC standard, although they are not in fact high definition. In this interim period, such programming will be displayed on the wide screen display with blank borders on each side of the 4:3 aspect ratio picture, or as a 16:9 display by discarding some lines at the top and bottom of the picture.

During other day parts, much of the network or syndicator-supplied

programming is produced electronically in the 525-line NTSC format, and this will be "upconverted" as described above during the interim period. For locally produced programming such as local news, a similar interim option is available.

By these means, local stations will be able to provide a full broadcast schedule in short order following the introduction of the new service, and thus will not impede the penetration of the market, as was the case with the introduction of color.

In summary, while programming will be available as described, the actual delays in terrestrial broadcasting will be caused by the need to acquire and install a new HDTV transmitter and antenna, and to make necessary modifications to the in-plant equipment.

2.4 Station Conversion Costs.

While earlier transition scenarios for local television stations had assumed that smaller market stations might not start conversion to HD service for five years after the FCC selects a transmission standard, and could then take a further nine years to complete the transition, the recent FCC Notice of Proposed Rule Making suggests that application for a license must be filed within two years of the issuance of allotments, and that the construction of the HDTV transmitting facility must be completed three years thereafter.

For many stations in smaller markets, completing the transition in the suggested periods could pose a financial problem. However, to satisfy the FCC Proposed Rules, it will probably be necessary for a station to effect the first two phases of conversion only; namely, to provide a HDTV transmitting system allowing network or syndicator-supplied HDTV programs to be passed through the station and transmitted terrestrially. In addition, for the station to secure a source of revenue, means must be provided to insert local commercial messages in this programming. The remaining phases of the conversion may presumably be implemented as the financial resources allow, and as market conditions dictate.

In the CBS study of transition scenarios, it was projected that for the first stations to effect the first two phases, the cost would be on the order of \$3 million. For the last group of stations to convert, the cost would fall to about \$1.8 million. Since the CBS study was published, a number of interim options has been investigated, and the resultant reduced costs are now being developed. These may result in a 30 percent reduction in the costs presented above, and thus provide direct encouragement to the more rapid conversion to HDTV service. This matter is of vital importance to the development of market penetration projections which depend in part on the terrestrial transmission of HDTV programs.

Assuming that the proposed time frames of the FCC are applied, we project that, in the first year after allotments are made, 30 stations in the markets 1 - 10 will start conversion; in the second year, 40 stations in markets 11 - 30; and in the third year, 80 stations in markets 31 - 100 will start conversion. If each station takes the allotted three years to convert to the point where HD programs can be passed through the station, and where local commercials can be inserted, it follows that in five years, 150 stations will be equipped, serving 76 million TV households, or 83 percent of the total.

This then is the market to be penetrated by sales of HDTV home equipment in the first five years. Competitive need and lower equipment prices for broadcast equipment will encourage other stations in all markets to apply for licenses in Years 4 onwards. Because by Year 7, HDTV may be the dominant distribution medium in some markets, it is anticipated that the FCC will set a time of 15 years when NTSC licenses will be revoked in favor of HDTV. This fact will further encourage the remaining local broadcasters to apply for the new license and start the conversion process.

2.5 The Cost of Programming.

The cost of electronic production of programs in high definition has been shown to be no greater than production on film, even when taking account of the depreciation charges for the production equipment.

The extraordinary creative flexibility provided by the new medium, and the ability to see exactly what has been recorded during production has led to more perfectionist efforts by the director and the photographer. These tend to extend the actual shooting time during the process of familiarization with the new tools.

In post-production, however, the savings in time and hence cost are real and well established, and have led to the increasing use of electronic post-production of programs shot on 35 mm. film, and the provision of a master print on high definition video tape.

Overall, high definition programming, whether produced on film or electronically, is less expensive than programs produced entirely in the film medium.

The production of programs in the film medium, today representing 70 percent of primetime programming for television, requires that they be transferred to videotape using telecine equipment. This transfer to HD is essentially the same as that normally conducted for NTSC broadcast, and incurs little additional operational cost.

Programs shot in the standard 525-line NTSC format require an "up-conversion" process for broadcast on the HD channel, and this leads to additional cost for the broadcaster. This cost is incorporated in the conversion costs for local stations defined above.

For local studio program origination, high definition cameras and