Year 0 is taken to be the year in which the FCC selects a transmission standard, issues a Report and Order, and publishes a table of spectrum allotments for which television stations may apply for specific channel assignment. A conservative estimate is that 5 percent market penetration will be reached by Year 5, and 37 percent by Year 10. The more optimistic projection is that 8 percent market penetration will be reached by Year 5, and 56 percent by Year 10.

The working party was initially Chaired by Michael Tyler and later by Rupert Stow. The Vice Chairs were Nancy Kowalski, Bruce Owen, and Charles Steinberg.

4.6 PS/WP6 - WORKING PARTY ON SYSTEMS SUBJECTIVE ASSESSMENT

PS/WP6 was established to conduct the planning for subjective evaluations of unimpaired video quality as well as the effect of impairments and interferences. PS/WP6 had among its members a number of experts in both psychophysics (experimental or sensory psychology and subjective testing) and social science (audience research and measurement). It became clear during the first interim period that the two disciplines had fundamentally different testing interests. Eventually, the Planning Subcommittee formed a new working party, PS/WP7, to handle separately planning for audience research. The first interim report of PS/WP6, however, was issued in June 1988 (before the establishment of PS/WP7) and contained the research proposals of both groups. After the formation of PS/WP7, PS/WP6 was free to focus on subjective assessments of basic quality, impairments and interferences.

During this first period of work general subjective test methods and procedures (pair comparisons) were agreed, along with viewing conditions (set-up of the viewing studio and displays). Four Drafting Parties were active: Test Material, Noise Weighting, Ghost Cancellation and Psychophysics.

By the end of the second period of work in February 1989, a great deal of detail had been added to the subjective test design for video, and a psychoacoustic test design had been added. A liaison with Canada had been established and an effort begun to consider running the non-expert subjective tests in Ottawa, based on an offer by the Communications Research Centre of the Canadian Department of Communications.

Going into the third interim period, the primary unresolved problem was how to produce the multiple-format test materials required. At issue was whether to transcode from the 1125-interlace format, for which production equipment was readily available, or to conduct a multi-standard shoot with a collection of one-of-a-kind cameras which scanned directly into the other formats. The test material selections were intended to provide identical picture content for each format in order that they themselves would not cause differences among system evaluations. The five formats required were:

1) 1125/60/2:1
2) 1050/59.94/2:1
3) 787.5/59.94/1:1
4) 525/59.94/1:1
5) 525/59.94/2:1 (NTSC)

While NHK and Sony had designed and constructed a "transconverter" to convert 1125/60 material to several other formats, translation to the 787.5-progressive format had not been provided. Planning of subjective test material image content, as well as characterization testing of production equipment, was the dominant area of work for the third interim period. Eventually, a multi-format production was selected.

During the third period of work, progress was made on production of still test material. Photographs were taken by the NASA Lewis Research Center, and the resulting images scanned to a computer-based format by the Eastman Kodak Corporation.

Two new test concepts were developed that proved to be of significance — Experts Observation and Commentary (EO&C) and Range Recording Only (RRO). EO&C allowed observations to be read into the test record by the expert viewer panels when unusual conditions were noted, or where full subjective measurements were not possible or needed. RRO signified a plan to make recordings of certain impairments over a specific range, with a decision to be made later regarding the need for a full subjective assessment of these tapes by panels of non-expert viewers.

A previous decision that a direct-view CRT should be used for testing was reversed, and ATTC was asked to identify a multi-scan projection display.

At the end of the third work period, PS/WP6 focused closely on the production of test materials. By the end of the fourth interim period, the test materials for still and motion segments had been completed. The still test material was delivered to the ATTC in September 1990. The motion test material was produced during early 1991. Additional material was produced for the use of the proponents in their development efforts. For a variety of reasons, the additional material was produced in 1125 interlace, 1050 interlace, and 525 progressive formats, but not in 787.5 progressive format. A number of film sequences were transferred to the various formats with equipment provided by Zenith Electronics Corporation. Eventually, a series of computer-rendered graphics still and motion

At its July 1991 meeting, the working party agreed that an additional hour of Long-Form subjective test material would need to be produced for verification of the system selection after conclusion of the laboratory tests.

The working party was initially Chaired by Bronwen Jones, later by Craig Tanner, and finally by James Gaspar. The Vice Chairs were Jerrold Glasser and William Rubens. Craig Tanner and Bronwen Jones also served as Vice Chairs.

4.7 PS/WP7 - WORKING PARTY ON AUDIENCE RESEARCH

PS/WP7 was charged with defining, planning and executing research operations which would lead to an understanding of viewers' preferences in the field of advanced television programs viewed from the home. The scope of this work included: the type of programs most appreciated in ATV; the types of viewers who most appreciate ATV programs; the willingness of viewers who most appreciate ATV programs to pay a premium for ATV display equipment; the willingness of viewers to pay a premium for ATV services in the home; and the attributes of ATV most appreciated by viewers. PS/WP7 was essentially formed to provide a marketing input into the whole ATV standard setting process.

The plan of PS/WP7's work included but was not limited to: the types of programs to be used; sampling; the types of audience variables to be measured; the number and type of localities in which the tests would be conducted; the viewing conditions; and the types of

plans to conduct such a study, PS/WP7 concluded that such a study was not a productive use of resources.

While PS/WP7 was able to develop a comprehensive planned research program to investigate

It is essential that any program production standard adopted for use in the United States provide program producers with the highest possible picture and sound quality to offset the quality degradation inherent in post-production processing, and in down-conversion to television transmission formats.

It is important that the program production standard used in the U.S. should lend itself easily to successful conversions to all existing formats including NTSC, PAL, SECAM, and 35 mm film.

The advisory group was Chaired by James Hindman. The Vice Chairs were Topper Carew, Glen Larson, and Leavitt Pope.

4.9 PS/AG2 - ADVISORY GROUP ON CONSUMER/TRADE ISSUES

In considering consumer issues, PS/AG2 devoted special attention to the importance of retaining the diversity of programming and local programming. The advisory group concluded that if ATV service were to degrade NTSC picture quality, the introduction of ATV terrestrial broadcasting would be difficult to justify. On the other hand, consumer interests might suffer if ATV terrestrial broadcasting were to lag substantially behind ATV service on VCRs or cable.

In its study of trade issues, the advisory group observed that TV set manufacturing for the U.S. consists of the output of a single major American-owned company and a number of foreign-owned companies. While many TV receivers are assembled in the U.S., many of the components are imported from offshore sources. Nevertheless, the group believed that an opportunity may exist to establish domestic manufacturing of receivers for ATV service. If the development of ATV is successful, it could provide the stimulus for a revival of the U.S. consumer electronics industry which, unlike other U.S. electronics industries, has suffered lagging output and declining employment.

PS/AG2 completed its work at the time the Advisory Committee issued its second interim report. The last task of the advisory group was the drafting of the Advisory Committee's Report on ATV Service in response to a request for information on "the potential impact of alternative ATV policy strategies on the U.S. economy" by Representative Markey, Chairman of the House Subcommittee on Telecommunications and Finance.

The report drew upon studies conducted by the EIA, the AEA, and the NTIA. The current role of consumer electronics in the U.S. economy was presented, together with some

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5. CONTRIBUTIONS FROM THE SYSTEMS SUBCOMMITTEE

The Systems Subcommittee had the following Objective and Scope of Activity:

> *Objective: To specify the transmission/reception facilities appropriate for providing advanced television service in the United States.*
>
> *Scope of Activity: All steps necessary to provide advice on the parameters of systems to provide terrestrial advanced television service.*
>
> > *(a) Evaluate, on technical and economic bases, advanced television systems now under development for the purpose of determining feasibility for implementation in the United States.*
> >
> > *(b) Recommend advanced television system(s) now under development as candidate(s) for implementation, or specify the design of an appropriate system.*
> >
> > *(c) Advise on the appropriate transmission/reception technical standards and spectrum requirements for the recommended system(s).*

The Systems Subcommittee was Chaired by Irwin Dorros. The Vice Chairs were Tyrone Brown and John Abel.

The work of the Systems Subcommittee was divided among four working parties. The work of these groups is described in the following sections.

5.1 SS/WP1 - WORKING PARTY ON SYSTEMS ANALYSIS

SS/WP1 was assigned the task of analyzing proponent systems and further identifying and certifying those systems with sufficient technical merit to be recommended for test by the ATTC. The working party evaluated thirty-three proposals from twenty organizations and three consortia. Twenty-five submissions were system proposals of varying levels of completeness. Four proposals were limited to video compression techniques. Three proposals were audio only and one was a concept for a very high resolution video camera. In addition, several other organizations expressed interest in providing audio submissions. Four of the system proposals were for digital systems. A fifth digital proposal for a partially complete digital system was submitted. The remaining systems were largely analog. Many used digital processing techniques on otherwise analog systems.

Since SS/WP1's charter was to evaluate and recommend complete systems, the audio-only proponents were referred to the system proponents as possible customers. The submissions

that involved video compression only were evaluated for unique ideas. Of the system proposals, six were certified for test by the ATTC. These were ACTV and AD-HDTV from the ATRC, Narrow-MUSE from NHK, DigiCipher and CCDC from the ATVA, and DSC-HDTV from Zenith/AT&T.

To provide a rigorous forum where the large number of proposed systems could be compared and evaluated on level ground, SS/WP1 initiated the concept of long meetings wherein each proponent had several hours for presentation and response to questions. This process proved effective in weeding out the proposals that were not workable and those that were not sufficiently developed to proceed. Almost all of the dropouts were ultimately voluntary after rigorous question and answer sessions shed light on the limitations or incompleteness of specific proposals.

Once the likely candidates were identified, a technical subgroup, known as the Analysis Task Force, was initiated. The task force included representatives for the systems being considered for final certification as well as experts with both signal processing and transmission backgrounds. The task force generated the final system analysis reports which, after approval by SS/WP1, were submitted to SS/WP2 and the ATTC to use as a guideline in system testing.

The working party was Chaired by Birney Dayton. The Vice Chairs were Carl Eilers, John Swanson, and David Kettler.

5.2 SS/WP2 - WORKING PARTY ON SYSTEM EVALUATION AND TESTING

SS/WP2 was established to conduct tests of proposed systems and provide information to help the Advisory Committee in its recommendations to the FCC. The working party's charter was as follows:

> ***This group shall evaluate and test various ATV distribution systems based on guidelines developed by the Planning Subcommittee. Extensive subjective and objective testing shall be conducted.***

SS/WP2 developed extensive test procedures to be used to evaluate the performance of the ATV systems. These test procedures included the Test Management Plan, Objective and Transmission Tests, Cable Television Transmission Tests, Video Subjective Tests, Audio Subjective Tests, System-Specific Tests, Digital-Specific Tests, and Field Tests.

The Test Management Plan set forth the policies and procedures to conduct tests of ATV systems and to provide guidance for the laboratories, proponents, and the Advisory Committee. The Objective and Transmission Tests procedures included tests of image quality, audio performance, and terrestrial transmission. The Cable Television Transmission Tests were developed to test the performance of ATV systems in the cable television

environment. The Video Subjective Tests were developed to evaluate basic quality and to establish the threshold of visibility of impairments, the point where the impairments render the signal unusable, and some steps in between. The Audio Subjective Tests were developed to evaluate basic quality and the effects of transmission impairments. The System-Specific Tests and Digital-Specific Tests were developed to test specific areas of interest not addressed by the general test plans. The Field Tests were developed to verify the performance and operability of the selected system(s) under real world conditions, and to point out flaws not uncovered through laboratory testing.

Laboratory tests of ATV transmission systems began on July 12, 1991 and were completed on November 12, 1992. Testing was planned under the aegis of the Advisory Committee, and conducted in cooperation with three laboratories (Advanced Television Test Center, Cable Television Laboratories, and the Advanced Television Evaluation Laboratory).[1] Systems were tested in the following order:[2] ACTV, Narrow-MUSE, DigiCipher, DSC-HDTV, AD-HDTV and CCDC.

A system/digital-specific testing group was established by SS/WP2 to carry out system-specific and digital-specific tests on each ATV system during the proponent's test slot at ATTC. The group produced a report of test results for each ATV system which, after review and comment by the proponent, was included in the published Record of Test Results.

The working party was initially Chaired by Benjamin Crutchfield and later by Mark Richer. The Vice Chairs were Walt Ciciora, Joel Engel, and George Hanover.

5.2.1 Advanced Television Test Center (ATTC)

The Advanced Television Test Center (also see Glossary) is a private, non-profit organization established in 1988 and developed by the television broadcasting and other industry organizations to test advanced television (ATV) transmission systems seeking to become the new North American broadcast standard.

In 1987, with the creation by the FCC of its all-industry Advisory Committee, the television broadcast industry offered to provide the means to test the various ATV proposals. Agreements were concluded between ATTC and CableLabs in 1990, and between ATTC and ATEL in 1991, which led to a cooperative testing program using test plans and test materials developed and approved by the Advisory Committee.

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[1] The direct costs of testing at all three laboratories totaled some $26.5 million. Of this amount, $2.2 million came from test fees paid by the proponents (including both regular fees and additional amounts for certain retests); the remaining $24.3 million was funded by the sponsors of the respective laboratories.

[2] These test dates include testing of the ACTV system; those test results are not included in this report.

Working with the ATV system developers as these test plans evolved, a special-purpose laboratory was designed by ATTC to address the combination of requirements foreseen from some eight different ATV systems, all then involving analog transmission schemes (save one hybrid analog-digital submission). By the fall of 1990, laboratory construction was completed, most special-built equipment was delivered, proof-of-performance testing was started, and the test plans were largely completed. In November 1990, the newly invented ATTC/Tektronix Format Convertor successfully passed its proof-of-performance and prototype acceptance tests. The number of ATV systems reserving slots for testing had become six; testing was scheduled to begin April 12, 1991.

While one proponent had proposed an all-digital system in June 1990, by February 1991, four out of the five HDTV systems had been resubmitted as all-digital schemes. After review of these changes in March and April by the Advisory Committee, the start date for testing was moved to July 12, 1991, in order to permit modifications in ATTC systems and procedures to accommodate the amended test plans, and to conduct a partial "dry run" of the final test procedures. While testing did begin as scheduled, further test plan changes were approved in January 1992 — based on more detailed information about the digital systems — and these changes were implemented by ATTC in February 1992, just in time for use at the end of the test slot of the first of the four digital systems. Testing was completed on the final system on October 21, 1992.

The testing conducted at ATTC spanned some eight weeks per system (approximately seven weeks on broadcast-related and system-specific tests, and one week on cable-specific tests). During this period, video and audio tapes were made, as specified in the approved test plans. These tapes were used by ATEL (for video subjective tests) and, under contract to ATTC, by the Westinghouse Science and Technology Center (for audio subjective tests). In addition, before each system's testing began, about one week was devoted to ATV system-laboratory "interface" checks and "dry-runs" of some tests.

The testing at ATTC involved nearly 200 expert viewers. It also involved — in set-up, testing, and reviews — some 75 representatives from the ATV system proponents, as well as the 21 regular staff and consultants to ATTC. The comprehensive report on each system is some 700-850 pages, compiling the results from the three laboratories, as well as comments from the proponents. There are also some 700 reels and cassettes of digital HDTV and NTSC video tape, plus more cassettes of digital audio tape, which captured the performance of the systems under test.

5.2.2 Cable Television Laboratories Inc. (CableLabs)

Cable Television Laboratories, Inc. (also see Glossary) is a research and development consortium of cable television system operators representing more than 85% of the cable subscribers in the United States and 60% of Canadian cable subscribers. CableLabs was founded in May 1988 to ensure the proper development and creation of technological initiatives for the cable television industry.

CableLabs responded to a call from the Advisory Committee for a qualified laboratory to carry out the cable portion of the Advisory Committee's tests. The offer, in part, was to obtain necessary equipment to undertake the cable portion of the tests and, with industry input, to assist the Advisory Committee in developing test procedures, analyzing test results, and providing input to the Advisory Committee to assist in the selection of the best possible advanced television standard. CableLabs subsequently offered to undertake the cable portion of the field tests, including development of test procedures and analysis of the test results.

Over a period of a year and a half, CableLabs produced the cable portion of the test plans, designed and installed the cable television test bed and associated computer operating system and reviewed the test procedures. CableLabs commenced its tests on the first system on August 19, 1991 and completed tests of the final system on September 25, 1992. At the completion of the tests, reports were prepared, reviewed and commented on by the proponents, and submitted to the Advisory Committee for analysis.

5.2.3 Advanced Television Evaluation Laboratory (ATEL)

The Advanced Television Evaluation Laboratory (also see Glossary) is a facility of the Department of Communications, Government of Canada. Managed by the Communications Research Centre, ATEL was established to provide the special facilities needed to display pre-recorded video test materials under the rigorously controlled viewing conditions needed for sensitive and reproducible tests of advanced and conventional television systems.

In 1989, in response to a call from the Advisory Committee for qualified laboratories to carry out its advanced television test program, ATEL offered to undertake the video subjective test program. The substance of the offer was to conduct, according to the methods approved by the Advisory Committee, video subjective tests of ATV systems using pre-recorded digital videotapes prepared by ATTC and CableLabs to evaluate video quality and the performances of systems in simulated terrestrial and cable broadcast environments. This offer was accepted by the Advisory Committee in 1990.

After its offer was accepted, ATEL engaged in a 17-month period of preparation. This involved the preparation of facilities, the development of technical, operating, and scientific procedures, and a full dry run of the Advisory Committee's video subjective test procedures. The latter involved the production of test materials, examination of a satellite-based ATV system in a simulated satellite link, and conduct of formal subjective tests. The dry-run exercise was completed successfully, verifying ATEL's technical, operating, and scientific procedures as well as the methods adopted by the Advisory Committee. At the same time, ATEL was active in the Advisory Committee, contributing to the development and production of video test materials and to the development and refinement of test methods.

ATEL was ready to begin testing in August 1991. Following a short delay experienced by its partner laboratories, ATEL began its tests of the first system on September 4, 1991. ATEL completed tests of the final system on November 12, 1992. In the period from November

1992 to January 1993, ATEL completed its analyses of the data collected and finalized its reports to the Advisory Committee.

At the request of PS/WP-3, ATEL (in collaboration with ATTC) also carried out tests of Co-Channel Interference from NTSC to NTSC. These tests, which provided baseline data for PS/WP-3's analyses of ATV Service Area and Accommodation Percentage, were completed in July 1992.

Preparatory exercises, tests, and analyses and reports of the data involved about 36 months of continuous effort. More than 2,000 non-expert observers were used and more than 125,000 measurements were made.

5.3 SS/WP3 - WORKING PARTY ON ECONOMIC ASSESSMENT

SS/WP3 was assigned responsibility to make a comparative economic assessment between all contending ATV proponents and to establish technical viability of their systems.

The first phase of the work attempted a broad look at how the ATV systems would impact

proponents actively participated in a procedure which assigned costs to every element of these receivers. From this, total manufacturing costs were calculated using a computer model.

On the transmission side a different approach to the cost analysis was taken. Two specialist groups, one on ATV antennas and transmitters, and a second on ATV encoders and modulators were formed. The first worked directly with all of the ATV proponents and with manufacturers of antennas and transmitters. The second specialist group was made up of seven professional broadcast equipment manufacturers who independently cost analyzed each of the ATV modulators and encoders (based upon an agreed-to "information package" provided by each ATV proponent).

The working party was Chaired by Larry Thorpe. The Vice Chairs were the late William B. Loveless, Talmadge Ball, Shellie Rosser, and Richard Grefe.

5.4 SS/WP4 - WORKING PARTY ON SYSTEM STANDARDS

In its charter, SS/WP4 was charged with recommending standards for the transmission of ATV. It was agreed that documentation of the standard would not be the responsibility of the working party or the Advisory Committee. Furthermore, the working party anticipated its recommendations would be based on information supplied by other working parties in the Advisory Committee.

The primary agenda item at the first several meetings of SS/WP4 was discussion of the process that the working party would use to recommend a standard. Voting methods were considered but abandoned because of the difficulty in determining which persons or organizations would participate in a vote. The working party consistently concluded that consensus was the best method to select a recommended standard. The working party agreed on a process which could be used to lead to consensus. The first step in that process was the determination of the "selection criteria." SS/WP4 originated that list which was subsequently approved by the Advisory Committee.

As the time for testing proponent systems approached, the emphasis turned toward analysis of the test data. A task force of SS/WP4 worked with the test laboratories to determine the format for reporting test results. The test data were divided into two categories, spectrum data and all other data. The working party asked PS/WP3 to perform the analysis on the spectrum data for SS/WP4. SS/WP4 retained responsibility for the analysis of the balance of the data.

SS/WP4 was given responsibility for organizing and drafting the final report of the Advisory Committee. The working party agreed to an outline for the report and drafted the portion defining the "selection criteria" before the first test data were available.

Once test data became available, the primary emphasis of SS/WP4 was to review and summarize the test data for each system. This work was performed by a task force in

SS/WP4 and by PS/WP3. The results were integrated into the final report by another task force in SS/WP4 and approved by the full working party.

Other information for the final report was supplied by other working parties of the Advisory Committee. This information was edited and integrated into the final report and approved by the full working party.

At the time of its fifth interim report, the Advisory Committee agreed to appoint a "Special Panel" which would take the results of the analyses of the individual proponent systems in the final report and formulate recommendations for the Advisory Committee's consideration. Concerns had been expressed that the widely varying attendance witnessed in SS/WP4, along with the possibility that many of the experts may have a conflict of interest, would make it difficult to arrive at a consensus on recommendations in the working party. The Special Panel membership included "Advisory Committee staff leaders and other knowledgeable Advisory Committee members who were not affiliated with any system proponent."[3]

The responsibility of drafting the final report chapter titled "Comparisons and Recommendations" was assigned to the Special Panel. The balance of this report remained the responsibility of SS/WP4.

The working party was Chaired by Robert Hopkins. The Vice Chairs were Hugo Gaggioni, Bruce Sidran, and Louis Williamson.

[3] Fifth Interim Report of the Advisory Committee on Advanced Television Service, March 24, 1992, page 17.

6. CONTRIBUTIONS FROM THE IMPLEMENTATION SUBCOMMITTEE

The Implementation Subcommittee had the following Objective and Scope of Activity:

> *Objective: To establish a scheme for implementation of advanced television service in the United States.*
>
> *Scope of Activity: All steps necessary to provide advice on policies, regulations, and standards for implementation of terrestrial advanced television service.*
>
> > *(a) Develop a transition scheme for implementation of advanced television service in the United States.*
> >
> > *(b) Recommend appropriate FCC policies and regulations to oversee implementation of advanced television service and develop guidelines for industry activities.*

The Co-Chairs of the Implementation Subcommittee were James J. Tietjen and George Vradenburg III. The Vice Chairs were Brenda Fox and Henry L. Baumann.

The work of the Implementation Subcommittee was divided between two working parties. The work of these groups is described in the following sections.

6.1 IS/WP1 - WORKING PARTY ON POLICY AND REGULATION

IS/WP1 attracted a diverse group of participants, including representatives of broadcast, cable, manufacturing, legal, policy, and regulatory interests. Although an obvious benefit to the discussion of policy issues, this diversity of interests at times made achieving consensus on particular issues difficult. IS/WP1 served as a useful forum for outlining the particular issues to be debated so that those issues could be more clearly presented to the Advisory Committee and to the Commission by the participating organizations. FCC staff also regularly and actively participated in the group's meetings. IS/WP1 adopted and submitted several policy recommendations to the Implementation Subcommittee.

Early discussions centered around defining the best role for this particular working party. The myriad of issues relevant to this subject area (policy and regulation) often indicated the need to establish separate "subgroups" to examine particular issues in depth. For example, subgroups were established to examine the FCC's role in setting standards and the importance of the Ashbacker[1] doctrine to HDTV allotment/assignment methodology.

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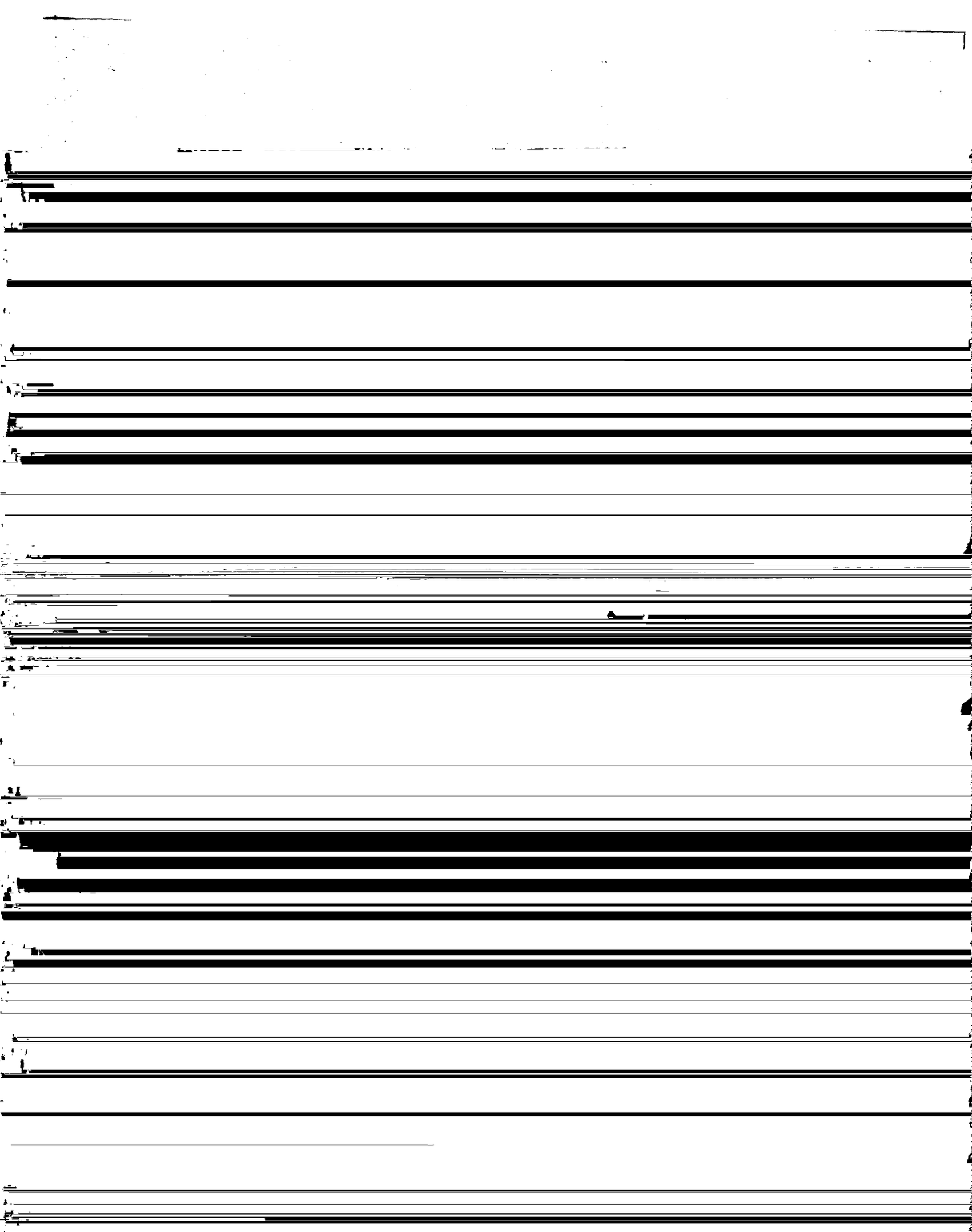
[1] Ashbacker Radio Corp. v. FCC, 326 U.S. 327 (1945).



The transition scenarios are presented as PERT and Gantt charts (together with underlying assumptions) developed by industry segment experts serving on the working party or enlisted for the task. Supporting information and answers to other implementation questions were sought by direct communications and by surveys from proponents and affected industry segments.

The scenarios identify the major work steps involved in ATV implementation and represent the shortest times in which motivated participants can be expected to implement ATV. They do not purport to show what participants will actually do in practice because, for example, IS/WP2 did not impose or account for financial or resource limitations or attempt to judge motivation.

The working party found that, in general, the time required to implement ATV is approximately the same for all industry sectors and for all proposed systems. IS/WP2 found that, in principle and subject to the limitations outlined below, stations can implement ATV within the FCC's six-year window.

The working party examined the critical path to implementation and identified key, potentially limiting tasks. First and foremost among these is the disclosure of, and agreement on full technical details of the selected system, which will underlie design and manufacture of integrated circuits and equipment for encoding, transmitting, receiving, and decoding ATV signals by parties other than the proponent. A second key item is development time for professional broadcast equipment to support several of the scenarios. IS/WP2 assumed availability within one year following the Commission's adoption of an ATV standard. Third, consumer product manufacturers pointed out that agreement on a standard consumer VCR format is an additional initiating event for that product and needs to be expedited.

A distribution standard is needed for effective interoperability among the diverse organizations within the affected industries. In addition, confirmation of the operational assumptions and techniques is required prior to a large-scale industry commitment.

IS/WP2 found and reported a potentially serious shortage in industry capacity to erect and reinforce towers and install antennas. IS/WP2 surveys indicate that, depending on the exact power requirements of systems, between one-third and one-half of television stations will require new towers. All will need new antennas.

IS/WP2 identified the need for new towers in high population centers as critical to the delivery of ATV to the largest proportion of the U.S. population. The working party established study groups in major metropolitan areas.

Expert input and a survey of all consumer manufacturers indicate that ATV receivers can be generally available in the marketplace 2-3 years following the Commission's adoption of an ATV standard. Transmitters and antennas will be available within the necessary time frame.

The working party conducted a survey that indicates software producers and users are generally in agreement that sufficient ATV software will be available by the time it is needed.

A distributed approach to transmission (multiple sites sharing the same frequency) has been suggested. Such an approach may alleviate the physical limitations encountered by some stations in achieving a single, full power, full coverage installation. IS/WP2 identified key issues that must be investigated before the implications of distributed transmission can be understood.

Specific recommendations are included in the IS/WP2 final report.

The Co-Chairs of the working party were J. Peter Bingham and Craig Tanner. The Vice Chairs were Edward J. Callahan, S. Merrill Weiss, and Daniel R. Wells.

7. SELECTION CRITERIA

7.1 INTRODUCTION

The Selection Criteria constitute the key issues that must be examined in order to recommend an ATV system. Each of the proposed systems was measured against the Selection Criteria and compared with one another in these key areas to determine the best system. The ten selection criteria fall into three categories: Spectrum Utilization (Service Area and Accommodation Percentage), Economics (Cost to Broadcasters, Alternative Media, and Consumers), and Technology (Audio/Video Quality, Transmission Robustness, Scope of Services and Features, Extensibility, and Interoperability Considerations). Where applicable, target values of the Selection Criteria have been developed to represent the level of performance aspired to in an advanced television system.

7.2 SPECTRUM UTILIZATION CRITERIA

7.2.1 Background

In September 1988, the FCC concluded that the public interest would be served best by the introduction of ATV in a "simulcast" mode.[1] That is, each broadcaster would be assigned a second channel for the exclusive purpose of broadcasting an ATV signal, while continuing to broadcast NTSC on the previously assigned channel. The Commission concluded further that ATV would have to be accommodated in the spectrum currently allocated to the VHF and UHF broadcast service.[2]

7.2.1.1 Station Spacing

For NTSC allotment purposes, the United States is divided into three zones. Zone I is the relatively high population density northeastern part of the country. Zone III, an area with unusual propagation conditions, includes all of Florida, southern Georgia, and a band skirting the Gulf of Mexico. Zone II is the balance of the country.

In any spectrum allotment plan, co-channel spacing is by far the principal determinant of the number of allotments that can be accommodated in any area. The FCC Rules specify the minimum co-channel spacing for the NTSC service as shown in Figure 7-1.

Minimum first adjacent-channel spacings for all zones are 95.7 kilometers (59.5 miles) for VHF stations and 87.7 kilometers (54.5 miles) for UHF stations.

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[1] Tentative Decision and Further Notice of Inquiry, MM Docket No. 87-268, adopted and released September 1, 1988, FCC 88-288, 3 FCC Rcd 6520 (1988).

[2] *Ibid.*

Zone	Channels 2 - 13 (km / miles)	Channels 14 - 69 (km / miles)
I	272.7 / 169.5	248.6 / 154.5
II	304.9 / 189.5	280.8 / 174.5
III	353.2 / 219.5	329.0 / 204.5

Figure 7-1. Minimum co-channel separation distance for the NTSC service.

Published ATV allotment studies by the FCC and others have assumed uniform spacing requirements throughout the United States without regard to zones. The expectation is that no separation differentiation is likely to be made on the basis of population density, but some allowance may be appropriate for the Gulf of Mexico and Southern California Coastal regions where propagation phenomena suggest different treatment than for the balance of the country.

7.2.1.2 Taboos

In addition to the foregoing restrictions on NTSC allotment spacings, so-called "taboo" restrictions are placed on allotments in the UHF portion of the television broadcast spectrum. The taboo restrictions are designed, principally, to avoid interference to UHF television reception that might occur due to receiver tuner characteristics.

To permit ATV broadcasting by every authorized television broadcaster, a second channel must be provided to each broadcaster from within the presently allocated broadcast spectrum. This requires that the ATV system adopted be able to operate at closer co-channel spacings than its NTSC counterpart. Such closer spacings apply to both the ATV/NTSC and ATV/ATV combinations. Since the greatest portion, if not all, of the ATV accommodation must come from the UHF band, the system must be relatively immune to taboo restrictions and able to operate in an adjacent-channel situation where stations are closely spaced.

7.2.1.3 Spectrum Allotment/Assignment

Studies made by the Commission staff and others have shown that minimum co-channel spacing on the order of 160 kilometers (100 miles) between ATV and NTSC stations is required if full, or nearly full, accommodation of authorized broadcasters is to be achieved. Furthermore, ATV stations should be capable of being operated at or near the sites of adjacent-channel NTSC or ATV stations without taboo restrictions and without unacceptable interference being caused or received. Allotment studies indicate that minimum ATV-to-ATV separation need not be as restrictive as ATV-to-NTSC separation. In any plan, whether NTSC or ATV, very few allotments are required to be at the minimum spacing. Therefore, the degree of interference experienced with stations spaced at minimum distance is rare. Nevertheless, the ATV service must be regarded as interference-limited rather than noise-

limited. Contrary to the often held belief that the NTSC service area is defined by the Grade B contour, substantial interference from co-channel and adjacent-channel stations is encountered within the Grade B contour of most NTSC stations. That interference is found particularly in the case of VHF stations in Zone I.

The principal allotment/assignment criteria applied herein are: the achievement of full accommodation of all NTSC authorized facilities with a companion ATV assignment, and the provision of ATV service in all areas currently receiving NTSC service. The application of these twin criteria is believed to provide the best basis for comparison of the systems offered by proponents. The procedure is intended to be used for system comparison; it is not intended to yield the best allotment/assignment plan for the United States. After an ATV system is selected, the planning factors specific to that system, and the full capability of the computer program, should be used to produce an allotment/assignment table aimed at achieving the two criteria specified above, but tempered by optimization of ATV service and holding interference to NTSC service to the minimum achievable. At the start of the "transition period" (defined as that period during which both ATV and NTSC will be broadcast), and to a lesser degree as years pass, NTSC will be the primary service for television viewers.

A further consideration dictating the need for an ultimate allotment/assignment table different from that used herein for system comparisons, relates to the effective radiated power assumed for some ATV stations. For the system comparison objective herein, the effective radiated power for each ATV facility was set to produce the same distance to the noise-limited ATV coverage contour as the distance to the companion NTSC station's Grade B contour. Since the antenna height of the ATV stations was assumed to be the same as that of the companion NTSC station, the resulting effective radiated power assumed in instances where VHF stations are operating with relatively low antennas, can be too great from the standpoint of available equipment. Particularly in the case of digital systems, the need to maintain linearity during transient peaks places a requirement on the ATV operator to employ a transmitter capable of achieving peak power levels substantially in excess of the average power used in service and interference studies. Consequently, the implementation of some ATV stations may include lower power levels or greater antenna heights than used in the spectrum studies

Despite the disparity in appearance of the two types of interference, they can be compared subjectively. Degrees of objectionability can be assigned by viewers to interference phenomena. By employing a numerical grading system, or even a descriptive grading system, the degree of ATV-into-NTSC interference can be equated to the same degree of NTSC-into-NTSC interference for a fixed NTSC desired-to-undesired ratio.

Allotment/assignment plans were first developed to compare the spectrum performance among the various systems. Plans included use of the entire VHF/UHF TV broadcast spectrum and for only the UHF portion of that spectrum. To achieve full accommodation for all 1,657 stations in the data base, a minimum co-channel spacing of 155 kilometers was used. The allotment plan was then adjusted for optimum assignments using co-channel and adjacent-channel laboratory results for each of the systems. The optimization consisted of attempting to provide ATV service in at least all locations where the companion NTSC station provided service, without violating an assumed ATV/NTSC adjacent-channel separation restriction of 10-80 kilometers. No further consideration of interference was given in the assignment of an ATV station from available allotments. Power levels for the ATV stations were selected to provide noise-limited coverage equal to the Grade B coverage of the companion NTSC stations. Transmitting locations and antenna heights were assumed to be identical to the companion NTSC stations.

7.2.1.4 Interference and Picture Quality

Being interference-limited, special consideration must be given to ATV system design to produce a system that minimizes interference to the NTSC service and, in turn, is relatively immune to interference from that service. In particular, this minimization of interference is effected by limiting the energy transmitted in those portions of the 6 MHz television channel wherein the NTSC signal is most sensitive to interference. In the case of interference received by the ATV system, a trade-off exists between image (and sound) quality and interference potential. Digital systems reserve some portion of transmission capacity for error correction and concealment. As more channel capacity is reserved for error correction and concealment, the less channel capacity will be available for improved image and sound quality.

7.2.2 Service Area

7.2.2.1 Definition

The service area of a NTSC television station is defined as the area within the station's Grade B contour reduced by the interference within that contour. For an ATV station, service area is defined as that area contained within the station's noise-limited contour reduced by the interference within that contour.

The service area of the new ATV signal expressed as a percentage of the existing NTSC service area, is as follows:

$$\frac{\text{ATV service area}}{\text{NTSC service area}} \times 100\%$$

Coverage area is not the same as service area. The coverage area of a NTSC television station is defined as the area within the station's Grade B contour without regard to interference from other television stations which may be present. For an ATV station, coverage area is defined as the area contained within the station's noise-limited contour without regard to interference which may be present.

7.2.2.2 Method of Determination

A model developed by PS/WP3, and implemented by a computer program funded by broadcasters, permits the rapid analysis of coverage and service provided by NTSC and ATV systems for individual stations and, globally, for the entire United States. The planning factor values used in the model are based on PS/WP3 analyses, including those of laboratory data from ATTC and ATEL. NTSC coverage and service area determinations consider the actual locations, power and height data for the existing inventory of authorized NTSC television facilities. ATV coverage and service area calculations assume locations and heights identical to those of the companion NTSC stations, and power sufficient to achieve distances to the noise-limited coverage contours equal to the distances to the NTSC companion stations' Grade B contours.

7.2.2.3 Target Value

Comparable to NTSC.

7.2.3 Accommodation Percentage

7.2.3.1 Definition

The percentage of existing NTSC stations that can be accommodated with an additional simulcast ATV channel (independent of the resulting service area).

7.2.3.2 Method of Determination

The number of existing NTSC stations that can be accommodated with an additional simulcast ATV channel is determined by a computer program. The result is dependent, particularly, on the minimum permissible co-channel spacing, but possibly affected also by other restrictions, such as required adjacent-channel spacing. System characteristics measured in the laboratory were employed as the determinant. Using the method of Section 7.2.2.2, the power/height limitation for the ATV station is determined. The allotment/assignment plan is developed for 100% accommodation with the goal of providing ATV service comparable to current NTSC service. The power/height data permit the calculation of coverage and service provided by the ATV facilities. This information, and the allotments derived from the

computer program, permit relating either single station or global service to accommodation percentage.

7.2.3.3 Target Value

100% of currently authorized full service stations and pending applications for full service stations. It is desirable to accommodate all noncommercial vacant allotments.

7.3 ECONOMICS CRITERIA

7.3.1 Background

Initially, a key issue for broadcasters and cable operators would be the cost to "pass" programming. A key issue for consumers would be the cost of a receiver and a VCR after five years of production.

It is difficult to establish target values for cost issues. Furthermore, cost is a function of market conditions and production volume. In the case of consumer equipment, the cost of current top-of-the-line NTSC projection receivers and top-of-the-line VCRs may be noted for reference only, but not as target values.

7.3.2 Cost to Broadcasters

In implementing ATV, broadcasters will incur costs of new studio equipment such as ATV encoders and monitors, router/switchers and video recorders; new transmission equipment such as ATV broadcast transmitters, ATV antennas, transmission lines and studio-to-transmitter links; and possibly other new equipment.

Differences in the proponent ATV systems may result in cost differences in professional broadcast equipment and/or studio/station equipment configurations. These variations are analyzed and identified, as an element in the ATV selection process.

7.3.2.1 Definition

The equipment cost for a broadcast station to deliver a simulcast terrestrial ATV signal.

A "transitional" station was defined as one that provided the ability to "pass through" the signals of a network or syndicated program source with essentially the same production values in the program integration as today. The transitional station also was to have the ability to upgrade easily to more extensive ATV operations and to higher levels of performance as dictated by audience growth and station finances.

A "minimal" station was defined as one that provided the ability to "pass through" the signals of a network or syndicated program source with compromises made in its capabilities in

order to reduce costs to a minimum. The minimal station would not bear the costs associated with providing for future upgrades and might require replacement if an upgrade were needed.

7.3.2.2 Method of Determination

Broadcast station equipment configurations are analyzed to determine cost variations due to differences in ATV proponent systems. Costs to broadcasters are based on a transitional television station — this being a generic station representative of one offering an early ATV service. A minimal ATV model was developed also to allow an estimate of what would constitute a "bare minimum" investment by a local broadcaster.

Broadcasters are expected to convert to ATV in phases, as follows:

Network pass-through
Local commercial insertion
Local program origination
Local program playback
Full ATV operation

The investment required to implement the first two phases above is taken to be an estimate of the cost to broadcasters for implementing ATV. Based on block diagrams of typical broadcast station configurations, the equipment needed to implement these two phases may include:

Satellite receiver
ATV routing and switching equipment
ATV videotape recorder
NTSC upconverter
ATV encoder
ATV receiver for off-air monitor
Studio-to-transmitter link (STL)
ATV transmitter and antenna

ATV encoder costs are estimated for an initial production run during the 1994-95 time frame. Encoder cost estimates are developed from the amount and speed of memory, count of gates, and other elements of electronic design, based on information supplied by each proponent.

Other equipment costs depend on the signal format and data rate (i.e., whether the signal is compressed or not) at various points in the broadcast plant. Block diagrams of the broadcast station plant are used in this analysis to estimate total station costs.