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ABSTRACT

The integration of television into a digital framework makes possible the merger of television and computers. Development of a digital system will permit the consumer to receive television and computer images on the same screen at a quality approaching 35mm film. If fiber optic telecommunications lines are linked to the home and standards are developed, the American consumer will be able to receive high definition information products through the telephone line. A high resolution information system could have far-reaching effects on international industrial competitiveness and on the American quality of life. Possible applications include product development and design; improved manufacturing efficiency; better diagnosis of disease; and improved instructional techniques. Digital information systems could also provide consumers with access to a wide array of new information services such as the video/telephone and, at the same time, reduce the cost of basic telecommunications services. The Federal Communications Commission (FCC), following the Subcommittee's hearing, has taken steps to give representatives of computer imaging industries a more prominent role in its deliberations; however, the FCC remains focused on systems for terrestrial broadcasting rather than on a comprehensive system capable of incorporating television and computer applications. The hearings also identified a number of impediments to commercializing the technological advances. This report includes information on the development of and activities concerned with these technologies in Japan and Europe as well as in the United States; summaries of the testimony given at the May 1991 hearing; discussions of the major issues involved; and an overview of the current status of high resolution information systems (HRIS). Seven recommendations conclude the report. (KRN)

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[COMMITTEE PRINT]

HIGH DEFINITION INFORMATION SYSTEMS

REPORT

PREPARED BY THE

SUBCOMMITTEE ON
TECHNOLOGY AND COMPETITIVENESS

TRANSMITTED TO THE

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SCIENCE, SPACE, AND TECHNOLOGY
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*Ranking Republican Member.

LETTER OF TRANSMITTAL

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC, June 30, 1992.

Members of the Committee on Science, Space, and Technology:

DEAR COLLEAGUES: I transmit for your attention a report on high definition information systems by the Subcommittee on Technology and Competitiveness prepared at the direction of Subcommittee Chairman Tim Valentine. The report was circulated to the Members of the Subcommittee for review. The Subcommittee staff revised the report in light of the comments received. The revised report was approved by the Subcommittee by voice vote on June 24, 1992. Members of the Subcommittee were given three days to file separate remarks. None were received.

The report discusses issues identified in hearings held by the Subcommittee on high definition information systems during May 1991, and includes information collected during previous full Committee hearings on high definition television and Subcommittee hearings on critical technologies. It also draws upon information collected during a detailed Subcommittee review prior to the most recent hearings as well as important events which occurred after the May 1991 hearing.

Our Subcommittee on Technology and Competitiveness, through its oversight activities on high definition systems, is seeking to ensure that activities of the Federal Communications Commission and Executive Branch agencies result in the implementation of a comprehensive, flexible, high definition information system for the United States. I commend the report to your attention.

Sincerely,

GEORGE E. BROWN, Jr.,
Chairman.

LETTER OF SUBMITTAL

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC, June 29, 1992.

Hon. GEORGE E. BROWN, Jr.,
Chairman, Committee on Science, Space, and Technology,
House of Representatives.

DEAR MR. CHAIRMAN: I submit herewith a report on high definition information systems by the Subcommittee on Technology and Competitiveness. The report was prepared under my direction by the staff of the Subcommittee.

The report follows up on the May 14 and 21, 1991 Subcommittee hearings on high definition information systems. In the report the Subcommittee staff has also brought together and analyzed information received during a number of other hearings which bear on the same issue area. These include previous full Committee hearings on high definition television and Subcommittee hearings on critical technologies. The report also draws upon information collected by the Subcommittee as part of its continuing oversight of this topic which is important and relevant for a complete understanding and examination of the issues.

The objectives of the May hearings were:

(1) examination of recent advances in communications and information technologies and of the importance of these fields to the U.S. economy;

(2) exploration of the scope and direction of the various Federal government, advisory committee, and private sector activities aimed at developing a comprehensive, flexible, high definition infomation system for the United States; and

(3) exploration of what further Federal government actions might be required in this area.

The Federal Communications Commission (FCC) hopes to decide on the standard for the next generation of terrestrial television transmission next year. The Committee hearings highlighted the need for the FCC to ensure that the standard selected is compatible with non-entertainment applications of high resolution systems, and in particular with high resolution computer imaging applications. The hearings also established the need for a fully digital system to accomplish this goal.

The hearings have already had an impact on the FCC activities. After the hearings, the Commission appointed one of the Subcommittee's witnesses, who represented the computer imaging industry, to a vice-chairmanship on its Advisory Committee working party that is considering compatibility issues.

The hearings also established that much remains to be done. A fiber optics infrastructure must be deployed to businesses, schools, and residences. Standards must be established for Broadband Integrated Services Digital Networks. There also must be better coordination among the various standards groups that are now working separately on standards for various components of a high definition information system. The government should provide a forum around which the various standards groups can coalesce.

I hope that this report will serve as a catalyst for U.S. industry, the Administration, and the Congress to take the steps that are necessary to ensure an American industrial presence in the high definition information future that we look forward to for all Americans.

Cordially,

TIM VALENTINE, *Chairman,*
Subcommittee on Technology and Competitiveness.

CONTENTS

HIGH DEFINITION INFORMATION SYSTEMS AND THEIR IMPLEMENTATION

The Subcommittee on Technology and Competitiveness held hearings on May 14 and 21, 1991 on high definition information systems and their implementation. This report examines the major issues identified during those hearings. It includes information collected during the full Committee hearings on high definition television in March 1989 and the Subcommittee hearing on critical technologies in April 1991. These previous hearings by this Subcommittee and the full Committee documented the importance of high resolution information systems and component technologies to U.S. competitiveness across a broad range of industries. This report also includes information obtained in the course of ongoing and detailed Subcommittee review and inquiry relating to the activities and issues discussed.

The May 1991 hearings had a number of objectives. First, as a follow-up to the earlier hearings, they examined the importance of the communications and information technologies contained in the critical technologies list prepared in early 1991 by the National Critical Technologies Panel of the White House Office of Science and Technology Policy (OSTP) and reviewed recent advances in the development of the architecture and standards for a high definition information system.

Second, they explored the scope and direction of the various federal government, advisory committee, and private sector activities that are designed to assure that a comprehensive, flexible, high definition information system is implemented.

Third, they explored what further Federal government actions might be required in this area.

I. INTRODUCTION AND EXECUTIVE SUMMARY

The term "high definition system" can refer to a range of different systems involving different technologies. Included are analog high definition television systems. These analog systems are an extension of existing television with finer detail broadcast over the airwaves. These systems can provide the consumer with a much sharper picture and truer color than current television sets.

Recent technological developments have made possible digital high definition television. The integration of television into a digital framework makes possible the merger of what have heretofore been distinct products—televisions and computers—into a comprehensive high definition or high resolution information system. Development of the architecture and standards for a digital system, if done correctly and with the participation of all the relevant parties concerned with standards setting, will permit the consumer to re-

ceive television images and computer images on the same screen at a quality level approaching 35 mm film.

If fiber optic telecommunications lines are linked to the home, and standards for a Broadband Integrated Services Digital Network (B-ISDN) developed, the American consumer will be able to receive high definition information products through the telephone line. The current copper telephone cable does not have the capacity to transmit high definition visual images. However, fiber optic cable does. The current generation of ISDN standards is inadequate to permit efficient transmission of full-motion video. But, standards for B-ISDN would permit the higher data rate required for delivery of high definition systems through fiber optic telecommunications networks.

The hearings of the Subcommittee have described the far-reaching effects a comprehensive high resolution information system could have on the competitiveness of American industry and, at the same time, on the quality of life for all Americans.

High definition information systems could facilitate greatly the design of products through the interactive contributions of engineers in different locations. Moreover, they can bring efficiencies to the manufacturing process by the transmission of instructions over fiber optic networks.

An interactive fiber optic network serving the medical community would offer remote diagnostic capability featuring the highest quality video resolution. For example, high resolution images of x-rays and slides of tissue samples could be transmitted by the broadband network from surgeons at one location to world-renowned radiologists and pathologists at other locations for accurate disease diagnosis and consultation on treatment.

Some of the most exciting possibilities for use of high resolution systems are in education. Graduate students at different locations in a university system could see the university's best professor of aeronautical engineering in one window of a high resolution screen; in another window, the students could see the mathematical equations for the problem he is trying to solve; in another window they could see a computer image of an airplane design, which can be taken apart and rotated, either by the professor or by the students from their own terminals and displays.

Digital information systems could also provide the American consumer with access to a wide array of new information services such as the video/telephone while at the same time drastically reduce the cost of basic telecommunications services.

The forum for deciding on a high definition television system for the United States is the Federal Communications Commission (FCC). The FCC, following the Subcommittee's hearing, took steps to give representatives of computer imaging industries a more prominent role in its deliberations. However, the FCC activities remain focused on high definition television systems for terrestrial broadcasting, rather than a comprehensive high definition information system capable of incorporating television and computer applications. Since no other forum exists at the present time which can address this critical issue, FCC decisions and activities take on unusual importance.

The United States is now the leader in development of some technologies critical to the development of digital high definition television. Another challenge facing the United States is commercializing technological advances. The Subcommittee hearings have identified a number of impediments to commercialization, which are generic problems inherent to a range of other technologies.

II. BACKGROUND

A. Critical Technologies

Digital high resolution information (HRI) systems include high resolution video technologies (television, VCR, video disc) and high resolution computer technologies (computer imaging). Development of HDTV/HRI systems are of growing importance to American companies that are competing in a world market in the areas of telecommunications and information products and services, computers, semiconductors, and consumer electronics. In contrast to analog systems, digital transmission systems can be virtually transparent; what goes into the systems is what comes out. Images will be able to be processed and manipulated without signal degradation.

A number of component technologies in HDTV/HRI systems have been identified by the Executive Office of the President's Office of Science and Technology Policy (OSTP) as essential for the Nation's long-term security and economic prosperity. These generic, enabling technologies include high definition imaging and displays, sensors and signal processing, data storage and peripherals, and computer simulation and modeling.[1]

B. The Importance of Digital Technologies

United States industry has made major advances in the development of some of the digital technologies necessary for a HDTV/HRI system. These technologies include digital processors, analog to digital conversion technologies, electronic memories, and signal coding and compression technologies. The United States now leads the world in digital image compression, or bit rate reduction, techniques which permit a higher resolution picture to be transmitted on a narrow bandwidth channel. Digital systems will permit a common broadcast/computer interface to be developed that will lead to the highest resolution picture needed for video or computer image applications. For broadcasters, digital systems will offer noise-free and ghost-free reception, and CD quality audio.

Commercial development of digital technologies, by combining both entertainment and non-entertainment uses, presents the best possibility for the United States to regain a market share in consumer electronics. The country that takes the lead in high resolution digital technologies will have an overwhelming advantage in components, including semiconductors, computers, software, and test equipment.

Advances in digital technologies in the United States permit the development of an open architecture and standards for an interac-

[1] Report of the National Critical Technologies Panel, March 1991.

tive HDTV/HRI system. Such architecture can be upgraded and evolve as technology evolves. Specific concepts have been identified as necessary to a high definition information system to encourage a greater degree of compatibility between video and computer imaging applications and to minimize the costs of conversion equipment. These include the development of a header/descriptor that identifies the digital signal and reveals its origin. Design objectives for a header/descriptor include extensibility, meaning the system should be able to incorporate future technological advances over time which are compatible with then-existing components and infrastructure. The header design should also permit scalability, meaning the system should be able to accommodate displays of varying degrees of resolution, including windows of different resolutions displayed simultaneously on one monitor.

C. The Importance of Fiber Optics

Related to development of digital technologies is the use of fiber optic cable which replaces coaxial and copper cables. Major long distance telecommunications networks are now almost fully digital. "Fiber to the curb" is beginning to come to some urban areas, and a number of state regulatory authorities are considering implementation plans for fiber to the home. Transmission of high resolution video and computer imaging over the telecommunications network requires a bandwidth that only fiber optic cable permits. Deployment of fiber also permits the opportunity to design a ubiquitous two-way interactive multipurpose communications system providing very high quality, high resolution, feature-rich services for both entertainment and non-entertainment purposes.

The efficient transmission of high resolution video and computer imaging over fiber optic telecommunications lines will also require the development of standards for a broadband Integrated Services Digital Network (B-ISDN). At present, the telecommunications industry is developing standards which will permit the telecommunications network to handle digitized voice, fax, and computer data streams. However, full motion video and computer imaging will require development of the standards to support a much higher data rate than required for other digital applications.

D. The 1987 FCC Rulemaking on Television in the United States

Terrestrial television in the United States is currently transmitted to the home by means of analog signals. The original National Television System Committee (NTSC) standard for black-and-white television was adopted in 1940. A second NTSC standard for color television was adopted in 1953. This is the standard used today. In 1987, the National Association of Broadcasters and the Association of Maximum Service Telecasters asked the FCC to initiate an inquiry and rulemaking concerning the development of a new standard for the terrestrial transmission of the next generation of television in the United States.

The immediate impetus for the request for U.S. broadcasters was a request that the FCC release unused spectrum reserved for broadcasting for mobile services uses. In their petition to the FCC,

the broadcasters requested that the FCC limit the portion of the radio spectrum allocated for television broadcasting for broadcast television and related imaging purposes only, until the completion of work on advanced television. The Commission has done so.

In response to the broadcasters' 1987 request, that same year the Federal Communications Commission (FCC) announced a rulemaking proceeding on ATV and, the same year, created an Advisory Committee on Advanced Television Service (ACATS) with the following objective:

> The Committee will advise the Federal Communications Commission on the facts and circumstances regarding advanced television systems for Commission consideration of the technical and public policy issues. In the event that the Commission decides that adoption of some form of advanced broadcast television is in the public interest, the Committee would also recommend policies, standards, and regulations that would facilitate the orderly and timely introduction of advanced television services in the United States.[2]

Through its 1987 rulemaking, the FCC has set in motion an activity that will change the face of broadcasting in the United States. It represents the most significant development in the state of the television art since the advent of color. The Commission has cast its inquiry broadly. Although many equate "advanced" television with "high definition" television (HDTV), the two terms are not synonymous. ATV includes the range of possible improvements to the existing NTSC television standard. HDTV is near the top end of these possibilities, with a picture quality approaching that of 35 mm film. In between the existing NTSC standard and HDTV are various concepts of what generically may be referred to as "enhanced definition television."

A coalition of broadcasting companies and industry organizations formed the Advanced Television Test Center (ATTC) during 1988 to assist the ACATS and the FCC in this process. The ATTC is a private sector, non-profit organization which has agreed to assume the principal burden, both technically and financially, involved in testing proponent systems in a terrestrial broadcast environment. The ATTC has stated that its test laboratory reflects a $15 million commitment by its sponsors.[3]

On a parallel track, the cable television industry in the United States organized its own broad research and development activity and created the Cable Television Laboratories in 1988 (CableLabs). CableLabs is evaluating ATV systems when transmitted by Cable TV, including both coaxial cable and fiber-optic transmission. CableLabs has committed in excess of $4.1 million to the laboratory and fields test phases of the ATV test program. The member com-

[2] First Interim Report of the FCC Advisory Committee on Advanced Television Service, June 16, 1988.

[3] The sponsoring members of the ATTC are Capital Cities/ABC, Inc.; CBS, Inc.; NBC, Inc.; Public Broadcasting Service (PBS); the Association of Independent Television Stations (INTV); the Association for Maximum Service Television (MSTV); Electronics Industry Association (EIA); and the National Association of Broadcasters (NAB).

panies of CableLabs serve more than 85% of the cable subscribers in the United States and 20% of the subscribers in Canada.

The first ATV systems submitted to the FCC for consideration were analog systems. Through a self-screening process, a total of 23 different ATV systems were reduced to six by early 1990. The first all-digital system was proposed in June 1990. Within a few months, three of the existing proponents changed their submissions to all-digital systems. On March 2, 1992 one of the analog system proponents requested that consideration of its system be deferred, stating that the emphasis should be on ditigal transmission systems. Four of the five remaining systems are all-digital.[4]

The presence of four fully digital systems on the list shows the ability of the FCC process to adapt to the rapidly changing technology, especially advances in digital video compression and transmission techniques. Digital systems permit a higher degree of compatibility with other television distribution media such as cable and fiber, satellite and VCRs. They also permit a higher degree of compatibility with non-broadcasting digital media, including high resolution computer imaging.

The FCC directed that its Advisory Committee study the implications of a terrestrial broadcasting transmission standard for alternative media. As early as 1988, the Advisory Committee stated that expeditious consideration should be given to the achievement of effective and inexpensive interfaces between broadcast and non-broadcast media. However, the four interim reports of the Advisory Committee to the FCC covering the period from June 1988 through April 1991 show that during that period the Advisory Committee was considering alternative distribution media, such as satellite, fiber optics, cable television, microwave, VCR and video disc, not computer imaging. The fifth interim report of March 1992, acknowledges for the first time that the Advisory Committee began studying harmonization issues involving advanced imaging in non-broadcast applications.

Those involved with the Advisory Committee argue that the Advisory Committee process has been open to participation by anyone, including representatives of the computer industry. However, only in September 1991 was a representative of a company involved in non-broadcasting applications of high resolution imaging formally designated a vice-chairman on the Advisory Committee's working party concerned with alternatives media compatibility issues.

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[4] Currently, the five active proponents are:

1. Narrow MUSE—a hybrid analog/digital system proposed by NHK. This is a reduced bandwidth version of the MUSE system in use in Japan.
2. DigiCipher—the first digital proponent from General Instrument, in partnership with the Massachusetts Institute of Technology. It uses interlace scanning, which is incompatible with high resolution computer imaging.
3. Digital, Spectrum Compatible HDTV—a digital progressive scan system proposed by the partnersh: of Zenith and AT&T.
4. Advanced Digital Television (ADTV)—a digital system proposed by the Advanced Television Research Consortium (ATRC) comprised of David Sarnoff Research Center, NBC, North American Philips, and Thomson Consumer Electronics It uses interlace scanning, and video compression technology based on the International Standards Organization's emerging Moving Pictures Export Group (MPEG) standard.
5. ATVA Progressive System—a digital system proposed by the partnership of General Instrument and Massachusetts Institute of Technology. It combines General Instrument compression methods with MIT's progressive scan and signal processing technology.

E. The Computer Industry

The computer industry is concerned about the FCC's narrow focus on a standard for terrestrial television transmission. They fear it could force consumers to accept a standard which supported the "least common denominator" medium, and would ignore non-entertainment uses of high resolution displays for users for whom image quality is very important.

Representatives of the computer industry argue that we should be developing the standards and architecture for a comprehensive high definition information system rather than a standard for advanced terrestrial broadcast television. Such a system could include video, voice, computer image and data capable of delivery by multiple modes (satellites, cable, fiber), across the traditionally distinct industries of terrestrial broadcast and cable TV, personal computers and work stations, and consumer electronics. The computer industry is concerned that the FCC inquiry may lead to adoption of a narrow standard for terrestrial broadcasting which will be incompatible with other applications of high resolution systems in fields such as defense, education, science, medicine, publishing, and industrial processes.[5]

F. Activities of Other Executive Branch Agencies

In 1988, the American electronics industry raised concern about the broader implications of advanced video display systems for both commercial and defense uses. The industry argued that the development and production of the underlying technologies were integrally related to the future of the domestic electronics manufacturing and semiconductor industries. The electronics industry saw the issues of advanced video displays, including HDTV, as being related to national economic welfare and the future domestic availability of defense technology. The electronics industry also raised concerns about the future of U.S. high-tech R&D and the U.S. manpower skills base.

In response, Commerce Secretary Mosbacher initiated a high level review of high definition television issues. However, even though he initially took the position that HDTV issues had broad trade and competitiveness implications for U.S. industry, Commerce later opposed specific appropriations for HDTV R&D.

Through its Advanced Technology Program, Commerce's National Institute of Standards and Technology (NIST), is providing modest support to the private sector and to other federal agencies as they prepare for high definition systems. NIST is supporting industry research into the following component technologies of high definition systems identified as critical technologies by the National Critical Technologies Panel: (1) high-definition vision; (2) real-time signal processing; (3) high-rate data transmission; (4) high-density data storage; and (5) high-definition displays. NIST is also helping to develop ISDN standards, helping industry commercialize

[5] Testimony and prepared statement of Dr. David Staelin, hearing transcript, pp. 11 and 32; prepared statement of Michael Liebhold, hearing transcript, pp 167, 169; testimony and prepared statement of Kenneth L. Phillips, hearing transcript, pp. 188, 197; testimony and prepared statement of Gary Demos, hearing transcript, pp 204-206; 214-216.

ISDN through the North American ISDN User's Forum, and developing related measurement and test technology for use by industry in designing and testing its products.

The State Department has the responsibility, with Commerce's National Telecommunications and Information Administration (NTIA) and the FCC, for advocating U.S. positions in meetings and conferences of the International Telecommunication Union (ITU). The ITU is a specialized agency of the United Nations whose primary purpose is to ensure the interconnectivity of a worldwide telecommunications network. The ITU is considering HDTV issues because its mandate also covers technical and operating aspects of broadcasting and broadcasting satellite services, as well as the overall performance and quality of signals delivered to the general public, when they are used for television, data, and associated ancillary services. The ITU's International Radio Consultative Committee (CCIR) develops international standards for all parts of the broadcast chain from production to reception.

The State Department chairs the U.S. National Committee for the CCIR, an Advisory Committee that provides advice and recommendations to the U.S. Government on issues being considered in the CCIR. The State Department has led the negotiation of a worldwide HDTV production standard for the studio and for international program exchange in the CCIR. A worldwide production standard would help maintain the U.S. leadership in the production and distribution of video programming.

The CCIR is also engaged in analyzing the harmonization of HDTV between broadcasting and non-broadcasting applications. Federal agencies and U.S. industry, including the computer industry, are taking an active part in this work. There is merit in development, at the international level, of an open architecture for high definition information systems. The future benefits of video and other image technologies will be greatly enhanced if universal interchange of all kinds of images and image sequences can be implemented and managed economically.

G. Developments in Japan and Europe

Other countries or regions have also been engaged in research and development on advanced or high definition television. In Japan, research and development of HDTV has been underway for more than 20 years. The Japanese have an experimental operational HDTV system, using the Multiple Sub-Nyquist Sampling Encoding (MUSE) system. It is a 1,125 line, 60-field-per-second interlaced analog system designed for direct broadcasting from satellites (DBS). The Japanese Broadcasting Company (NHK) developed the MUSE technology and has fostered the development of technology through continuing research in its own laboratories and through cooperative activities with a number of Japanese companies. For over a year, NHK broadcasted one hour a day in MUSE HDTV, and initiated 8 hours of HDTV broadcasting in late-November 1991. The overwhelming majority of HDTV receivers, however, are located in areas of public accommodation, not private residences. The limited program offerings and high cost of receivers have served as obstacles to wide-spread Japanese consumer acceptance

of HDTV. The Japanese government and industry still promote the MUSE standard. Most in the industry believe, however, that MUSE is anachronistic. Telecommunications authorities in Japan believe that if fiber optics reach the home by 2020, HDTV could become a multimedia technology served by cable rather than broadcast.

In 1986 the European Community (EC) adopted a directive on satellite television transmissions requiring all direct broadcasting television satellites to use a standard from the multiplexed analog component (MAC) family of standards. The intent was to replace the different terrestrial transmission standards in Europe, PAL and SECAM, with a transmission standard that would be used by satellite and cable throughout the entire market. MAC will not initially be for transmission of an advanced or high definition television. However, the EC directive contemplated a number of incremental steps toward the introduction of HDTV (HD-MAC) by using the MAC family of standards. HD-MAC is a 1,250 line, 50 field-per-second interlaced system. While the MUSE and MAC systems have a number of common technical features, these scanning parameters are different from the MUSE system and they differ on other technical points.

The 1986 directive expired in 1991, and negotiations began on a new directive. In the past, the debate in the EC over television transmission standards has been dominated by the European electronics manufactures. During negotiations in 1991, broadcasters, particularly satellite broadcasters having installed bases of receivers and significant program offerings, pressed the EC and member states for flexibility to continue using the existing PAL standard. On December 20, 1991, the EC negotiators agreed on a new directive which gives existing satellite broadcasters the right to continue to broadcast with no obligation to broadcast simultaneously in the MAC standards. The directive specifies that MAC transmission standards will be compulsory for new satellite television services after January 1, 1995. The directive leaves open the possibility of digital HDTV competing with MAC standards in the future.

The future of HDTV in Europe is highly political, as the two major consumer electronics manufacturers in Europe have invested heavily in the development of equipment for the MAC standard. It has been reported that failure to go forward to HD-MAC would endanger one of the companies. Many European experts believe that the MAC technology is already obsolete when compared to U.S. technology.[6] European companies appear to be covering their bets by investing heavily in digital technologies including work at Sarnoff labs.

In order for Japanese and European consumers to receive television programming after the MUSE and MAC standards are introduced, the consumers must buy either a new television set or decoders because current receivers are incompatible with the new

[6] See, for example, the following articles: (1) "Let HDTV take care of itself," The Economist, March 16, 1991; (2) "MAC attack," The Economist, March 16, 1991; (3) "Europe's HDTV standards," The Economist, May 11, 1991; (4) "Dish of the day," The Economist, June 29, 1991; (5) "Brussels tables draft on HDTV standard," The Financial Times, June 29, 1991; (6) "Europe and high-tech TV," The Financial Times, July 3, 1991; and (7) "High-definition tunnel vision," The Economist, November 9, 1991.

technologies. In contrast, the FCC decided that advanced/HDTV service in the United States should be compatible with the existing NTSC service and receivers. In initiating its inquiry, the FCC also stated that the introduction of advanced/HDTV in the United States should not adversely affect the unique character of the United States television industry and the benefits it has gained from diverse program content and local service providers.

III. WITNESSES

The Committee's hearing was divided into two sections. The witnesses the first day, May 14, were asked to discuss the necessary components of a national strategy to encourage the development by U.S. industries of the technologies and products necessary to a high definition information system.

Dr. Robert Kahn, President, Corporation for National Research Initiatives, stressed the need for academic, industrial, non-profit, and governmental organizations to work together in building a national information infrastructure. In addition to the much-discussed concept of an information highway, the U.S. also needs to focus on "higher levels" of infrastructure such as a national digital library, a knowledge bank for science and technology, and an infrastructure for engineering design and manufacturing. Dr. Kahn also stressed the importance of standards for interactive exchanges. Dr. Kahn urged that harmonization of standards become a more important part of the dialogue on high definition systems. The emphasis should be on systems integration rather than independent approaches. Dr. Kahn testified that it is important to look at the legal and regulatory environment in which high definition systems and high speed networks are developing, particularly with regard to issues of intellectual property protection. Dr. Kahn further suggested that social issues would be important; the U.S. needs to ensure that the poor are not further disadvantaged by not being able to afford the high definition systems of the future.

Dr. David Staelin, Professor of Electrical Engineering, Massachusetts Institute of Technology, concurred with the view of Dr. Kahn that the real issue for the United States is not the development of high definition video, but the development of the framework and standards for a HDTV/HRI system. This involves answering the questions of how and by whom the system should be designed and how the process can be shaped to best ensure the continued competitiveness of U.S. industry. The United States must also consider what steps to take to protect industry from the effects of strategic trade and technology policies implemented by other countries.

In Dr. Staelin's view, the use of government bodies to resolve this type of complex issue has had little successful precedent, although historically there have been successful government programs to provide seed funding or an imprimatur for activities undertaken by others. Since the effort to develop an HDTV/HRI system must involve cross-industry efforts, Dr. Staelin suggested the establishment of a consortium of industry, academic and private entities. Although he cited the FCC process as an example of the use of regulatory powers to further U.S. industry, he remained concerned that the evaluation process for proponent systems did not include ade-

quate criteria concerning interconnectivity, modularity, flexibility and extensibility to ensure that HDTV broadcast transmission standards do not frustrate high resolution computer imaging.

Dr. Staelin stated that government could promote the effort to develop an HDTV/HRI system by liberalizing antitrust laws, continuing the modest financial support already provided for high definition studies and for support of technology development in universities, by lowering the cost of capital and reinstituting R&D tax credits, and by ensuring that regulatory decisions further the competitiveness of U.S. industry.

Clark Johnson, a consultant to the data storage industry, testified that manufacturing of many of the components of video storage equipment has been lost to Japan. Necessary parts, such as the single crystal ferrite needed to make high capacity magnetic recorders, are manufactured only in Japan, and Japanese companies refuse to sell U.S. industry top quality material. Digital storage is a critical technology component to an HDTV/HRI system. The techniques for making consumer digital recorders at very low cost have been perfected to the degree that many of the critical precision parts are made in automated factories. For a U.S. manufacturer to reenter this market with a digital tape recorder would be a major undertaking requiring a significant capital investment. Mr. Johnson urged the Subcommittee to address the question of how American firms may reenter this market. In his view, the current process of developing the next generation products which are critical HDTV/HRI components is uncoordinated, chaotic and often redundant. The government, therefore, has a vital role to play in providing a nucleus and a forum around which participants can coalesce.

Dr. William Glenn, Professor, Electrical Engineering Imaging Systems Laboratory, Florida Atlantic University, concurred with previous witnesses that high definition imaging is just as important to the computer industry as to broadcasters. Dr. Glenn reviewed for the Subcommittee the key technologies in high definition systems and the relative strengths of U.S. industry in the technologies. The U.S. is ahead in computer software, ahead in digital compression techniques, and probably ahead in the possibility of high definition distribution, but behind in many of the areas involving manufacturing hardware. One of the most important components is the display. A larger display for high resolution systems requires new technology. The Japanese are working on active matrix flat panel displays. They dominate portions of the recording and storage business. Although the United States dominates program production, all the professional equipment needed for video program production, such as cameras, is Japanese. These areas need stimulation if the U.S. is to reenter the consumer electronics equipment manufacturing market. At the present time, there is no incentive for U.S. companies to manufacture.

Dr. Glenn agreed with previous witnesses on the importance of an architecture and standards for high definition systems. The most important aspect is the development of a header/descriptor that identifies the signal and reveals its origin, since the same receiver must be able to receive and identify different video, image, audio, and data streams.

Dr. Robert Sanderson of Kodak stressed the importance of developing standards for interoperability of a HDTV/HRI system that will reach across industries, including communications, computing, consumer electronics and imaging. Kodak is a major supplier of imaging products which, in the future, will be more electronically based. A high definition information system must give the various affected industries confidence that their products and services will be interoperable with each other. In Dr. Sanderson's view, emerging U.S. standards are uncoordinated in spite of preliminary work on medi_ harmonization issues in the ACATS and the CCIR. Dr. Sanderson stated that government help was needed to create an environment for cooperation and to encourage industry to engage in cross-industry cooperation.

Alan R. Blatecky, Vice President, Communications, Microelectronics Center of North Carolina (MCNC), testified about the benefits of high definition imaging in a non-entertainment setting—the role of high quality video systems in educational and research collaboration. MCNC runs a network which connects major centers of research and learning in North Carolina. The current "high quality" video in place with current technology is barely adequate. What is needed is a networking infrastructure which can support high-powered workstations in video-conference facilities for the exchange of high resolution images.

During the second day of hearings, May 21, the Subcommittee explored the Government's role in the standardization and implementation of high definition systems. In particular, the Subcommittee wanted to hear about the impact of an FCC terrestrial broadcasting transmission standard on computer imaging and the other components of high definition systems, and what implementation efforts are needed to make a nationwide high definition information system a reality. The Subcommittee wanted to be sure that all the involved industries are developing interoperable components so that equipment costs can be kept to a minimum through mass production.

The first panel permitted the Subcommittee to hear from two key government agencies, NIST and the FCC. Dr. John Lyons, Director of NIST, testified that NIST supports the technical aspects of high definition systems in two ways: (1) through laboratory programs to develop the measurement and test technologies that industry needs to design, develop, test, sell, and service products; and (2) through the Advanced Technology Program which contributes to the support of generic storage and display technology. In addition, NIST contributes broadly to the standards infrastructure for high resolution systems. NIST has contributed technical expertise to the development of ISDN standards and is helping United States industry commercialize ISDN through the North American ISDN User's Forum.

Dr. Thomas P. Stanley, Chief Engineer of the Federal Communications Commission, reviewed the FCC activities and testified that a digital transmission standard would be a significant step toward compatibility between broadcast television technologies and other digitally-based applications including computer imaging technology. He was confident that digital technology will permit a common broadcasting/computer interface to be developed. Dr. Stanley

stated that it would be desirable for those developing high resolution computer imaging systems to join the other participants in the ACATS to explore areas of compatibility. Dr. Stanley was optimistic that if this occurred, the ACATS could make significant progress in harmonizing broadcast and non-broadcast high definition applications. In Dr. Stanley's view, the primary work has to be done by the private sector. The FCC defers to the private sector in defining services and interface standards.

The members of the second panel represented a number of industries directly affected by the ACATS and CCIR activities. The first witness, Michael Liebhold, Manager, Media Architecture Research, Advanced Technology Group, Apple Computer, Inc., appeared on behalf of COHRS, the Committee for Open High Resolution Systems. Mr. Liebhold echoed the testimony of previous witnesses that there was a need for the creation of an environment which encourages the coordination and integration of standards for different media to minimize the cost of the receivers and other equipment that will deliver video and computer images to customers. He testified that the criteria of interoperability, extensibility, scalability and harmonization should be given more weight in the ACATS process.[7]

In the view of COHRS, the ACATS process historically has not given serious consideration to format compatibilities with non-broadcast systems. The ACATS process does not appear to have an adequate mechanism to consider related imaging standards being developed concurrently by various computing and telecommunications bodies. Mr. Liebhold endorsed the importance of development of a header/descriptor to identify a digital stream and urged that development of a header be introduced into the work of the ACATS. He testified that a header/descriptor is inherent in the imaging standards for B-ISDN developed in the CCIR's sister body, the ITU's Consultative Committee on International Telephone and Telegraph (CCITT). The CCITT develops international standards for telecommunications networks and the equipment connected to them.

Kenneth L. Phillips, Science Adviser and Chairman for Legislative Affairs of the Committee of Corporate Telecommunications Users, focused on the importance of developing a framework and standards which would be compatible with future digital telecommunications services. This would drastically cut the cost of providing access to basic telecommunications services for users. In Mr. Phillips' opinion, standards adoption should not be based solely on the broadcast-oriented activities at the FCC. He suggested that Congress pass legislation creating an advisory committee with a mandate to focus on the harmonization of standards among the various groups engaged in standards-setting.

Mr. Phillips also noted the importance of a fiber optic network to the implementation of a high definition information system and

[7] The definitions of these terms have been refined over time. Mr. Liebhold provided the following definitions. Interoperability is the capability of operation among video and image formats. Extensibility is the ability of a video/image standard to incorporate extended functions over time. Scalability is the degree to which video and image formats can be combined in systematic proportions for distribution over communications channels. Harmonization is the organization of different standards-setting efforts into an orderly process.

discussed a number of the regulatory and economic issues which have slowed deployment of fiber to the home.

Gary Demos, President and CEO of DemoGraFX, testified that U.S. Government agencies should shift their focus from high definition systems as an entertainment medium to designing a national interactive high definition information system. While the needs of the broadcast industry are important, they should be met in the context of serving the broadest public interest, rather than to the exclusion of the broader public interest. He also stressed the importance of deployment of fiber optics as the transmission backbone for the system.

The final witness was David Deas, Director, Technology Planning, Southwestern Bell Corporation, Technology Resources, who endorsed previous testimony that standards should take into account converging technologies and should be compatible with digital and fiber optic technology already deployed in the telecommunications network. Mr. Deas stated that if judicial and regulatory restraints were removed that prevent telephone companies from providing information services and depreciation policies are addressed, high definition television can be offered over the public telecommunications network.

IV. MAJOR ISSUES

A. The FCC/ACATS Process

The FCC rulemaking on advanced television is an example of a farsighted regulatory process that can be used to further U.S. industry and U.S. competitiveness. With the ever-growing demands on use of the radio frequency spectrum, the FCC is rightly addressing a critical issue of spectrum usage. This is so even though introduction of HDTV by broadcasters may be years away and even though there are alternative modes for delivery of television signals.

The FCC process has been flexible and adaptive. Several years ago, the U.S. appeared to be years behind in HDTV. Now, the situation is radically different. Japan and Europe have invested heavily on analog systems that are incompatible with current receivers, and which will require consumers to purchase conversion equipment or expensive new receivers if they wish to continue to view television once the new systems are introduced. The Japanese and European analog systems cannot be used for non-broadcasting applications such as high resolution computer imaging. The FCC has assured U.S. viewers that sets built under the NTSC standard will not be obsolete under the new standard. More importantly, the United States has catapulted ahead of Japan and Europe to test four fully-digital systems. A digital standard would be a significant step toward compatibility between broadcast television and digitally-based applications. Dr. Stanley testified that he is confident that with digital technology a common broadcast/computer interface will be developed.

While the work of the FCC should be encouraged, the FCC process has significant limitations. The FCC's jurisdiction is over telecommunications common carriers and broadcasters. Although the

ACATS process is considering implications of a terrestrial broadcasting standard for other media, the process is designed primarily to assure that terrestrial broadcasting be given the opportunity to compete with other television program distribution media. It is not clear that the FCC process can adequately address the economic and competitiveness issues which must be assessed in developing a nationwide high definition information system. The FCC and ACATS, in deciding upon a digital terrestrial transmission standard, must factor into the evaluation process criteria necessary to ensure compatibility between HTV and HRI. These criteria include interconnectivity or interoperability, scalability, extensibility, and harmonization.

Dr. Stanley stated that it was desirable for the computer industry to join the broadcasters in the ACATS process to explore compatibility issues. Terrestrial broadcasters, for whom the FCC inquiry is undertaken, have no special reasons for taking the needs of the computer industry into account. The appointment of Dr. Sanderson of Kodak, one of the witnesses before the Subcommittee, to be vice chairman of an ACATS working party exploring compatibility issues, is a positive step to assure that both industries talk to one another.

Since the ATTC has already finished the laboratory testing of three of the proponent systems, the issue of how computer imaging compatibility criteria can be incorporated in the testing process must be addressed immediately. The testing process is not inexpensive; the costs are being borne by the broadcasters and system proponents. As a result of significant revenue losses in the broadcasting industry, its engineering and research staffs have been depleted. The computer industry, however, has strong R&D capabilities and financial resources.

B. Infrastructure

A nationwide high definition information system capable of handling HDTV, HRI, and high performance computing will require wider bandwidth than is currently available. High priority must be given to the deployment, to the home, of a nationwide fiber optic network. With advances in mobile and cellular technology, including wireless computers and personal communications networks, the United States will also have to begin thinking of how to extend high definition capabilities to the mobile environment.

The most immediate need is for a fiber infrastructure. Subcommittee witnesses testified that the U.S. has no national telecommunications strategy to use and connect fiber. Our national information infrastructure is integrally related to our competitiveness. There are a number of important issues that must be addressed in order to encourage deployment of fiber. Some are legal and regulatory in nature, such as provisions in the Cable Act that affect who can provide information services in the United States. Others are economic, including depreciation rates. Fiber is used almost exclusively in intercity and international applications, but for the most part has not been used for the local loop to individual residences and businesses. Telephone companies have argued that it is uneconomic for them to deploy fiber to the home because they are pre-

cluded from offering the services that would permit them to recoup their investment and are precluded from depreciating their investment at a reasonable rate. However, the cost of deployment of fiber to the home is rapidly approaching the cost of deploying copper pair. Fiber to the home is being considered actively in a number of states.

Integrally related to this is the need to develop the standards for B-ISDN to permit the efficient transmission of full motion video and computer imaging. The standards for ISDN currently being developed by the telecommunications industry, if adopted, would enable fiber optics networks to handle digitized voice, fax, and data, but not applications such as high resolution imaging which will require a much higher data rate.

C. System Design

An HDTV/HRI system should be planned to assure that its evolution will be technically sound, economically efficient, and be in the best long-term interests of society. Development of a system which serves all HDTV/HRI applications requires cooperative cross-industry efforts. Moreover, since "open architecture" means different things to different industries, much more coordination is needed than the public specification of an interface.

D. Standards and Protocols

It is important for the future competitiveness of U.S. industry that the United States create a high definition information system environment where interoperable products are available at an affordable price. Standards are the key to interoperability. In a high definition information systems environment, standards must reach across industries, including communications, computing, consumer electronics, and imaging. The various standards-setting bodies determining standards for different media must carefully coordinate and integrate their efforts to minimize the cost of the receiver or other devices that consumers will purchase. The government in its roles as regulator and supporter of standards development must be careful to assure that its efforts advance this cause.

The Subcommittee received testimony that as of that time the FCC's ACATS process had not given serious consideration to format compatibilities with non-broadcast systems and had not included consideration of computer imaging harmonization. Witnesses appearing before the Subcommittee were unanimous in testifying that standards for terrestrial ATV should be created in a wider context, involving a thorough consideration of related imaging standards being developed concurrently in various computing and telecommunications bodies. Testimony focused on the need for the criteria of interoperability, extensibility, scalability and harmonization to be factored into the testing process for the proponent terrestrial ATV systems.

E. Legal and Regulatory Concerns

Several witnesses referred to the need for the FCC, the courts, or the Congress to rethink the statutory framework that governs

which companies can participate in these industries given the blurring of the distinctions in a digital context among television, telecommunications, and computing. Many of these issues are critical in determining the range of information services that will be available to the American consumer at a reasonable price.

The FCC regulates telecommunications common carriers and radio and television broadcasting. By and large, it regulates transport rather than content. It does not regulate the computer industry. One witness was of the opinion that even though an HDTV/HRI system permits the convergence of broadcasting, telecommunications and computers, regulation of transport and the content of services should continue to be separate.[8] Another witness argued that since a digital world is transparent as to content, it would be difficult in the future to justify separate regulatory treatment of telecommunications and television.[9] Another witness testified that intellectual property issues need to be examined closely. This will be important, for example, if publishers are to become active participants in using a high definition system.[10] However these issues are resolved, regulation should not be permitted to become complex and bureaucratic and to block progress toward development of a high resolution information system.

F. Where Is U.S. Industry Competitive?

The development of digital systems for testing in the FCC process has been a positive step that has placed the U.S. in the position of technological strength. The Japanese and European systems are analog systems which cannot be used as the basis for a high definition information system.

Digital technology permits an open, modular, scalable, extensible system to be developed. These concepts will provide the basis for standards for implementing interoperability of multimedia systems across traditionally distinct industries. Implementation of a digital system could also drastically cut the costs of providing access to basic telecommunications services.

The Subcommittee asked witnesses to comment on whether the development of digital systems in the United States provides opportunities for commercializing the R&D advances inherent in the proponent systems, and provide an avenue for American firms to regain a market share of consumer electronics manufacturing.

Witnesses who addressed these issues were consistent in citing several factors which act as disincentives for industry. Foremost among these factors is the high cost of capital in the United States. Witnesses also referred to the need to reinstate R&D tax credits and the need to change U.S. antitrust law to permit joint manufacturing. The depreciation schedule for critical infrastructure components was also cited as a disincentive.

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[8] Testimony of Dr. David Staelin, hearing transcript, p. 17.
[9] Testimony of Kenneth L. Phillips, hearing transcript, p. 185.
[10] Testimony of Dr. Robert Kahn, hearing transcript, p. 14.

G. The Role of the Executive Branch, Regulatory Agencies, and the Congress

Many witnesses testified to the need for government coordination of standards-setting activities. Standards-setting in the United States has traditionally been a voluntary private sector activity. Mandatory government-directed standards-setting which may exclude key economic factors can stifle innovation and productivity.

None of the witnesses before the Subcommittee took issue with this basic philosophy. At the same time, the witnesses identified ways the government could and should be playing a more active role. The need for the government role has been brought about by the technology convergence inherent in a high definition information system. Numerous groups involved in setting standards for technologies and components of a high definition information system are working in isolation and not talking to one another. A high resolution information system will work only if standards for different technologies, media, and applications are as carefully coordinated and integrated as possible.

The witnesses testified that the government needs to provide a forum around which various standards-setting groups can coalesce, and act as a moderator or ombudsman. Several forums already exist where the government coordinates activities, but they are limited in scope. Even though the FCC has taken steps to give the computer imaging industry a more prominent role in the ACATS process, the process remains focused on developing a broadcast transmission standard.

Some witnesses testified that Congress could support the harmonization process by legislating the establishment of an Advisory Committee with a broader mandate than the ACATS. The role of the Committee would not be to dictate standards, but to create an environment which will encourage all the relevant standards-setting bodies to work together. The National Institute for Standards and Technology, NIST, was cited as an agency well positioned to take on this coordination role. NIST already provides support for technical research on high definition information systems through its laboratory programs and through the Advanced Technology Program.

V. FINDINGS

1. High resolution information systems (HRIS) are growing in importance to American companies competing in the areas of telecommunications, information technologies, computers, semiconductors, and consumer electronics. Several technologies which are necessary components of such systems are on the list of critical technologies released by the President's Office of Science and Technology Policy (OSTP). Development of data storage and flat panel display technologies are particularly critical, and in both areas the U.S. lags behind other countries.

2. Over the past decade, key industries have worked independently to develop new generations of high resolution products. The U.S. terrestrial television broadcasters have been developing a new generation of television—often referred to as high definition television (HDTV). HDTV will bring to the television viewer a picture quality

approaching that of the 35mm film seen on a movie screen. The computer industry has been refining the capabilities of computer graphics—referred to as high resolution imaging (HRI)—to the point where it is difficult to distinguish computer imaging from video imaging. The high resolution systems being developed for broadcasting and computers have heretofore been incompatible because HDTV was an analog system and HRI is digital.

3. Revolutionary advances in United States digital technologies now offer the real possibility of the merger of HDTV and HRI services into one interoperable system. Displays of the future could be designed to receive the highest resolution picture needed for both video and computer applications. Such systems will permit broadcasters to offer noise- and ghost-free reception and CD quality audio.

4. Industries that lead in commercializing high resolution digital technologies will also have the advantage with respect to consumer electronics and related key components such as semiconductors, next generation computers, software, and test equipment. The United States now leads the world in some critical digital technologies and lags in others. Development of the technologies required for HRIS presents United States companies with new opportunities in consumer electronics and new risks in computer technologies. It is an opportunity to leapfrog to the forefront.

5. Development of an open architecture receiver is essential if a system for both broadcasting and computer applications is to become a reality. Through use of a "head/descriptor" at the beginning of the digital signal, such a receiver would be able to identify video, computer, audio, telephone image, and data digital streams in any of a variety of formats and display them to the user. The architecture for the system must be "extensible," that is, it must permit a receiver to handle future technological advances. It must also be "scalable," that is, it must be capable of receiving and displaying images of different degrees of resolution. Computer imaging may require a higher resolution than entertainment applications. Multiple video "windows" of different quality should be capable of being displayed simultaneously on one monitor.

6. Development of fiber optic transmission facilities to homes, schools, and businesses, and development of B-ISDN standards will be needed before the full advantages of multiple simultaneous services can be realized. Deployment of "fiber to the home" will not only permit users passively to receive video and computer images, but will permit them to engage in interactive communications. This will provide the basis for the creation of entirely new industries and applications, and may bring fundamental changes to society. Major long distance telecommunications networks are almost fully digital, using fiber. "Fiber to the curb" is beginning to arrive in some urban areas. However, replacing the copper wires to homes, schools, and individual businesses is a major expense that has not been undertaken extensively by most telephone companies.

7. The forum for deciding on a high definition system for the United States is the Federal Communications Commission (FCC). The FCC is in the process of choosing a transmission standard for terrestrial broadcast of the next generation of television. Most of the proposed standards being considered are digital and offer the

possibility for development of the architecture and standards for a high definition information system for both high definition television and high resolution imaging. The FCC decision, expected to be made in 1993, will thus influence the development of technologies, industries, and services beyond the FCC's regulatory reach.

8. The FCC rulemaking process has been flexible, permitting consideration of evolving technologies. The ATTC is currently testing for the FCC the second of four digital candidate systems for the new broadcast standard. Four of the five active proponent systems being considered are fully digital.

9. While the work of the ACATS has been focused on terrestrial television transmission, it is also addressing issues of compatibility with non-broadcast media. Until late 1991, these efforts were limited to the study of compatibility with other delivery media, such as cable television. However, the ACATS has expanded the scope of its inquiries to include the compatibility of a terrestrial standard with digital information and imaging. This creates the possibility of development of the standards and architecture for a comprehensive high definition information system accommodating a wide range of applications including both HDTV and HRI.

10. Other agencies are also involved in activities important to the development of a high definition information system for the United States. Commerce's National Institute for Standards and Technology (NIST) is supporting research into a number of component technologies for high definition systems, contributing to the development of ISDN standards, fostering the commercialization of ISDN, and is developing measurement and test technology for industry use. Commerce's National Telecommunications and Information Administration (NTIA) is studying U.S. telecommunications infrastructure needs and is conducting policy studies on the development of HDTV.

11. The State Department, with NTIA and the FCC, has the responsibility for negotiations in the International Telecommunication Union (ITU), a specialized agency of the United Nations, to assure the connectivity of a worldwide communications network and development of international standards for communications media. The ITU's International Radio Consultative Committee (CCIR) is responsible for development of international standards for broadcasting. The State Department has led negotiations in the CCIR of a worldwide production standard for high definition television and is coordinating government/industry input into CCIR analysis of questions of harmonization of HDTV between broadcasting and non-broadcasting applications.

12. Despite the activity in the government and the private sector described above, smooth and efficient implementation of a high definition information system is not assured, because it will require the active participation and cooperation of a number of standards groups which, only after these hearings, have begun talking with one another. The digital systems being considered in the FCC/ACATS process must meet compatibility criteria for high resolution computer imaging. Doing so involves significant issues as to who will bear the financial burden of the additional activity. The computer industry, not the television industry, will be the primary beneficiary.

13. The digital systems proposed for the United States are technologically superior to analog systems being developed in Japan and Europe. This itself does not translate into a competitive advantage in manufacturing the components for a high definition information system within the United States. However, development of digital high resolution information systems does offer new opportunities for the U.S. computer industry to draw upon its technological strengths and its R&D capabilities to develop a wide range of new products and services.

14. The cost of capital deters U.S. industry from commercializing and manufacturing products. This is not specific to high definition information systems. It is generic to the loss of a U.S. manufacturing capability in consumer electronics.

VI. CONCLUSIONS AND RECOMMENDATIONS

1. The FCC has initiated a process which should permit adoption of a forward-looking television standard that can accommodate rapidly changing technology, especially advances in digital technology. Digital terrestrial broadcasting transmission systems permit development of the architecture and standards for a comprehensive high definition information system combining television, imaging, telecommunications, and computer functions. However, it is not certain that the Commission will adopt a digital terrestrial broadcast transmission standard, and it is not certain that the testing process of proponent systems now underway will be adequate for assessing whether the systems will be compatible with the criteria necessary for an open, high definition information system.

The Commission should consider the issue of compatibility of terrestrial broadcasting transmission systems with computer imaging systems and other computer applications to be of paramount importance, and unless there is compelling evidence to the contrary, to bring forward a digital system which embodies the principles of interoperability, extensibility, scalability, and harmonization.

2. The fifth interim report of the ACATS acknowledges that to achieve harmonization of broadcast and non-broadcast applications it will be important to include headers and descriptors so that a HDTV/HRI receiver can identify different video, image, audio and related data streams. Development of a universal header/descriptor will identify the origin and type of signal and additional information such as the program creator, broadcaster, and intellectual property restrictions.

The Commission should explore fully development of a header/descriptor for a universal digital signal.

3. The economic and competitiveness implications for U.S. industry are too important to permit unnecessary slippage in the work program of the ACATS, and the ATTC and CableLabs testing of systems. However, it is not certain that in-depth analysis of alternative media compatibility issues can be completed before the mid-1993 deadline set by the FCC for a decision on a new terrestrial broadcasting standard. The FCC and the ACATS are to be complemented for appointing a representative of the computer imaging industry to a formal position in ACATS and for including work on headers and descriptors in the ACATS work program. No changes

have been made, however, to the testing schedule for proponent systems. Representatives of the computer industry argue that the proponent ATV systems must be tested for compatibility with criteria necessary for computer imaging systems.

The ACATS should adhere to the 1993 deadline unless it becomes clear that such an adherence will compromise the goal of compatibility.

The computer industry should become involved actively in contributing its R&D resources and technical expertise to the ACATS work on media compatibility issues.

The testing activity to date is funded entirely by the broadcasters and system proponents, and the computer industry has yet to commit R&D and financial resources to help the broadcasting industry solve media compatibility issues.

The computer industry should provide money for the testing process to assure that its interests are fully considered.

4. The capabilities and resources of the Commerce Department's National Institute for Standards and Technology and the Defense Advanced Research Projects Agency (DARPA) are critically important to development of a domestic high definition information system.

In carrying out its program regarding critical technologies, NIST should continue its research into component technologies of a high definition information system such as flat panel displays, signal processors, and high-rate data transmission systems. Continued support by DARPA is also important. Digital displays similar to those used in a jet fighter are likely to find their way into a wide range of high resolution systems.

5. The deployment of a fiber optics infrastructure is critical to the establishment of a national high definition information system. Witnesses appearing before the Subcommittee have identified a number of regulatory and other impediments to the rapid deployment of fiber optics.

Continuing analysis by NTIA of the United States telecommunications infrastructure should give great weight to the role of a bi-directional broadband fiber optic network in delivery of HDTV/HRI products and services to the American consumer, and should include policies and strategies to address the impediments the Subcommittee testimony identified in deploying fiber optic cable to the home.

6. The State Department advocacy of positions helpful to U.S. industry is important to the U.S. continuing to be the world leader in the production and distribution of video programming, to the promotion of digital ATV standards, and to the development of a universal header/descriptor for HDTV/HRI.

The State Department should ensure that the needs of all segments of U.S. industry are put forth in the CCIR work on international harmonization issues.

7. It is clear that there is no shared articulated vision of a high resolution imaging future for the United States. Those involved in standards-setting issues in the FCC and the Executive Branch of the United States Government have yet to act upon advanced/high definition television as part of a larger information infrastructure which will need an enhanced broadband transport medium, a core

of common video and imaging services available to everyone, and common standards for easy convertibility and interoperability. There is presently no central focal point within the Executive Branch with the responsibility to bring the disparate actors from telecommunications, computing, and broadcasting together.

Developing a HDTV/HRI system for the United States requires the cooperation of entities presently working separately in standards-setting activities. An open, high definition information system will become a reality only if the separate standards-setting bodies work together. While the FCC process is a step in the right direction, the FCC process is limited to developing a broadcasting transmission standard. The government should provide a forum around which the various standards-setting groups can coalesce.

The National Institute for Standards and Technology (NIST) should establish a working group with a mandate to focus specifically on the harmonization of standards among the many standards-setting groups.

GLOSSARY OF TERMS

ACATS—Advisory Committee on Advanced Television Service, an Advisory Committee created by the Federal Communications Commission in 1987.

ATTC—Advanced Television Test Center, created by broadcasting companies and industry organizations in 1988 to test proponent advanced television transmission systems.

ATV—Advanced Television.

B-ISDN—Broadband Integrated Services Digital Networks.

CCIR—International Radio Consultative Committee, an organ of the International Telecommunication Union charged with studying technical and operating questions relating to radio services, including broadcasting, and issuing recommendations on the questions.

CCITT—International Telephone and Telegraph Consultative Committee, an organ of the International Telecommunication Union charged with studying and issuing recommendations on technical, operating and tariff questions relating to telecommunications services other than radio communications services.

COHRS—Committee on High Resolution Systems.

DARPA—Defense Advanced Research Projects Agency.

EC—European Community.

FCC—Federal Communications Commission.

HDTV—High Definition Television.

HRI—High Resolution Imaging.

HRIS—High Resolution Information Systems.

ITU—International Telecommunication Union, a specialized United Nations agency charged with ensuring the connectivity of a worldwide telecommunications network.

MAC—Multiple Analog Component, the family of standards proposed by the European Community for television transmission in EC member countries.

MUSE—Multiple Sub-Nyquist Sampling Encoding System, the Japanese HDTV system.

NIST—National Institute for Standards and Technology, an agency of the Department of Commerce.

NTIA—National Telecommunications and Information Administration, an agency of the Department of Commerce.

NTSC—National Television System Committee, the name both of the present US television standard and of a broadcasting industry group helping to develop a new television transmission standard.

OSTP—Office of Science and Technology Policy, part of the Executive Office of the President.

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