Chapter 2
The Historical Development of HDTV

INTRODUCTION

Japan is currently the world leader in HDTV development. Sony began selling HDTV studio production equipment in 1984 and HDTV receivers are now being sold commercially. Regular satellite broadcasts in Japan began in June 1989 and, by 1991, NHK (the state-owned Japan Broadcasting Corporation) plans to broadcast 6 to 7 hours of HDTV prograrnming daily.

Driven by the threat of Japanese domination of European consumer electronics markets, industry in 19 European countries initiated Eureka 95 in 1986-a collaborative crash HDTV development effort—that has made rapid progress in developing a European HDTV system. They have since demonstrated numerous pieces of production, transmission, and reception equipment and they plan to begin Extended Definition ED-MAC broadcasts in 1991.

U.S. electronics manufacturers have a significant set of handicaps as they move to meet the competition. U.S. broadcast standards are not scheduled to be established until 1992. U. S.-manufactured HDTV consumer equipment probably could not be commercially available until 1993 or 1994. U.S. manufacturers are running a distant third in a three-way race.

This chapter addresses the history of HDTV development. By far the most detail is provided on Japan's efforts because of their magnitude and complexity. The HDTV work in the United States and Europe will be briefly examined here.

JAPAN[1]

NHK researchers began investigating HDTV following the 1964 Tokyo Olympics. A formal research program was begun in 1970. In 1972, NHK proposed an HDTV research program to the CCIR (the ConsultativeCommitteeon International Radio).[2] Development of techniques for program production and to make broadcasting practical followed. In 1979, NHK began experimental transmission tests.[3]

Sony began marketing HDTV studio production equipment in 1984 and introduced a second generation of HDTV studio equipment in 1989.[4] NHK experimentally broadcast HDTV pictures of the Seoul Olympic Games in 1988 via optical fibers and satellite, and began daily l-hour experimentalHDTV broadcasts in June 1989 using satellite BS-2. Limited HDTV "HiVision' satellite broadcasts are scheduled to begin in 1990 using the BS-3A satellite; regular broadcasts will begin in 1991 with BS-3B.[5]

At the same time, Japanese TV manufacturers have developed Improved Definition TVs (IDTV) which use digital electronics to improve the picture attainable with current NTSC broadcasts. In August 1989, private Japanese Broadcasters began terres-

[1]The principal sources for this section are: James G. Parker and E. Jan Vardaman, "HDTV Developments in Japan,'' TechSearch International, Inc., Austin, TX, 1989; Mark Eaton, MCC, personal communications,Austin, TX, May 11,1989, Oct. 12,17, and 18, 1989; and Pamela Doughmanand Mark Eaton, "HDS Projects and Developments in Europe and Japan," unpublished manuscript, MCC, Austin, TX, August 1988; See also: Takao Shimizu, "High Definition Television: Comparison of Research and Development Strategies," M.Sc Thesis, Sloan School, Massachusetts Institute of Technology, May 1989; Chalmers Johnson, ''MITI, MPT, and the Telecom Wars: How Japan Makes Policy for High Technology," in *Politics and Productivity: The Real Story of Why Japan Works,* Chalmers Johnson, Laura D'Andrea Tyson, John Zysman (Cambridge, MA: Ballinger Publishing, 1989); Robert B. Cohen, "A Profile of Japan's HDTV Industry, Its Links to Other Sectors, and Policies Adopted to Promote HDTV Development" for the JTEC Panel Report, National Academy of Sciences, draft.

[2]The CCIR is an organization involved with international telecommunications standards setting. It is associated with the International Telecommunications Union and chartered under the United Nations. ThITU was founded in 1865 and has been a United Nations organization since 1947. Currently 160 members strong and headquartered in Geneva, Switzerland, it is the supreme internationalorganization dealing with issues of telecommunications and standards setting. For more information see: George A. Codding, *The International Telecommunications Union in a Changing World* (Dedham, *MA:* Artech House, 1982).

[3]Kenneth R. Donow, "HDTV: Plarming for Action,'' National Association of Broadcasters, Washington, DC, April 1988. Note that these early tests werewideband-Birney Dayton, NVision, personal communication Oct. 12, 1989; WilliamSchreiber, Massachusetts Institute of Technology, personal communication Oct. 12, 1989.

[4]''Super Television" *Business Week,* Jan. 30, 1989; "Development of MUSE Family Systems," NHK, Nov. 15, 1988, mimeo; David Sanger, "Japanese Test Illustrates BigLead in TV of Future," *New York Times,* Mar. 21, 1989; and, Larry Thorpe, Sony Corp., personal communication Oct. 12, 1989,

[5]Parker and Vardaman, op. cit., footnote 1; Eaton, op. cit., footnote 1.

trial broadcasts of an NTSC compatible Extended Definition TV (EDTV) System known as "ClearVision" in the Tokyo and Osaka area. Later phases of this project will provide a wider screen picture and add *digital* soundtracks.[6]

The Japanese may not have begun their quest for HDTV in the 1960s with anything more in mind than high-quality pictures and the prospects offered by large consumer electronics markets. Beginning in 1983 with the emergence of the "teletopia"7 concept, HDTV became something more than that-an integral part of their information society of the future. The Japanese envision not a service economy but an information economy with more and higher value-added manufacturing than today. By the year 2000, the Japanese expect fully one-third of their industrial investment to be in manufacturing related to information technologies and products.[8]

In developing such an economy, several principles are shaping their policies, including: "technology fusion, "9 or the potential of a technology to impact a broad range of other technologies and industries; sharing risk between companies and the government; the promotion of consortia designed to stimulate competitiveness; and the importance of developing mutually supporting markets.

Within this framework, the Japanese Government is providing an intricate web of direct and indirect supports for the development of HDTV. In addition, the government has worked with industry to establish standards and has aggressively promoted these standards and Japanese commercial interests worldwide.

Research and Development

The Japanese Government performed the initial high-risk R&D for an HDTV system under the umbrella of the state-owned NHK. Once the major system parameters were developed, NHK ' 'encouraged" equipment suppliers to participate in the development of the system components. Companies were assigned specific research areas and sometimes even specific production tasks, the results of which were shared with NHK and the other participating companies for at most a nominal licensing fee.

NHK divided the development of specialized integrated circuits (ASICs) for the MUSE HDTV receiver, for example, among six different companies to avoid the duplication of effort and cost if each firm had to design a complete set of ASICs itself. Thus, Toshiba developed motion compensation chips; NEC developed color signal processing chips; Matsushita developed audio processing chips; and so on.[10] Similarly, MUSE to NTSC converter chip set development was divided between Sanyo, Mitsubishi, and Matsushita. These designs were then shared by all participants.

Numerous firms are involved in other joint (or perhaps more accurately described as partitioned) R&D efforts on HDTV-related technologies that are coordinated by NHK, MITI, MPT, or the Key Technology Center.[11] These include the development of: camera sensors (CCDs) and related camera equipment; CRT, projection, and LCD displays; analog and digital HD-VCRs; optical recording technologies; bandwidth compression equipment; and graphics software. Examples of the HDTV-related R&D and product development of various Japanese companies are shown in table 2-1.

Some types of production are being partitioned as well. For example, to minimize duplication and ensure economies of scale, NHK assigned the highly capital-intensive development and production of a 35-inch color picture tube for HDTV to Mitsubishi. In turn Mitsubishi agreed to provide competitors picture tubes off the same production line on an equally shared basis. They continued to share production even when the capacity proved to be insufficient for the unexpectedly large market.[12]

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[6]Bob Whiskin, BIS Mackintosh, personal communication, Mar. 29, 1989.

[7]Note that "teletopias" are one set of approaches to local and regional information system development efforts. There are many other approaches. More broadly, one should speak of these many efforts under the rubric of "information society.'

[8]Parker and Vardaman, op. cit., footnote 1.

[9]Eaton, op. cit., footnote 1.

[10]TechSearch International, Inc., MUSE Decoder Block Diagram from Nikkei Electronics, Aug. 7, 1989, pp.126-127; and "Report Of the JTEC Evaluation Team on HDTV Developments in Japan," National Science Foundation, July 26, 1989.

[11]Parker and Vardaman, op. cit., footnote 1.

[12]Howard Miller, PBS, personal communication, May 8, 1989; Oct. 12, 1989.

Table 2-l—Selected HDTV Technology Development Efforts by Japanese Companies

Firm	Cameras		Recording		Transmitter/receiver		Displays				Total corporate sales (est. 1989) ($ billions)
								Projection			
	Tube	CCD	Optical	Digital	Analog	Encoder/decoder		CRT	SS	FPD	
Canon	-	-		R		C	C				$8.9
Fujitsu	-	R		R	R	R	R	C	R	-	R	17.8
Hitachi	R	-	R	R	R		C	R	C	-	R	46.0
Ikegami	C	R				C		C	C	-	-	0.4
Matsushita	R	R	R		R		R	C	C	-	R	40.0
Mitsubishi	-	-			C		R	C	C	-	R	19.2
NEC	-	R	-		R	R	C	C	C	R	R	22.4
Pioneer	-	-	R				R	C	R	-	-	1.5
Sanyo	R	R	C	R	R	R	C	C	C	R	R	10.7
Sharp	R	R	R		R		R	C	C	R	R	10.0
Sony	C	R	C		R		R	C	C	-	R	15.5
Toshiba	-	R	R		R	C	C	C	C	-	R	29.2
JVC	R	R	C		R		R	C	R	-	-	5.9

NOTES: R—research; C—commercializing. Camera tubes are similar to those used today; CCDs (charge-coupled devices) are a type of solid-state sensing element. Optical recording systems are typically optical disks; digital recording systems are usually for studio use; and analog recording systems are primarily for home use, although some using l-inch tape are for use in the studio. CRT (cathode ray tube) displays area large high-quality version of the picture tubes used at home today. SS (solid-state) projection displays are typically either LCDs (liquid crystal displays-like those used on many laptop computers) or deformable membranes from which light is reflected. FPD (flat panel displays) are usually LCDs but plasma display panels and other types of thin displays (ch. 5) are also under development by some firms. Whether or not the technology is under research or being commercialized is a subjective judgment because the status of these technologies is changing rapidly and because these same firms are often marketing similar technologies in less demanding applications today.

SOURCE: James G. Parker and E. Jan Vardaman, "HDTV Developments in Japan," TechSearch International, Inc., Austin, TX, 1989, citing Nikkei Electronics, Oct. 3,1988, p.1 14; and Mark Eaton, personal communications, MCC, Austin, TX. Please note that many other developments, such as equipment for studio production or satellite transmission, or subcomponents of some of the above listed systems, are not included here. Development efforts by Fujitsu General are shown as part of Fujitsu Ltd. even though it is only 33 percent owned by Fujitsu Ltd.

Through this mechanism, the competitive efforts of the participating firms are being redirected from early, high-risk basic system design to secondary features such as overall product quality, ease of operation, and manufacturing cost.[13]

The development of large area LCD displays presents a particularly interesting example of the numerous linkages-' 'technology fusion' '-that is in part guiding Japanese policy. The most ambitious LCD effort, known as the Giant Electronics Project, is planned by MITI to be a 7-year approximately $100 million project to develop a 40-inch diagonal flat panel display by 1996.

MITI foresees a variety of technological linkages and potential spinoffs to result from this effort. Participants will have to: produce an alkali-free glass substrate with less than 0.001-inch (20-microns) variation in thickness over the entire 40-inch diagonal area; deposit a high-precision thin-film on this substrate; develop the manufacturing skills to etch circuitry into this film to a precision of roughly 0.0001-inch (3 microns) over this entire area; develop precision techniques for automatically attaching leads and assembling the display; and invent new technologies to test it. It is relatively easy to achieve such precision in the confines of today's tiny integrated circuits, but doing so across large areas poses formidable technological challenges.[14]

MITI expects these capabilities to be applied in such diverse products as: ultra-high-density optical recording systems; ultra-thin photocopying systems; solar cells; optical engraving; large flat-light sources; high-precision electronic components; and ''chip-on-glass' electronic packaging and assembly. The ''chip-on-glass' packaging and assembly technologies in particular offer the potential for significant

[13]U.S. Congress, House Committe on Energy and Commerce, Subcommittee on Telecommunications *and Finance, Report of the Public Broadcasting* Service and *Comments of the Association of Maximum Service Telecasters, Inc. on High-definition Television,* Hearings March 1989, Print No. 101-E; This approach has been used quite generally in Japan, and in several of the exceptions where basic system design was done independently a different companies; there have been serious conflicts and losses as a result. One of the best known such cases was the Sony development of Betamax and the Matsushita development of VHS Video Cassette Recorders. Although many believe that the Betamax was technically superior, the marketing muscle of Matsushita successfully made VHS the industry standard.

[14]Ministry of International Trade and Industry, "Development of Basic Technology for Large Surface Circuit Elements, ' Tokyo, September 1988; English translation provided by Parker and Vardaman, op. cit., footnote 1; Gary Stix, ' 'Manufacturing Hurdles Challenge Large-LCD Developers,' *IEEE Spectrum,* September 1989.

improvements in the production and the performance of advanced electronic systems (ch. 5).[15]

Since the mid-1960s, the total investment of NHK in HDTV R&D and related activities has been about $150 million. The projects funded through MITI, MPT, and the Key Technology Center, as well as investments by private firms greatly increases the total R&D expenditure. Including the costs of setting up production lines, private sector investment is estimated to range from $700 million to as much as $1.3 billion. Japanese Government financial policies have provided an enormous pool of low-cost capital that greatly aids such investments by individual fins.

The Japanese Government is supporting much more than just HDTV. They are, for example, funding both R&D and construction of networking, database, and other information infrastructure at levels 10 to 100 times greater than their support of HDTV.lG Some argue that this indicates the greater importance of these activities; others argue that the technology and manufacturing infrastructure for producing the terminals (HDTV and related technologies) for these information networks is now in-hand and that the Japanese Government has simply moved on to the next step in developing their information society.

Financial Supports

A variety of direct and indirect government financial mechanisms are supporting the development of HDTV in Japan. NHK performed much of the initial research on HDTV. Funding for NHK is from a mandatory household color TV subscription fee of Y107O ($8)[17] per month from television households. In August 1989, this fee was increased to Y2000 ($14) for homes with satellite broadcast reception.

The Key Technology Center (KTC) was founded by MITI and MPT in 1985. It is funded in part by dividends from government-owned shares of NTT and Japan Tobacco, Inc., and direct contributions from government financial institutions and the private sector.[18] By mid-1989, the KTC had supported some 141 company projects and 75 consortia, of which several are HDTV-related.19 Loans of up to 70 percent of the total outlay are available with no payments due on the principal or interest for up to 5 years. The principal is then repaid within 10 years of completion of the project. There is a ceiling on the interest of about 5 percent which is paid if the project is successful, but is waived entirely if the R&D project fails. An advisory board to the KTC passes judgment on the degree of success of a project and the amount of interest to be repaid.[20]

A web of financial supports is also being provided for HiVision development and promotion efforts. In the MITI HiVision Communities program, special loans are available from the Japan Development Bank and the Hokkaido Tohoku Development Fund for HiVision equipment, software, or promotion. The loans will cover up to 40 percent of the costs at 5 percent interest with up to 3-year grace periods and 15-year repayment times. No-interest loans for facility construction are available with similar grace periods and repayment times.[21]

Small and medium-sized businesses are included in the MITI plan. Performing R&D, initiating a business, or promoting a market related to HiVision, or purchasing HiVision-related products can make one eligible to receive a 15-year loan of up to Y1OO million ($700,000) at 3.5 percent interest the frost 3 years and 5.4 percent after. Even more favorable loan rates are available to small businesses in smaller towns and rural areas.[22]

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[15] MITI, "Development of Basic Technology for Large Surface circuit Elements," Op. cit., footnote 14.

[16] Cohen, op.cit., footnote 1; Denshi Kogyo Geppo, Mar. 1989, pp. 2-11; Kenneth Flamm, Brookings Institution, personal communications; Oct. 13 and Oct. 25, 1989.

[17] Based on Y140=$1.00 and rounded off.

[18] Parker and Vardaman, op. cit., footnote 1.

[19] Mark Eaton, MCC, personal communication, Oct. 17, 1989. Note tit&e KTC functions much like an investment bank. It creates new companies in the form of consortia and provides up to 70 percent of the capital. If the effort of tlconsortia looks like it will besuccessful, the companies involved will then fund an increasing portion of the work until, after 5-7 years, it is a stand-alone company. Other activities of the KTC include: lending to projects within companies, mediating (especially technology transfer) between thnational laboratories and private companies; supporting contract research; creating and promoting databases; and handling trust funds to sponsor foreign researchers in Japanese labs.

[20] Parker and Vardaman, op. cit., footnote 1.

[21] MITI, "HiVision Application Guide, HiVision Community Concept," July 31, 1989, p. 31; Translation provided by Eaton, op. cit., footnote 1.

[22] MITI, op. cit., footnote 21.

Potentially significant tax benefits are provided in the MITI plan as well. For example, expenditures on HiVision promotion in MITI HiVision Communities can be taken as a loss for tax purposes.[23] Tax advantages can occur in a wide range of other settings. For example, small and medium-sized businesses that buy or lease satellite communication facilities can receive accelerated depreciation or other tax considerations.[24]

The government has also directly reduced risk to firms by acting as a holding company-purchasing expensive equipment and then leasing it back to firms. The MPT is now planning to establish a $740 million holding company for the BS-4 satellite due to be launched in 1997. Companies will then be able to lease HDTV channels on that satellite according to market conditions.

Using satellites for HDTV is an example of the Japanese effort to develop mutually supporting markets. Although the satellite systems for HDTV could have been purchased from the United States, the Japanese Government has instead pursued a program of developing a domestic space industry. This effort began with the February 1983 launch of Japan's frost commercial communications satellite, which cost three times more than similar or better systems that could have been purchased from the United States.[25] Japanese efforts to create a domestic HDTV industry are thus channeled into supporting the domestic space industry as well.

Finally, HDTVs will not be purchased if HDTV-compatible programrning is not available. Thus, both MPT and MITI have established leasing companies. Nippon HiVision was formed in April 1989 by the MPT, NHK, and 40 private companies to purchase and then lease HDTV equipment to broadcasters. MITI is establishing a leasing company with about 30 private companies to lease HDTV equipment and software to movie producers, electronic publishers, and non-profit groups such as schools and museums. These leasing companies reduce risks for both manufacturers and users of HDTV equipment—by guaranteeing sales for producers, providing equipment to users at low cost, and ensuring that movies and TV programs of HDTV quality are produced for viewers to watch. Sony's recent purchase of Columbia Pictures for $5.6 billion is seen by some as a move to ensure that there will be programrning available for Sony manufactured HDTVS.26

Market Promotion

R&D and financial supports can assist in getting the products to market, but will not sell them. To stimulate market demand, the MPT and MITI have established a number of promotional committees and councils. These groups are staging public events with HDTV and have begun extensive procurement efforts.

The MPT HiVision Promotion Council, for example, broadcast the Seoul Olympics to 205 HiVision sets at 81 public sites across Japan. Other promotional efforts organized by NHK, MITI, and MPT include: The World Fashion Fair held in Osaka, Kobe, and Kyoto during HiVision week (Nov. 18-26, 1989); the HiVision Gallery for the Gifu Museum of Art-in which nearly half of their works have been put into an electronic file system for viewing on a large screen; the Exposition of Flowers and Greenery in Osaka (April to September 1990); and many others.[27] MITI's HiVision Promotion Center also helps set standards for industrial HDTV equipment and surveys new uses for industrial use of HDTV,28

Private firms and consortia are also investing heavily. Recently, Japan Victor Company (JVC) contracted with a Hollywood producer for $100 million to produce films.[29] It had earlier considered purchasing a Hollywood studio but backed off for

[23]Ibid.

[24]Parker and Vardaman, op. cit., footnote 1.

[25]Johnson, Op. Cit., footnote 1.

"'WhySony is Plugging Into Columbia,' *Business Week,* Oct. 16,1989, p. 56. There have been other notable deals for U.S. entertainment companies recently, including Australian Qintex Entertainent, Inc. purchase of MGM/UA Communications, Inc. for $1.5 billion. Such deals are not related to the development of HDTV nor the penetration of the potential U.S. HDT market, however. "Invasion of the Studio Snatchers," *Business Week,* Oct. 16, 1989, p. 52.

[27]Parker and Vardaman, op. cit., footnote 1.

[28]James G. Parker, TechSearch International, Inc. personal communication, Oct. 6, 1989.

[29]Richard W. Stevenson, "Japanese Put Up $100 Million To Back Films in Hollywood," *New York Times,* Aug. 21, 1989.

fear of a consumer backlash to the large number of recent foreign purchases of Hollywood companies.[30]

The parallel MPT HiVision Cities and MITI HiVision Communities programs are among the more ambitious of these market development efforts.[31] These projects are intended to demonstrate HiVision hardware and software, stimulate the purchase and use of HiVision equipment, and provide a test market for HiVision applications.[32] The MPT HiVision Cities program, for example, selected 14 cities from 71 proposals in March 1989 to receive support in purchasing and using HiVision equipment. These cities are pilot projects to study uses for HDTV, including developing video and graphics databases for museums, schools, and other public uses, and to use leading-edge information technologies and services to stimulate the local economy .33

By American standards the Japanese seem to be marching in lock step, but there are inevitable tensions. The development of HDTV has created conflicts between NHK and private broadcasters. Similarly, the numerous parallel programs described above indicate the intensity of the competition between MITI and MPT to take the lead in HDTV—which both see as the gateway to Japan's information society of the future.[34] For MITI, this maybe a particularly important turf battle as their traditional role of ''protecting and nurturing Japanese industries until they could compete in any market in the world' '[35] is ending and they must find new roles to play.[36]

It is too early to tell whether this competition between MITI-MPT will slow or speed Japanese efforts in HDTV and telecommunications. For example, MITI proposed its "New Media Community' ' and MPT countered with its ''teletopia' program in the summer of 1983. The combined costs, however, proved too much for the Diet (the Japanese parliament), and both proposals were dropped in 1984. Not until 1986 was a compromise found that allowed them to move forward.[37] In other cases, competition might heighten efforts.

Given their lead in developing HDTV technology and their desire to penetrate foreign markets, the Japanese have worked intensively to ensure that their standard was adopted worldwide. This effort stalled at the May 1986 meeting of the CCIR in Dubrovnik, Yugoslavia, when European countries refused to accept the Japanese standard. Their refusal was based on: the lack of compatibility[38] of this standard with existing European systems and the cost of converting between these formats; the competitive threat they foresaw to European domestic television manufacturers posed by the Japanese; and the haste with which the single standard was being pushed on them.[39]

EUROPE

Europeans formed a joint venture HDTV development effort in June 1986 known as ''Eureka Project 95." The project is charged with development of European production, transmission, display, recording standards, and equipment. Proposals are expected to be ready forpresentationto the 1990 and/or 1994 Plenary Assembly of the CCIR for acceptance

"'Invasion of the Studio Smtchers," *Business Week,* Oct. 14, 1989, p. 54.

[31]Note that there are no reliable estimates of how much the MITI Communities and MPT Cities plans are going to cost; it all depends on how many projects apply and how much is requested by each. TheMPT program reportedly has roughly $100 million pending in requests; there are no figures available for MITI. So-called "third sector" enterprises are being created to actually run the trial cities and communities programs once they have been formed. Mark Eaton, MCC, personal communication, Oct. 18, 1989.

[32]U.S. Congress, House Committee on Energy and Commerce, House Subcommittee on Telecommunications and Finance, *Consortia and the Development of High Definition Systems,* testimony presented by Barry H. Whalen, Sept. 5, 1989.

[33]Parker and Vardaman, op. cit., footnote 1.

[34]Johnson, op. cit., footnote 1.

[35]Johnson, Op. cit., footnote 1, p. 183.

[36]David E. Sanger, "Mighty MITI Loses Its Grip," *New York Times,* July 9, 1989, p. El.

[37]Johnson, 0p. Cit., footnote 1.

[38]This l.k .f compatibility is believed by some to have been a strategic choice by Japanese manufacturers to force the junking of existing equipment, to increase their companies sales, and to squeeze competitors-who generally cannot afford to risk the long payback times that an incompatible system would require due to its slow acceptance. At the same time, the lack of compatibility with presenTV sets was the fundamental flaw of the Japanese system which allowed it to be successfully attacked. Adam WatsoBrown, "Towards the Triumph of the Matte Black Box," vol. 16, No*l, Intermedia,* January 1988.

[39]Joseph Roizen, "Dubrovnik Impasse Puts High-Definition TVOn Hold," *IEEE Spectrum,* September 1986.

as a co-world standard. NV Philips Co. (Netherlands) is President of Eureka Project 95 and Thomson SA (France) is Vice President. Robert Bosch GmbH (Federal Republic of Germany), Them/EMI (United Kingdom), and more than 20 other organizations from 9 countries are participating in the effort as well. Approximately 1,700 engineers, technicians, and support personnel have been involved full time in the project.[40]

The first phase of the Eureka Project 95 ended in December 1989 and cost an estimated $318 million.[41] Sixty percent of these funds were private.

Europeans plan to begin public broadcasts of digital sound and provide a slightly improved picture to viewers through their MAC (Multiplexed Analog Components) system in 1990. Broadcasts using the Extended Definition wide-screen EDMAC system are scheduled for late 1991, and full HDTV-MAC broadcasts are planned for 1994.[42] By 1995, European broadcasters plan to offer full HDTV satellite and cable services.[43] Like the Japanese, the major focus of European HDTV efforts has been Direct Broadcast Satellite systems.[44]

HDTV promotional efforts currently scheduled include broadcasts of the 1990 World Cup Soccer Championships from Italy; and broadcasts of the 1992 Summer Olympics from Barcelona, Spain. One thousand public receivers will be scattered throughout Europe to receive these broadcasts.[45] As in Japan, there have also been efforts in Europe to extend the performance of existing TV systems rather than proceeding to new and completely incompatible systems. There is some concern that such a move could slow the market acceptance of their MAC system.[46]

Market Protection

The Europeans formed the Eureka Project 95 in part to support their domestic consumer electronics industries. In addition to stimulating R&D to ensure competitiveness, the Europeans have aggressively enforced antidumping statutes and have imposed domestic content requirements in those sectors where dumping has occurred. In electronics, for example, there are now domestic content requirements for both systems and components. Regulations require the skill-intensive integrated circuit fabrication steps, for example, to be done in Europe. Minimum prices have been set on DRAMs, as in the United States.[47] Regulations have also been implemented that prevent products from simply being transshipped through other countries (including the United States) with minimal additional manufacturing.[48]

Similarly, Europe is concerned with protecting its domestic movie and TV-program producers as well as its cultural identity. As Direct Broadcast Satellites (with conventional TV broadcasts) begin operations over new charnels in Europe they are filling air time with U.S. TV programs and movies.[49] Faced by a deluge of U.S. programs, the European Community

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[40]Eureka Secretariat, project documents.

[41]Peter De Selding, "Europeans Feeling Cocky When It Comes to HDTV," *New Technology Week,* Sept. 11, 1989; Eureka Secretariat, project information. The budget for 1988-90 is 270 million ECU.

[42]Note that the European system is compatible with existing standards only by using electronic converters in their satellite receiving equipment to change the MAC transmissions to PAL or SECAM. William Schreiber, Massachusetts Institute of Technology, personal communication Oct. 12, 1989.

[43]Wesley R. Iverson, "U.S. Gropes for Unity on HDTV," *Electronics,* March 1989; Bob Whiskin, BIS Mackintosh, personal communication, Mar. 28, 1989; Hugh Carter Donahue, "Choosing the TV of the Future, "*Technology Review,* April 1989.

[44]Paul Gregg, "Satellite TV Flies European Flag,'' *Electronics Weekly,* Sept. 27, 1989.

[45]Roger Woolnough, ''World-Class HDTV," *Electronic Engineering Times,* Sept. 11, 1989, p. 18.

"'German EDTV Tests," *TV Digest,* vol. 29, No. 32, Aug. 7, 1989, p. 15.

[47]Andrew Pollack, "Europe Sets Prices for Japan's chips, " New *York Times,* Jan. 24,1990. Note that EC regulations have recently been successfully challenged under GATT See, William Dullforce, "Japan Scores Victory Over EC on Duties," *Financial Times,* London, Mar. 29, 1990; and Peter Montagnon and Lucy Kellaway, "EC Refuses To Adopt GATT Report on Dumping, " *Financial Times,* London, Apr. 4, 1990.

[48]The new EEC rules require that the most substantial process in producing a semiconductor be done in Europe. *European Market Digest,* vol. II, No. 6, June 1989, p. 9.

[49]Jacques Neher, "A Revolution Brews In European Television@"*Washington Post,* Mar. 5, 1989.

recently set guidelines to devote the majority of air time "where practical" to European programs.[50]

Eureka

The Eureka Project 95 to develop HDTV is part of the much larger Eureka program begun in July 1985 by 19 European nations to support collaborative multinational efforts in high-technology R&D, manufacturing, and services. Eureka was founded on the recognition that many of the European national markets are too small for a "national champion" firm to achieve a level of sales capable of recovering development and manufacturing costs for many high-technology items. For example, the R&D costs for a new generation of public phone switching equipment have been estimated at $700 million to $1 billion and it would require sales of $14 billion to recoup these costs.[51] As a consequence, numerous European collaborative R&D efforts have been launched in recent years, including the $1.5 billion RACE project in telecommunications, the $5 billion JESSI project in semiconductors, and several others.[52]

Procedures for establishing a project under Eureka are both fast and flexible. Industry groups define and propose their project to their respective national governments. If they do not already have partners to work with, the Eureka Secretariat tries to identify such groups. With the agreement of the respective national governments, the proposal begins a 45-day period of circulation and discussion. At the end of this period a gentleman's agreement or, sometimes, an early formal agreement is reached on whether or not to move the project forward.

European nations are also moving rapidly to upgrade their communications systems through the implementation of ISDN (Integrated Services Digital Network). ISDN allows voice, video, and data to be carried over telephone networks in a digital format (ch. 3) and is the next important step in telecommunications systems. European efforts in HDTV and telecommunications promise to make them important competitors in these markets.

UNITED STATES

After black and white TV was introduced in the 1940s and color TV in the 1950s, American researchers looked for ways to further improve resolution, color, and picture quality during the late 1950s and 1960s. They achieved resolutions in experimental systems roughly comparable to those now being demonstrated by the Japanese.[53] These advanced capabilities, however, were not pursued: the costs of these systems would have been far too high for consumer use; the newness of the medium had not yet whetted consumers' appetites for dramatic improvements in picture resolution; and practical transmission technologies (e.g., bandwidth compression) were not available. By the late 1970s when electronics technologies had matured sufficiently to make consumer HDTV systems a reasonable goal, U.S. firms were rapidly ceding TV manufacturing to foreign firms (see table 1-2). These factors limited further development of HDTV in the United States until recently.

RCA's Sarnoff labs began research in HDTV in the late 1970s. By mid-1987, some $40 million had been spent overall on its advanced television work, with an estimated $35 million required to finish development of the system they are proposing to the FCC.[54] CBS has also worked on HDTV. In 1981, CBS requested permission from the FCC for use of the 12 GHz spectrum and began terrestrial broadcast experiments in 1982.[55] Some foreign firms have been active in HDTV research in the United States as well, including Philips (Netherlands) and, with its recent purchase of RCA, Thomson (France).

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[50] Steve Lohr, "European TVs Vast Growth: Cultural Effect Stirs Concern," New York *Times*, Mar. 16, 1989, p. Al; U.S. Congress, House Committee on Energy and Commerce, Subcommittee on 'Telecommunications and Finance, *Television Broadcasting and the European Community*, Hearings July 26, 1989, Serial No. 101-84; Edward Cody, "EC Adopts European TV Program Quota," *Washington Post*, Oct. 4, 1989, p. F1; Paul Farhi, "U.S. to Fight EC Directive Limiting Foreign TV Shows,' *Washington Post*, Oct. 11, 1989, p. F1.

[51] Godefroy Dang Nguyen, "European R&D Policy for Telecommunications" Kurzfassung einer Studie im Auftrag des WIK, Bad Honnef, April 1989, Nr. 49.

[52] Steven Greenhouse, "Europeans United To Compete With Japan and U.S.," *New* York *Times*, Aug. 21, 1989.

[53] William Glenn, Florida Atlantic University, Boca Raton, Feb. 10, 1989; Schreiber, op. cit., footnote 42.

[54] U.S. Congress, House Committee on Energy and Commerce, Subcommittee on Telecommunications and Finance, *Testimony of Steven Bonica*, Serial No. 100-188, Oct. 8, 1987.

[55] Corey P. Carbonara, "History of High Definition," paper presented at the "HDTV: The Second Annual conference and Exhibition on High Definition Television," Arlington, VA, Feb. 12, 1990.

Other HDTV efforts that began in the late 1970s and early 1980s include those by: Zenith; William Glenn, New York Institute of Technology[56]; William Schreiber, Massachusetts Institute of Technology; Yves Faroudja of Faroudja Laboratories; Richard Iredale, Del Rey Group; and others. The small size of most of these efforts, however, has limited the extent and rate of progress in HDTV and related technologies in the United States. Total private expenditures on HDTV R&D in the United States were roughly $70 million[57] as of early 1988.

There has been little public-private cooperation in the U.S. HDTV effort compared to Japan and Europe. Significant amounts of money have been spent, however, on related technologies such as digital signal processing for military radar and sonar applications.[58]

Production Standards

HDTV requires new standards for producing video material. These standards might include such factors as the number of lines (resolution), the frame rate (50 in Europe v. 59.94 in the United States), and the type of scarming (interlaced or progressive). If these production standards differ from one region to another, expensive transcoding might be required for programs produced in the United States to be shown in Europe and vice versa. This could dampen international trade in movies and TV programs.

Many U.S. movie and TV-program producers have promoted a single international production standard to avoid this possibility. A single worldwide production standard would aid the exchange of video material between countries and help U.S. program producers maintain their current $2.5 billion annual export market.[59] Everyone is interested in improving international communication and understanding: uniform world standards might help achieve this ideal.

The Society of Motion Picture and TV Engineers (SMITE) formed a Working Group on High Definition Electronic Production in 1977 and began work in 1981 on a production standard. One concern of this group was to document and standardize HDTV-production equipment development. A second concern of the SMPTE was that differing European, American, and Asian production standards would limit the U.S. producers global marketing of their programs.

The work done by the SMPTE resulted in a set of parameters which differed slightly from the NHK 1125/60 system, then the only system available in the world and one of the focuses of the SMPTE work. These parameters were adopted by the Japanese.[60] The U.S. Advanced Television Systems Committee[61] (ATSC) recommended the resulting 1125/60 standard to the U.S. State Department and it was supported by the official U.S. delegation at the Dubrovnik meeting of the CCIR in May 1986. A chronology of all these various activities within the United States is listed in table 2-2 and many of the groups actively involved with Advanced TV development in the United States are listed in table 2-3.

A number of domestic groups, however, opposed the 1125/60 standard developed by the SMPTE and others. NBC and ABC, for example, have opposed approval of the 1125/60 format because they expect that conversion from 1125/60 to whatever standard is chosen for the United States, such as 1050/59.94, will be costly and will introduce unacceptable flaws in the picture-thus hurting their domestic broadcasting market.[62] Instead, they believe that a transmission standard should be chosen first that meets U.S. needs. Following that, a family of international production standards can be established to best fit the national needs of each country. American broadcasters are also concerned with the potential costs of converting their equipment to HDTV and

fire. Glenn is currently with Florida Atlantic University, Boca Raton.

[57] Larry F. Darby, "Economic Potential of Advanced Television Products," National Telecommunications and Information Administration, Apr. 7, 1988.

[58] For research directly related to HDTV, relatively little has been spent, with NASA a particularly important supporter of HDTV-like R&D.

[59] This is the net U.S. trade for 1988 in motion pictures and TV programs. Motion Picture Association of America/Motion Picture Export Association of America, "Fact Sheet: Film and Video Piracy."

[60] The SMPTE began their work assuming no parameters and spent several years looking at a variety of factors such achromaticity before setting line and frame rates. Birney Dayton, NVision, personal communication, Oct. 12, 1989.

[61] An ad hoc group formed in 1984 by various groups (see Box 3.3) to develop voluntary standards for HDTV.

[62] C$HDTV Production: The Future Is Almost Now," *Broadcasting*, Oct. 17, 1988, p. 39.

Table 2-2-Chronology of N development

1928	Radio Manufacturers Association begins planning for B&W TV
1936	RCA demonstrates prototype B&W TV
1939	First public TV broadcast done at New York World's Fair
1941	NTSC standards are set for B&W TV
1953	NTSC standards are set for color TV that is compatible with B&W sets
1960s	U.S. firms develop prototype high-resolution TV systems
1964	All-Channel Receiver Law enacted
1964	Japanese state-owned broadcasting system NHK begins HDTV development
1972	NHK submits draft HDTV study program to CCIR
1977	Society of Motion Picture and TV Engineers (SMPTE) begins study of HDTV
1979	NHK conducts first satellite transmission tests of HDTV
1981	First demonstration of HDTV in US; SMPTE recommends action on HDTV in US
1982	CBS conducts transmission tests in satellite broadcasting frequencies
1982	CBS announces two-channel HDTV system
1983	The Center for Advanced Television Studies (CATS) is formed
1984	The Advanced Television Systems Committee (ATSC) is formed
1984	Japanese NHK establishes the MUSE transmission standard for DBS
1984	FCC allows the introduction of stereo sound broadcasts
1985	ATSC recommends the NHK production standard to Department of State
1986	National Association of Broadcasters forms task Force on HDTV
1986	U.S. Department of State and Japanese propose NHK production standard to CCIR
1986	Europeans begin Eureka project to develop their own HDTV system
1987	National Cable Television Association forms Committee on HDTV
1987	FCC creates Advisory Committee on Advanced Television Services (ACATS)
1988	Electronic industries Association forms an Advanced TV Committee
1988	American Electronics Association forms a task force on HDTV
1988	Advanced Television Test Center established
1988	Bell South/Bellcore transmits HDTV by fiber at Democratic National Convention
1988	FCC tentatively decides HDTV must be compatible/ simulcast with NTSC; no additional spectrum will be made available outside existing bands
1989	DARPA announces $30 million of funding for HDTV R&D

SOURCE: Adapted from: "A Chronology of High-Definition Television Development," *Variety*, Oct. 12, 1988, pp. 74-75: Tony Uyttendaele, ABC, personal communication, Sept. 7, 19&; and Electronic Industries Association, "Chronology-of TV and" AT/ Development," Nov. 30, 1988, Washington, DC.

are considering intermediate EDTV quality systems as a substitute.

Official U.S. support for the Japanese/ATSC 1125/60 standard was reversed in May 1989 due to the unsuitability of its use within the United States; the recognition that 1125/60 would not be adopted as a world standard due to European opposition; and political opposition to handing the Japanese a competitive advantage in manufacturing HDTVS.63

Program production standards that can easily be transcoded from one system to the other (which the original Japanese NHK system cannot) are, however, still possible and desirable.[64] Work on such a "Common Image Format" was proposed by the U.S. delegation and endorsed for further study at the May 1989 CCIR Extraordinary Meeting for HDTV.

Transmission Standards

The FCC formed the Advisory Committee on Advanced Television Service in 1987. The Advisory committee formed three Subcommittees—Planning, Systems, and Implementation-to review proposed terrestrial broadcasting standards for the United States.

In September 1988, the FCC issued a tentative decision that whatever new transmission standard was chosen, HDTV broadcasts should also be available to those with today's NTSC sets. Further, additional spectrum outside of today's UHF and VHF bands for TV broadcasting would not be made available for HDTV, although individual stations might get as much as 6 MHz additional spectrum within these bands.

New *Initiatives*

U.S. Government efforts in support of HDTV R&D have increased during 1989. In December 1988, Defense Advanced Research Projects Agency announced a $30 million, 3-year R&D program for high-resolution displays and supporting electronics.

[63] John Burgess, "U.S. Withdraws Support for Studio HDTV Standard," *Washington Post*, May 6, 1989; Lucy Reilly, "State Department Changes Stance On HDTV Standards," New *Technology Week*, May 1, 1989.

[64] W. F. Schreiber, "A Friendly Family of Transmission Standards For All Media and All Frame Rates," Draft, Feb. 12, 1989, Massachusetts Institute of Technology, Cambridge, MA.

Table 2-3-Private U.S. Groups Involved With HDTVa

Group	Purpose	Members
Ad Hoc Group on ATV	To recommend policy to aid U.S. HDTV efforts	Various; organized by researchers at MIT
Advanced TV Research Program (ATRP)	R&D for advanced TV systems and Associated Regulatory Policies	ABC; NBC; HBO; PBS; Ampex Tektronix; RCA; Zenith; Kodak; Generai Instruments; etc.
Advanced TV Systems Committee (ATSC)	Develop voluntary standards for HDTV	Electronic Industries Association; IEEE; National Association of Broadcasters; National Cable TV Association; Society of Motion Picture and TV Engineers; etc.
Advanced TV Test Center (ATTC)	Testing of ATV systems	National Association of Broadcasters; Association of Maximum Service Telecasters; Association of Independent TV Stations; Capital Cities/ ABC; CBS; NBC; PBS; etc.
American Electronics Association (AEA)	To assist U.S. firms in electronics manufacturing	U.S. hi-tech electronics firms including: AT&T; iBM; Hewiett-Packard; Motorola; Intel; ITT DEC; National Semiconductor; Tektronix; Ti; Zenith; etc.
American National Standards Institute (ANSI)	A national standard setting organization that sets voluntary standards for the U.S. and helps develop U.S. position internationaily	Various
Association of Maximum Service Telecasters (MST)	To find means for 100al stations to provide HD service	270 local stations: independent ornetworkaffiiiate
Broadcast Technology Center	R&D for broadcasters into HDTV	National Association of Broadcasters; CBS; etc.
Cable TV Labs. Inc.	R&D in HDTV for the cable TV industry	63 cable TV companies with over 75% of U.S. cable subscribers
Center for Advanced TV Studies (CATS)	Funding for independent TV R&D	ABC; Ampex; CBS; Kodak; Zenith; NBC; PBS; RCA; HBO; 3M Co.; Harris Corp.
Electronic Industries Association (EIA)	To recommend policies on Advanced TV	Foreign and U.S. firms: Foreign consumer electronics firms include: Mitsubishi, NEC, Sony, Philips, Panasonic, Thomson, Hitachi, etc.
HDTV 1125/60 Group	To promote the 1125/60 (modified version of original NHK) production standard	Sony; NEC; Panasonic; JVC; Toshiba; Chyron; Cinema Products; Compression Labs; Dynair Electronics; etc.
Institute of Electrical and Electronics Engineers (IEEE) Technology Activities Council	To recommend policy to promote U.S. interests in electronics	Represents 240,000 engineers in the U.S.
Motion Picture Association of America (MPAA)	Trade Association for U.S. motion picture industry	Various
National Cable TV Association (NCTA)	To assess HDTV systems for cable applications	Telecable; Scientific Atlanta; Generai Instrument; HBO; ESPN United Artists Cable; Fox Cable; Warner Cable; etc.
National Association of Broadcasters	Trade Association for U.S. radio and TV broadcasters	Various
Society of Motion Picture and TV Engineers (SMPTE)	Technical society developing voluntary recommended standards and practices	Various end users, manufacturers, and individual engineers from the TV and fiim industry
Telecommunications Industry Association (TIA)	To present position of telecommunications supply companies on HDTV	Alcatel, NA; AT&T; Corning Glass; GTE; Hughes; IBM; Motorola; Scientific-Atlanta

[a]This list is not inclusive.

SOURCE: Electronic Industries Association, "Non-Governmental Groups Involved WithHDTV," HDTV Information Packet, Washington, DC, Nov. 30, 1988; Greg Depriest, Association of Maximum Service Telecasters, personal communication, Jan. 18, 1990.

DARPA received 87 proposals requesting roughly $200 million. By November 1989, 11 contractors had been named.[65] Congress appropriated $20 rnillion for this R&D in the fiscal 1990 budget, but stipulated that the money could not be spent until the Administration had developed a comprehensive program for HDTV.

U.S. commercial interests have also attempted to forge a basis for public-private cooperation. In May 1989, the American Electronics Association (AEA) Advanced Television Task Force, representing 36 U.S.-owned firms, proposed a $1.35 billion (government share) 6-year program of R&D, low-cost loans, and loan guarantees to assist U.S. manufacturers in

[65]Brian Robinson, "DARPA Names HDTV ContractorS," *Electronic Engineering Times,* June 19, 1989, p. 11; Richard Doherty, "Six Firms Get DARPA HDTV Nod," *Electronic Engineering Times,* Oct. 30, 1989, p. 1.

designing, developing, and producing HDTVs.ti This effort, however, met considerable skepticism. A report from the Congressional Budget Office (CBO) in July 1989 questioned the premise-that HDTV was an important market that U.S. firms should enter.[67]

Lacking support at home, the tentative unity of U.S. industry groups began to fray. In November 1989, an initial agreement was reached between the U.S. Semiconductor Industry Association and the Electronic Industry Association of Japan for U.S. firms to supply Japanese HDTV manufacturers with chips.[68] Some observers cited this action as a good faith effort on the part of Japan to increase use of American chips.

Skeptics, however, noted that U.S. producers received no guarantees as to what proportion of the semiconductors in Japansese HDTVS would be sourced from them. The general failure of the Semiconductor Trade Agreement to substantially increase U.S. chip sales in the Japanese market was offered as a basis for questioning the value of this HDTV accord. Skeptics suggested that the Japanese might use this agreement to influence the debate in the United States over which broadcast standards are chosen. If Japanese HDTVS contain a significant fraction of U. S.-sourced semiconductors, it would be much more difficult to restrict imports in favor of U.S.-developed or U.S.-produced HDTVS. In that case, it might also be more difficult to just@ supporting the development of a domestic HDTV industry.

[66]American Electronics Association, "Development of a U.S.-Based ATV Industry," May 9, 1989.

[67]Congressional Budget Office, "The Scope of the High-Definition Television Market and Its Implications for Competitiveness," Staff Working Paper, July 1989.

[68]David Sanger, "Industries in U.S. and Japan Form Alliances on New TV Technology," New *York Times, Nov. 9, 1989,* p. Al.