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ABSTRACT

The report of these two hearings on high definition information systems begins by noting that they are digital, and that they are likely to handle computing, telecommunications, home security, computer imaging, storage, fiber optics networks, multi-dimensional libraries, and many other local, national, and international systems. (It is noted that the Office of Science and Technology's National Critical Technologies Panel recognized the importance of the components of high definition systems when high definition imaging and displays, sensors and signaling processing and data storage and peripherals all made its list of the 22 most important technologies for future competitiveness and national security.) This transcript of the hearings includes testimony and prepared statements by eight witnesses: (1) Robert Kahn, the Corporation for National Research Initiatives; (2) David Staelin, the Massachusetts Institute of Technology; (3) Clark E. Johnson, Consultant; (4) William E. Glenn, Florida Atlantic University; (5) Robert Sanderson, Eastman Kodak Company; (6) Alan R. Blatecky, MCNC; (7) John W. Lyons, National Institute of Standards and Technology (NIST), accompanied by Robert Hebner, NIST, and Thomas P. Stanley, Federal Communications Commission (FCC); and (8) Michael L. Liebhold, Apple Computer, Inc., with Kenneth L. Phillips, Committee of Corporate Telecommunications Users, Gary Demos, Demografx, and David A. Deas, Southwestern Bell Technology Resources. (DB)

HEARINGS

BEFORE THE

SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED SECOND CONGRESS

FIRST SESSION

MAY 14, 21, 1991

[No. 19]

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WITNESSES

HIGH DEFINITION INFORMATION SYSTEMS

TUESDAY, MAY 14, 1991

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 1:35 p.m. in room 2318, Rayburn House Office Building, Hon. Tim Valentine [chairman of the subcommittee] presiding.

Mr. VALENTINE. Good afternoon, ladies and gentlemen. Welcome to the Subcommittee on Technology and Competitiveness.

Our topic this afternoon is high definition information systems. We want to explore high definitions capabilities as a total system. These systems are likely to handle home entertainment—that is, in the future—computing, communications, home security and much more.

The Office of Science and Technology's National Critical Technologies Panel recognized the importance of the components of high definition systems when high definition imaging and displays, sensors and signaling processing and data storage and peripherals all made its list of the 22 most important technologies for future competitiveness and national security.

Many companies and research organizations are looking at the component parts of the system. However, developing a vision of how these components will work together as a total system is equally important. This expansion will impact other industries such as computer imaging, storage and fiber optics networks, for example.

These systems also could devour a large percentage of the computer chips manufactured in the early part of the 21st century. How could high resolution information systems affect our daily lives? Sensors attached to the system could watch your house for thieves and fires, supervise a roast in the oven or turn off lights when rooms are not occupied. The system could provide an electronic vision of newspaper edited according to your particular needs. Its advanced video communications features could be used to transmit medical images such as x-rays, CAT scans, or high resolution color pictures to other experts for diagnosis.

Eventually, these systems could become multidimensional libraries where you could stroll through a storage record of an ancient city displaying the desired audio and video signals in response to your direction or downloading books or passages needed by students in your household.

Because these systems are digital, like our computers, they give the United States an opportunity to regain a market share of the consumer electronics manufacturing. This provides a needed opportunity to be competitive once again if we can successfully integrate all components and develop a methodology for concurrent development in engineering. This technology will contribute greatly to enabling this as one of our national strategic goals. Not having capabilities in these areas would be a catastrophe.

This is the first of two hearings on high definition systems. Today we want to hear from our witnesses on the vision of these systems into the future and how the United States can participate in these technologies.

In the second hearing on May 21, we want to discuss possible architecture and the implementation and standards of these systems.

Again, I welcome you here today. We are honored by the presence of the Chairman of the full committee, Mr. Brown but before recognizing him, I want to call on our good friend, the distinguished ranking member of the subcommittee, the gentleman from Florida, Mr. Tom Lewis.

[The prepared statement of Mr. Valentine follows:]

OPENING STATEMENT

CHAIRMAN TIM VALENTINE

Subcommittee on Technology & Competitiveness

Critical Technologies:

High Density Systems

May 14, 1991

Good morning and welcome to the Subcommittee on Technology and Competitiveness. Our topic this morning is high definition information systems. We want to explore high definition's capabilities as a total "system," capabilities that go far beyond the next generation of televisions. These systems are likely to handle home entertainment, computing, communications, home security and much more.

The Office of Science and Technology's National Critical Technologies Panel recognized the importance of the components of high definition systems when high definition imaging and displays, sensors and signal processing, and data storage and peripherals all made its list of the 22 most important technologies for future competitiveness and national security.

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How could high resolution information systems affect our daily lives?

-- Sensors attached to the system could watch your house for thieves and fires, supervise a roast in the oven, or turn off lights when rooms are not occupied.

-- The system could provide an electronic version of a newspaper edited according to your particular needs.

-- Its advanced video communications features could be used to transmit medical images such as x-rays, CAT scans or high resolution color pictures to other experts for diagnosis.

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Again welcome to the hearings! I look forward to hearing your testimony.

Mr. LEWIS. Thank you, Mr. Chairman.

Again, Mr. Chairman, I want to commend you for hearing this series of hearings on where the United States is as far as its competitiveness abilities.

The OSTP report on National Critical Technology lists high definition systems as one of 22 important technologies. The report states that the Japanese began selling high definition television for the home in 1990. The Europeans are not far behind the Japanese.

On the other hand, the report states the U.S. position with respect to HD television technology reflects declining competitiveness. What does the future hold for the U.S. high definition systems? What should the federal priorities in research funding be in this technology? Can we become competitive globally? I look forward and hope that today's hearings can shed some light on these particular questions.

Mr. Chairman, I will have to absent myself for a period of time for another hearing and I will return.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you for your interest.

I'm happy to recognize the Chairman of the full committee, the distinguished gentleman from California, Mr. George Brown.

Mr. BROWN. Thank you very much, Mr. Chairman.

Let me just say, very briefly, that I appreciate very much your focusing in the Subcommittee on this subject. As I'm sure you know, the subject of what was at first called high definition television engendered the interest of many of us in Congress going back several years and we actually had an ad hoc working group that sought to bring about a better understanding of what was happening here.

I think we acquired a little bit of that understanding and now it needs to be translated into specific programs that may enable this country to take advantage of the opportunities we have with high definition systems in general and how this may fit into a total program of strengthening the information environment for the country. I'm really delighted that you're going ahead with this.

Thank you very much.

Mr. VALENTINE. Thank you, Mr. Chairman.

The Chair recognizes at this time one of the Subcommittee's very special assets, the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

Mr. Chairman, this hearing brings together two of my own major interests in Congress—high definition systems and fiber optic technology. From my seat on the panel of the Telecommunications Subcommittee of Energy and Commerce, I've been working toward the goals, the dual goals, of fiber to the home and universal distribution of high definition television in the U.S.

Today, we have the benefit of technologies that 10 years ago were only visions in a science fiction film. Telecommunications has led the way for many of these advances, both in the communications field and in other related fields. We must keep striving for advances in telecommunications in order to maintain America's global competitiveness, to build on our diverse strengths where we, and not Japan or western Europe, are the world's pre-eminent information age economy.

When we were in the age of the automobile, America built the best highway infrastructure in the world and then built the best vehicles to travel on those roads. In the automobile age, we became for a long time the pre-eminent world economic power. Now, we are in the information age. In order to be competitive and indeed pre-eminent, as a world economic power, we need to build the best telecommunications infrastructure available, just as we did with the interstate highway system.

The Japanese government announced that it intends to guide the investment of up to a quarter of a trillion dollars to upgrade their digital communications capacity over the next 20 years. They are making these investments with the expectation that it will pay for itself through economic growth and technology exports to the United States and worldwide. I believe they are right on target.

A national fiber optic network is what America needs to survive and to be pre-eminent in the decades to come. We have a fractured telecommunications policy in this country. Many individual companies are laying fiber optic cable, but we don't have a national telecommunications strategy that will allow us to use and interconnect all that fiber so that the whole is greater than the sum of the parts.

We, in Congress, need to provide the climate for building the best telecommunications network in the world. Current levels of fragmentation are simply unacceptable and remain as a major deficiency in the post-MFJ era—that's the break-up of AT&T.

I've been developing legislation to spur modernization of our telecommunications infrastructure. The legislation has three main components. First, it authorizes the FCC to create standards for a nationwide seamless fiber optic network. These critical requirements will, in most cases, supersede State technical requirements. You can't have individual telecommunications policy for each of every 50 States in the Union.

Secondly, the legislation will call for a joint Federal/ State board to increase depreciation rates for current telecommunications plans. Compared to other communications industries such as cable television, the depreciation rates allow telephone companies an unrealistically long and inhibit technology progress by not taking into account the short life cycles of technology-related equipment in today's information age.

Finally, the bill will provide for a partnership between the Federal Government and private companies in building this fiber optic network. The Federal Government will provide low cost capital in exchange for some kind of involvement in the network via tolls or fees from new spectrum auction.

It's absolutely essentially that the Federal Government be involved to fill the holes, the gaps between all these different players. There's telephone companies, the local exchange carriers, there's long distance companies, interexchange carriers, there's corporate networks, there's major research networks, there's cable companies laying fiber.

Wouldn't it be effective if we started talking about how to put all of this together instead of doing each one in parallel with perhaps degrees of redundancies that are simply inefficient?

Our computing power in the United States is going through the roof. Our broad band network demand will push the system to the limits. Without greater broad band transmission, communication facilities and capabilities, we will inhibit our technological and economic growth in contributing to the stagnation of the economy.

We'll see chips potentially thousands of times more powerful than the chips today. How are we going to transmit this information without broad band capability? That's what we're trying to provide.

I intend to contribute to a national telecommunications policy that recognizes these needs and helps to solve problems of our network before they become critical in order to create the next generation network itself.

I'll be looking forward to the expert testimony of today's distinguished panels.

Thank you, Mr. Chairman.

Mr. VALENTINE. The Chair recognizes the distinguished gentleman from California, Mr. Dana Rohrabacher.

Mr. ROHRABACHER. Thank you, Mr. Chairman, and I'll be brief in this opening statement.

First, let me just commend my colleague, Mr. Ritter. I know he's put a lot of hard work in on this subject and I agree with about 90 percent of what he was talking about and I just want to note that today we're here talking about standards, HDTV standards, and not Government funding necessarily of HDTV development.

When I first got to Congress three years ago, that was a major issue and I think that as we've seen through time, had we been seduced at that time by the arguments that we should pick or choose winners as to technological winners and what companies were going to be able to have the capital they need for what we considered to be the important technological developments of that day, the United States would have been the big loser because we were focusing on technology three years ago which since has been proven to have been the wrong technology for us to focus on.

So we can be happy that the United States Government, unlike the Japanese, decided to leave the situation well enough alone and let the private sector focus on those technologies that they thought would be profitable.

The most I think the Federal Government should do is create the environment so that people with ideas and new technology can actually invest in them, and this is not inconsistent with what Mr. Ritter has just said, because we now have regulations—first of all, we have taxes that inhibit this, but we all have regulations of those corporations and companies in America that could succeed in accomplishing those noble goals that Mr. Ritter has just outlined for us.

I think it's important for us to focus on those and one of the other things we can do is provide leadership, and Government can provide leadership in the form of standards which will, as Mr. Ritter put it, help us create freeways on which information can travel and it would actually be at a minimal cost for Government, but instead will provide the maximum incentive for the private sector to move ahead because they know what the rules of the game are and they know exactly what the parameters are and how to best exploit that in the marketplace.

So, Mr. Chairman, we need to try to assure that HDTV standards are adopted that will not only help the development of HDTV but also standards that will take into account what America's place is right now, in our competition with overseas competitors. Let us make sure that any standards that are adopted give incentive to our own industries and provide our own industry with the ability to overcome the competition in this vital area.

So there's a lot to be discussed and a lot of information that needs to be examined before those standards are laid down. I'm just very pleased with your leadership, Mr. Chairman. Thank you for holding this hearing today.

Mr. VALENTINE. Thank you, sir.

The Chair recognizes another very faithful member of the subcommittee, the lady from Missouri, Ms. Joan Kelly Horn.

Ms. HORN. Thank you, Mr. Chairman.

I have no opening statement. I do appreciate the calling of the hearing and look forward to hearing from the witnesses.

Thank you.

Mr. VALENTINE. Thank you, ma'am.

To my left, another distinguished member of our subcommittee, the lady from Maryland, Congresswoman Morella.

Ms. MORELLA. Thank you, Mr. Chairman.

In the interest of time to hear our expert witnesses talk about the high definition systems, I would yield any time you might accord me for an opening statement.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you.

We'll yield at this time to the well-equipped former chairman of the subcommittee, a part of this subcommittee, the distinguished gentleman from Arkansas, Mr. Thornton.

Mr. THORNTON. Mr. Chairman, I appreciate the introduction. I also am interested in hearing from our distinguished witnesses and want to congratulate you on moving this hearing forward.

Thank you, sir.

Mr. VALENTINE. Thank you.

We have, ladies and gentlemen, two panels today. The first panel whom I'll ask to come forward, consists of Dr. Robert Kahn, who is with the Corporation for National Research Initiatives, Reston, Virginia and Dr. David Staelin, Professor of Electrical Engineering and Computer Science, Massachusetts Institute of Technology.

The second panel will consist of Mr. Clark E. Johnson, Consultant, from Denver Colorado; Dr. William E. Glenn, Professor, Electrical Engineering, Imaging Systems Laboratory, Florida Atlantic University, Boca Raton; Dr. Robert Sanderson, Technology Assistant to the Director, Eastman Kodak Company, Rochester, New York; and Mr. Alan R. Blatecky, Vice President, Communications, MCNC, Research Triangle Park, North Carolina.

Welcome, all of you. I would like to say at the outset and thank the members of the subcommittee for their attendance here. We have an above-average number on this busy Tuesday. I will ask each of you to please summarize your remarks. Your prepared statements will, of course, appear in the record as presented to us.

Dr. Kahn?

STATEMENT OF DR. ROBERT KAHN, PRESIDENT, CORPORATION FOR NATIONAL RESEARCH INITIATIVES

Dr. KAHN. Mr. Chairman, members of the committee, I welcome the opportunity to appear before you.

I'd like to make a few preliminary remarks and then turn to some specific issues which are of direct concern to the topic that the committee is addressing.

I'm currently President of the Corporation for National Research Initiatives, which is a nonprofit organization that I founded in 1986 to foster research and development for a national information infrastructure. At the time, those words — national information infrastructure—meant very little to most people because the concept was really so new, or worse, it was misunderstood by many people as somehow referring to the conventional infrastructures that we think about so often like pipes, bridges and roads.

What I was trying to get at was the need for a systematic and widespread electronic foundation that would make use of computers and communications to benefit all of the citizens as the use of conventional infrastructure does today.

I know that there are many other pressing matters on the congressional agenda but frankly I was very pleased to see this whole topic get on the list of concerns. In fact, when I decided to leave Government service in 1985 after a long tour at the Defense Advanced Research Project Agency, it was because I felt many of the same general concerns which are being addressed in specific terms in this hearing.

How do we get different groups—academic, industrial, nonprofit, Government—to work together toward a coherent national purpose such as this?

My approach is to get them to collaborate on research and development for a national information infrastructure. Although the resources that are currently available to this area are small by almost any measure, we've had significant success in developing this kind of model for cooperation so far.

I might point out that building a fiber optic network or whatever the telecommunications portion of the infrastructure might be is only one portion of the general problem of building an information infrastructure. One must also focus on the higher levels of the infrastructure which make it usable to the end parties that would benefit from it.

One area that we focused on in this regard is research and development for a national digital library. It is more than a repository—it's a network-based methodology for rapid and easy access to information of all kinds, information that can be provided by the owners of that information to the digital library as if it were an electronic marketplace.

I think the key to our approach has been the use of what we call "know bots" which are kinds of knowledge robots that move through the network in understood and agreed fashion retrieving information on behalf of their users.

A second area which could be incorporated into the digital library is a knowledge bank for science and technology in which information of the kind stored in textbooks is made available to computers so that they may be able to process it and reason about it. Such a knowledge bank could ultimately play a critical role in the Nation's educational system during the next century.

A third area is an information infrastructure for engineering design and manufacturing which could greatly facilitate custom design and flexible manufacturing.

While at DARPA we created a system called MOSIS which allows researchers, including students to submit VLSI designs electronically and over a network and to receive prototype chips back in a few weeks at affordable cost. This has sparked a wave of creativity in VLSI design across the country that continues unabated to this day.

A topic that is very relevant to these hearings is the gigabit testbed initiative which involves almost three dozen organizations within the United States collaborating with my organization to explore the feasibility, architecture and application of networks which operate at speeds of approximately a billion bits per second directly to the end user.

Seed funding for this activity was made available by the National Science Foundation and DARPA under a cooperative agreement between CNRI and NSF, and largely supports the participating universities. However, industrial contributions are also quite large and probably exceed substantially in aggregate amount the Government funding which enabled this program to get off the ground.

There are five such testbeds coming into existence around the country and additional testbeds may be added in the future. These testbeds, which cover many states around the country, are fiber optic-based and involve many of the leading researchers and industrial participants, and could provide a starting point for many of the experiments that I believe will be needed to develop a coherent national strategy for high definition systems.

The remainder of my remarks focus on five specific issues and areas: one, the difference between digital information and computer processable information; second, the role of protocols and standards in this process; third, architecture and systems integration; fourth, bringing together the various industrial participants; fifth, the social issues which are going to be crucial to address; and finally, what can be enabled in this process.

I don't plan to discuss the various technologies, either existing or on the horizon. I think you'll hear about them from the other speakers, it is certainly well-represented on the panel today. I would simply note that they include a very wide range of technological capabilities including display systems, storage systems, processing and distribution systems, including all the peripheral and associated equipments, transmission systems for interactivity. I take those in the broadest sense of the term.

The earliest communication systems in the United States—and around the world, for that matter—were digital, and the telegraph comes to mind. Then we took about a 100 year detour into the world of analog communications, particularly as we introduced voice. Not only is the telephone system an analog system but so also is television, records, tapes and other media. They have grown up as analog media.

This is all changing but by reintroducing digital technology I think, lead by pulse code modulation or a PCM, in the telephone industry, introduced a notion that was missing before—namely the idea that you could get exact reproducibility for a signal. With the use of adequate coding it was possible in principle to insure, with high probability, that a signal sent from one location would arrive at the destination, not approximately as it was sent, but exactly as it was sent. This concept in one form or another has applied to virtually every aspect of information technology that's critical, including high definition systems.

Computers cannot handle analog signals directly, but being digital doesn't guarantee that they can handle them either. For a digital signal or stream of data to be computer processable, at least the syntax of the signal, and usually the semantics of the signal as well, needs to be understood by the computer. If the signal is coded, either for protection or for efficiency, the computer also may need to know how to decode it.

Current TV transmission is analog, as you know. The recent discussions to introduce all digital versions are clearly a step in the right direction, but they may not go far enough if in addition the receiver simply gets a stream of interpretable bits which it has no flexibility in processing.

How will the user be able to determine what kind of display he wants to see? Where in the process is the description of the image contained in the bits? Will TV be a disadvantaged form of interaction right from its inception at the point of reception that only acts as a kind of an automated paint brush for the viewer's screen?

With advanced storage technologies, one can store hundreds or thousands of times as much detail as one may ordinarily want but this allows selective panning, zooming and may be made compatible with all digital technology. I think this will be a particularly important capability when we get transmission over fiber optic systems.

Fiber has few of the spectrum limitations that we encounter with over the air transmission and that may enable broadcasting very detailed descriptions of the component parts of scenes or even alternate views of images, graphics and even movies.

Protocols and standards are next on my list. This becomes the centerpiece of any systems architecture discussion, particularly where interactive exchanges can occur. Protocols will be essential for high definition systems as well.

The components of a protocol are its representations and its procedures. The latter deals with how actions take place; the former deals with what those actions cope with such as their parameters, the coding of those parameters and the formats.

When a protocol gains widespread acceptance, it qualifies as a generally-accepted procedure or even as a standard. Test beds are often the best way to develop, test and refine such protocols with the user community before they become generally accepted or standards.

The concept of protocols needs to be introduced in a very visible way into the dialogue on high definition systems. Protocols may be thought of as the programming language for distributed systems. We don't have them at the present time, but without them we don't have the basis on which industry can adequately deal with matters of architecture and systems integration except in the very limited specific spheres in which they choose to operate.

Hence we have, as has been noted earlier, independent approaches being taken in each of various technological areas and fully integrated systems are not easily assembled in the laboratory, much less available commercially, or achievable over a distributed telecommunications system. What is needed to achieve this is national leadership unless it's done for us from abroad.

There is a question, however, of how much "high definition" we need and how much individuals and organizations are going to be willing to pay for it. I believe this is best handled in the marketplace to the maximum extent possible.

What should be the roles for the various industrial participants? We don't need to define for them what they can do for themselves unless perhaps it might be to help reduce the cost of capital for long range research, as has been mentioned, or to change the depreciation schedules for critical infrastructure components.

The legal and regulatory environment needs to allow all the relevant players to have the opportunity to participate without disadvantaging any of them, if we can achieve that. Particularly let me cite three points.

One, increased awareness of the role of intellectual property protection will encourage the publishers to become more active participants in this process. Second, recognition that very high speed networks will help to change the mode of communication from what is currently primarily a text-based form to an image-based form and that every form of telecommunications service can benefit from this advance. Third, that tradeoffs can be made in enabling and nurturing research and development in this area, particularly in those cases which involve joint university, industry and Government research activities that benefit it.

Let me now turn to at least one of the important social issues that I think we'll need to deal with. I think we need to insure that as we spawn this kind of new technology that we do not further disadvantage those who cannot afford this new technology or for those whom it's uneconomical to provide.

I believe this is a very compelling issue and it shows up in many different quarters. It's one that has arisen almost without exception in every form of technological advance. We have dealt with rural electricity, libraries, pay phones and low cost transportation, just to give you a few examples.

I also believe that we cannot expect in the future that people will sit transfixed in their seats staring at high definition systems for very long. This may occur initially, but ultimately efforts must be made to extend those capabilities to the portable environment which will raise further legal, regulatory and research issues.

More important, it will serve to further distance those who never had the opportunity to partake of the capabilities of these fixed systems since they won't know what it means to "take it with you when you are on the go".

Finally, we'll need to insure that the rights of all parties who are involved in this are properly understood in this environment. I emphasize these social issues because it looms as an increasingly important aspect of what is one of the most exciting and potentially impactful developments in the history of technology, namely the melding of the telecommunications, computing, television industries and all the supporting technologies into the high definition systems of the future.

Finally, what is it that can be enabled. I'd like to try and elaborate on only a few notions here. I won't go into very detailed ideas although I have many in mind such as the electronic marketplace, the use of high definition systems for advanced engineering design, simulation and the use in education and medicine to name but a few.

I believe what is likely to be enabled with the right underlying infrastructure, however, is an unleashing of innovation and creativity in applying as well as developing this new capability. Testbeds, such as the gigabit network testbeds that I mentioned earlier can help us in exploring these possibilities.

With effective and forward-looking infrastructure in place, I believe industry will have the incentive to make the necessary investments and people in all walks of life will have the opportunity to build on those investments and to use the results as they assimilate high definition systems in their everyday lives.

This completes my remarks. I'll be happy to take any questions you might have.

Mr. VALENTINE. Thank you, Dr. Kahn.

Dr. Staelin?

STATEMENT OF DR. DAVID STAELIN, PROFESSOR, ELECTRICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. STAELIN. Mr. Chairman and members of the committee, I am David Staelin, Professor of Electrical Engineering at MIT. I'm here representing only myself.

I will begin with my vision of our future information and communications infrastructure and the role of high definition systems, and then move to the implications of that vision for the evolution of the architecture of that infrastructure, and for national policies that promote competitiveness.

I will recommend two things. We must now energetically and intelligently plan that architecture to ensure its evolution is technically sound, economically efficient, and that it reaches its full potential. Secondly, special steps must be taken to protect U.S. industry in this critical area from the side effects of strategic trade and technology policies implemented by other nations.

My vision begins with our national quest for enhanced quality of life despite rapid population growth and diminishing natural resources. We must substantially advance technology and the ways we use it. Knowledge, education, and communication will all be critical. Information is key to a bright future. It is a capital asset and the currency of national progress.

Today, we focus on one aspect of this asset, our national information and communication infrastructure and its relationship to competitiveness. This infrastructure, like our highways and railroads, is absolutely essential to our national well-being. It is the means by which our information and knowledge is collected, transmitted, interpreted, shared, stored, and experienced. It is basic to our economic, civil, and military institutions and performance.

We are now in a major transition which will last several decades, a transition from a simple and rather inflexible infrastructure, mostly analog-based, to a more powerful and flexible architecture of the future, digital-based.

The challenge of formulating this architecture will be increased by the emergence of high definition systems, which has been motivated by the biological fact that the richest modality for human perception is visual and that present technology is still relatively primitive and limited.

For decades such systems will continue to stress the technologies for generation, manipulation, transmission, storage and display, and will motivate development of an unprecedently wide range of video and other image services.

Relatively simple architectural decisions made now which provide for future flexibility, interconnectivity, modularity, and extensibility, could have a major long-term positive impact on this infrastructure, whereas failure to address these issues could lose this opportunity at considerable future societal cost.

A major question today is: institutionally, how should this new architecture be formulated and developed in the best long-term interest of society? Consider two prior examples—our national telephone and television networks—neither of which has been highly flexible or generic.

Users have seen only limited change over the past half century, partly because major changes could make much installed equipment obsolete. Interconnectivity is also an issue. For example, the NTSC, PAL, and SECAM television systems used by various nations were made incompatible partly as a substitute for sound global trade policies. The price paid in intellectual disconnect between nations so far has probably been modest, but this strategy could become costly as the diversity of message types and services continues its exponential growth in a global economy.

In a related vein, home audio cassette tape recorders today can land in the trash even before the previously discarded record turntable rusts and the associated tapes and records go with them. When will CDs follow?

Fortunately, much of our intellectual heritage still resides in books which remain more timeless, but even this is changing as the electronic office, library, and home are born. Society must decoupie better intellectual assets such as film content or computer software from the technological and physical life of the media in which they are stored or conveyed.

Digital systems of the future will permit such decoupling to become increasingly economic and user friendly. Intellectual assets are both a private and a public good.

This transition in information and communication infrastructure also has regulatory implications. It is essential that the complexity of regulation not parallel the complexity of future opportunities which could grow exponentially, resulting in a bureaucratic quagmire which chokes progress.

Instead, the architecture of this evolving infrastructure should be clearly divided into largely independent elements which are coupled only in simple ways. That is, the architecture of an interconnected infrastructure and the architecture of segregated regulation must be understood as a unit.

For example, clear and unambiguous separation between information transport, which generally has economies of scale characteristic of natural monopolies or may use scarce spectrum resources, and provision of associated services, which generally have lower entry barriers and therefore promote creativity and competition, would simplify the task of local or national regulators who could then more properly focus their efforts.

Today, the regulatory structures for broadcasting and telecommunications are separate. By crisply distinguishing transport or carriage and services, this regulatory separation could largely continue into the future, even in the limit of optical fibers to the home which obsolete other delivery means.

Even in this limit, one could imagine broadcasters and film studios as program originators, cable operators and others as packagers of broadcast offerings, and the network operators as carriers, still all being regulated—or not regulated—separately, reflecting totally different concerns.

The point is, the technical vision for the architecture must be developed with the regulatory vision in mind. In the absence of a clearly expressed governmental intent to maintain regulatory separation between these industries in this or in some other fashion, one or more of these industries may choose to resist technological progress that might conceivably blur the distinctiveness and security of their future role in our economy.

Many have concluded that U.S. competitiveness and industrial integrity is in serious jeopardy as a consequence of our national dedication to free trade and our failure to support industry while other nations exercise their sovereign right to pursue industrial policies in sectors they deem vital.

This U.S. position can only result in our eventual loss of critical industries selected by other nations for emphasis. The reason for this is that U.S. firms must please their shareholders and often do so by retreating into less threatening businesses, even though such remedies may offer only brief or uncertain relief. Loyalty to any critical roles they may play in our national infrastructure or public good is precluded by their superior obligation to their shareholders.

No nation today has wealth sufficient to pursue all industrial sectors simultaneously and choices must be made. Critical technologies are those which are vital to national industrial competitiveness and independence, and to these any available emphasis should be preferentially given.

Forums for identifying critical technologies include the National Research Council, OSTP, and others. The object should not be total national self-sufficiency, so much as simple retention of industrial freedom of action, sufficient to support a full range of entrepreneurial initiatives without firms being obliged to seek essentials from vertically-integrated or uncooperative competitors.

The problem is that such supplies, tools, or technologies may not be available so soon from competitors, or on terms so favorable, as they are within the competitor's circle of enterprises, and accessing them may require surrender by U.S. firms of critical competitive information or other advantages.

Antitrust laws act to help protect U.S. firms from the excesses of such dangers within the U.S. economy, but they offer diminished protection from similar practices by global competitors operating offshore. This weakness of our antitrust laws follows from the sovereignty of other nations and from the difficulties of discovery abroad in pursuit of U.S. lawsuits.

A key technology in the information and communications infrastructure is high definition systems. Are high definition systems critical? What happens if we vacate this industrial sector?

First, both military and civilian customers would be dependent on non-U.S. suppliers who could slowly extend at will this technological monopoly into adjacent industrial sectors such as computers, telecommunications, software, and movie production, and who could establish high prices because the cost of reentering a complex and difficult abandoned technological area can be prohibitive. Such high costs of reentry are another feature of a critical technology. Semiconductors and advanced machine tools are two other often cited examples.

The U.S. is not yet in this desperate situation because we still retain substantial relevant technical expertise within our firms, universities and national laboratories, but all of these are slowly losing their edge as related manufacturing capacity and ownership move offshore.

These opportunities and challenges can be reduced to two immediate questions. How and by whom should our future information and communications infrastructure be designed, and how might this process be shaped so as to best ensure our continued national economic health and independence?

Consider first the problem of infrastructure architecture. The importance of this infrastructure and the need for flexibility, interconnectivity, modularity, and extensibility have been described. The reason such objectives are elusive is less clear.

For several decades the computer industry was largely dominated by IBM architectural thinking, and AT&T played a similar architectural leadership role in defining our national telecommunications network. In both cases, most smaller firms simply adopted these standards. RCA played a similar role in the definition of our NTSC-based television broadcasting system, a role which was enormously enhanced by its vertical integration within the consumer and professional electronics industry, by its strong research and development capabilities, and by its link to NBC. This degree of vertical integration exists today principally in large offshore corporations.

U.S. antitrust actions, foreign competition, and other factors have now nearly eliminated U.S-owned firms manufacturing consumer electronics. They have separated AT&T long lines from local communications. U.S. software and hardware firms are not vertically integrated and broadcasters face economic pressures which could undermine the health of our independent free broadcasting system. Our architectural expertise is fragmented.

Unfortunately, the use of Government bodies to resolve complex architectural issues has little successful precedent, nor can we readily select one or two strong firms to perform such a service because of the cross industry nature of our information and communications infrastructure, and the conflicting competitive aims of various firms.

If we do nothing or proceed inadequately, the consequence almost surely will be that large vertically-integrated, non- U.S. firms will not only effectively become our architect, but they ultimately will be in a position to control our entire electronics industry as they now effectively control consumer electronics.

The risk here to U.S. industrial, and therefore military, independence is enormous because of the strong and growing role of electronics in all industrial sectors. Its links to the software and media industry are also noteworthy. With respect to media, most large U.S. record companies are already non-U.S.-owned, and in only the past few years a significant fraction of all U.S. movie assets and production capability has followed. Architectural decisions involve concurrence by both media and electronics producers and already some U.S. independence in these areas has been effectively lost.

What are the remedies? The cross-industry nature of the telecommunications, computer, and broadcasting sectors, individually and certainly collectively, mandate cross-industry architectural efforts. The first objective of these efforts should be to define simple but highly flexible, extensible, modular, and interconnective interfaces for information linked between the products and services of different industries and developed over many decades, and even centuries, into the future so that existing architecture efforts can better proceed with confidence, so the cross-industry synergism and future opportunities will not be lost.

I believe the best vehicle for accomplishing this task would be a tightly-organized and focused consortium of industry, academia and private entities, and perhaps even a consortium of consortia. The fragmented nature of our industrial skills mandates corporate cooperation, but such cooperation can benefit from additional intellectual catalysts that question positions without the pall of commercial interests.

Universities in particular have a strong track record in stimulating innovation and providing trained young people to industry to insure that new technology and paradigms are widely dispersed.

The role of Government in promoting such an approach would be crucial, but not excessively demanding. Most importantly, key technical decision-making would be left largely to the private sector. This role would include assistance in ensuring that antitrust laws were not used to inhibit or slow such well-intended efforts, and continuation of modest financial support to facilitate the initial participation of critical nonindustrial partners.

Such financial support could also have important symbolic value to corporations not used to operating in such cooperative modes, or in areas subject to intense foreign competitive pressures.

It has also been suggested the Government should help fund one or more significant infrastructure demonstration efforts in this area. I believe such demonstrations can be a critical step in the development process once the objectives are known, and could accelerate the process of cooperation in architectural development. However, such funding is not nearly so critical as is immediate support to catalyze formation of joint activities to develop a more widely shared technical and architectural vision.

Additional remedies promoting economic health and industrial integrity which I would recommend pursuing now with greater vigor include:

A, facilitate the formation and operation of consortia formed for precompetitive purposes in critical technology areas; competitively fund selected nonindustrial partners in such consortia and provide additional matching funds to selected industrial firms joined in especially long-term or high-risk efforts. High definition displays are a representative critical technology of this sort where cost- sharing by Government is having a remarkable catalytic effect well beyond the modest funds involved.

B, provide stable research and development tax credits that promote long-term technology investments.

C, continue active support of technology development in universities and other leading laboratories which are precompetitive by nature and which are successful at technology transfer through education of world class employees and other means.

D, ensure regulatory powers are not used to weaken U.S. industry. One useful positive example is the FCC search for new HDTV broadcasting standards which has produced more creativity and enthusiasm in U.S. firms in this market than has been seen in years.

All of these remedies have the advantage that Government is not making detailed product, process, or long-term corporate selection decisions, but is only taking generic steps within sectors known to be vital and suffering.

Potential remedies which I believe should also be studied aggressively and promptly include lowering the cost of capital in threatened critical technology areas by means of low cost, patient Government capital. Such loans could be provided, for example, through qualified investment groups, rewarded only if they retain their investments to the end, and if they prove profitable for the Government.

I have several others in this category which are contained in the written testimony. At that point, I'd like to simply summarize briefly.

We are at a watershed between the rigid information and communications infrastructure of the past and a much more flexible future made possible by digital technology. Further, U.S. industry and competitiveness is increasingly endangered by the side effects of strategic trade and technology policies implemented by other nations in related areas such as high definition systems, telecommunications, computation, and semiconductor manufacturing.

Our Government must act to address this problem. More specifically, Europe and Japan are developing their own architectures for this next generation infrastructure and it is essential that U.S. industry, universities, and Government energetically join forces now to develop and test our own vision if we are not to be left behind.

The main Government role would be that of a spark plug to start the engine, while the universities would catalyze cooperation and innovation.

Thank you.

[The prepared statement of Dr. Staelin follows:]

High Definition Systems:
U.S. Infrastructure and Competitiveness

Testimony by

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Committee on Science, Space, and Technology
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The views expressed here are those only of the witness, and are not necessarily those of any organization with which he is affiliated.

High Definition Systems: U.S. Infrastructure and Competitiveness

I. Introduction

Mr. Chairman and members of the committee, I will begin with my vision of our future information and communication infrastructure and the role of high definition systems, and then move to the implications of that vision for the evolution of the architecture of that infrastructure and for our national policies that promote competitiveness.

I will recommend two things: we must now energetically and intelligently plan that architecture to ensure its evolution is technically sound, economically efficient, and that it reaches its full potential; secondly, special steps must be taken to protect U.S. industry in this critical area from the side effects of strategic trade and technology policies implemented by other nations.

My vision begins with our national quest for an enhanced quality of life despite rapid population growth and diminishing natural resources--we must substantially advance technology and the ways we use it. Knowledge, education, and communication will all be critical.

Information is key to a bright future--it is a capital asset and the currency of national progress.

II. The Problem

Today we focus on one aspect of this asset--our national information and communication infrastructure--and its relationship to competitiveness.

A. Importance of Information and Communication Infrastructure

This infrastructure, like our highways and railroads, is absolutely central to our national well being. It is the means by which our information and knowledge is collected, transmitted, interpreted, shared, stored, and experienced. It is basic to our economic, civil, and military institutions and performance. It is increasingly impacting our industrial competitiveness[1],

[1] Communications and cooperation are vital for international corporations, and only electronics provides the speed and pervasiveness often required. International videoconferencing, high-quality electronic graphics, and capable user-friendly electronic mail services will increasingly impact our lives.

quality of life[2], democratic decision making process[3], and our performance in education[4], economics[5], health-care[6], and military affairs[7].

B. Architectural Challenge: Information and Communications Infrastructure

We are now in a major transition which will last several decades--a transition from a simple and rather inflexible infrastructure (mostly analog based) to a more powerful and flexible architecture of the future (digital based). The challenge of formulating this architecture will be increased by the emergence of high definition systems, which is being motivated by the

2 Beyond education, the linking of scattered families and friends, improved medical care in remote regions, and other impacts, there remains the fact that a remarkably large fraction of the waking hours of many people, particularly impressionable children, are spent watching or listening to broadcasts designed to appeal to the widest possible audience. Increasing the diversity and flexibility of these offerings will provide new opportunities to serve more specialized and socially productive purposes.

3 For example, television is perhaps the single most important communications medium by which voters learn about political candidates and their views, and by which society shapes its views of itself and its future directions.

4 The full potential of video education has scarcely been tapped or even researched, simply because the cost and availability of terminals has restricted the application of such educational materials to audiences which are small and uneconomic. A second key barrier is the lack of user-friendly toolkits to aid developers of electronic educational packages for broadcasting or interactive uses. Only if we define a transparent infrastructure encompassing all elements of the system--from image generation to processing, transmission, storage, and display--and economically accommodating both today's diversity and all reasonable future extensions, will we be assured of a sufficiently broad opportunity to motivate educational system developers. The key ingredients are computer hardware and software technology, and the widespread use of low-cost consumer systems with generic capabilities which lend themselves to this application. Failure in this endeavor could lead to excessive dominance by a single vendor of large educational markets though use of proprietary interfaces and other anti-generic means. Nintendo's admirable succcess in home video games illustrates the difficulty of ensuring existence of multi-vendor markets in this interlinked area.

5 Business and government run on information--fast, accurate, and interpreted. Recent progress in engineering graphics, automatic language translation, user-friendly data base retrieval systems, manufacturing automation, environmental monitoring, and many other areas will also have a continuing impact on national and global economic health.

6 Health care is already a multi-billion dollar user of image data, from dental film to sophisticated CAT-scan equipment that is increasingly used for internal diagnostics designed to avoid or improve surgery. The ability of high-definition image telecommunications to bring some of the very best diagnostic capability rapidly to remote areas is another of many growing opportunities in this field.

7 Correct information is key to military efficiency--from the avoidence of unnecessary conflict, and the development and maintenance of standing capabilities, to its efficient and conservative prosecution. High definition systems are already critical elements in military infrastructure, and increasing their capabilities, flexibility, interconnectivity, and economy must remain high priorities.

biological fact that the richest modality for human perception is visual and that present technology is still relatively primitive and limited. For decades such systems will continue to stress the technologies for image generation, manipulation, transmission, storage, and display, and will motivate development of an unprecedentedly wide range of video and other image services. Relatively simple architectural decisions made now which provide for future flexibility, interconnectivity, modularity, and extensibility could have a major long term positive impact on this infrastructure, whereas failure to address these issues could lose this opportunity at considerable future societal cost.

A major question today is "Institutionally, how should this new architecture be formulated and developed in the best long term interests of society?"

C. Discussion of Inflexibility versus Flexibility

Consider two prior examples, our national telephone and television networks, neither of which has been highly flexible or generic. Users have seen only limited change over the past half century, partly because major changes could make much installed equipment obsolete. Visible modifications have often involved separate new systems overlaid on the first, rather than low cost adjustments. Representative augmentations of our telecommunications network include VSAT satellite networks, cellular telephone systems, and private wideband networks. Data and fax links have necessarily incorporated some intelligence in each terminal which alternatively could have resided in a more intelligent and flexible network; these resources then could have been shared among many users rather than being duplicated in each unit. Similarly, television broadcast delivery has been bypassed by cable systems to achieve picture quality and channel diversity, and by video-cassettes and video discs to achieve program choice. These systems are often linked only loosely with their predecessors for both technical and competitive reasons.

For example, the NTSC, PAL, and SECAM television systems used by various nations were made incompatible partly as a substitute for sound global trade policies. The price paid in intellectual disconnect between nations so far has probably been modest[8], but this strategy could become

[8] There is a minority view that it is desireable to place impediments in the path of global communication so as to prevent excessive cultural and economic homogenization and perhaps instability. Technological incompatibility may not be the best tool to serve this purpose, however.

costly as the diversity of message types and services continues its exponential growth in a globa, economy.

In a related vein, home audio cassette tape recorders today can land in the trash even before the previously discarded record turntable rusts, and the associated tapes and records go with them. When will CD's follow? Fortunately much of our intellectual heritage still resides in books, which remain more timeless, but even this is changing as the electronic office, library, and home are born. Society must decouple better intellectual assets, such as film content or computer sowftware, from the technological and physical life of the media in which they are stored or conveyed. Digital systems of the future will permit such decoupling to become increasingly economic and user friendly. Intellectual assets are both a private and a public good.

Although society could afford the redundancy and obsolescence of this approach until now, simply because change was so slow during this period, technology has irreversibly changed that. We can not stay in our electrical past, any more than we could have retained our original cord roads made of logs, or our national canal barge system, while still hoping to forge a leading economy and society. Instead, our highways today convey cars, trucks, and other vehicles of all sorts, most of which were designed and built long after the highway system--our highways are generic carriers. They link all parts of our society, and serve both ancient and modern vehicles. This generic character will be even more essential in our future information and communication infrastructure.

D. Regulatory Implications

This transition in information and communication infrastructure also has regulatory implications. It is essential that the complexity of regulation not parallel the complexity of future opportunities, which could grow exponentially, resulting in a bureaucratic quagmire which chokes progress. Instead, the architecture of this evolving infrastructure should be clearly divided into largely independent elements which are coupled only in simple ways. That is, the architecture of an interconnected infrastructure and the architecture of segregated regulation must be understood as a unit.

For example, clear and unambiguous separation between information transport (which generally has economies of scale characteristic of natural monopolies) and provision of associated services (which generally have lower entry barriers and therefore promote creativity and competition) would simplify the tasks of local or national regulators, who could then address these issues separately. Today the regulatory structures for broadcasting and telecommunications are separate. By crisply distinguishing transport (carriage) and services, this regulatory separation could largely continue into the future, even in the limit of optical fibers to the home which obsolete other delivery means. In this limit one could imagine broadcasters and film studios as program originators, cable operators and others as packagers of broadcast offerings, and the network operators as carriers, still all being regulated (or not) separately, reflecting totally different concerns.

In the absence of a clearly expressed governmental intent to maintain regulatory separation between these industries, in this or in some other fashion, one or more of these industries may choose to resist technological progress which might conceivably blur the distinctiveness and security of their future role in our economy.

III. Industrial Integrity and Competitiveness

A. The General Problem and the Need for Choices

Many have concluded that U.S. competitiveness and industrial integrity is in serious jeopardy as a simple consequence of our national dedication to free trade and our failure to support industry while other nations exercise their sovereign right to pursue industrial policies in sectors they deem vital. This U.S. position can only result in our eventual loss of critical industries selected by other nations for emphasis.

U.S. firms must please their shareholders, and often do so by retreating into less threatened businesses[9], even though such remedies may offer only brief or uncertain relief. Loyalty to any critical roles they may play in our national infrastructure (a public good) is precluded by their superior obligation to their shareholders.

No nation today has wealth sufficient to pursue all industrial sectors simultaneously, and choices must be made. Critical technologies are those which are vital to national industrial competitiveness and independence, and to these any available support should be preferentially given. Forums for identifying critical technologies include the National Research Council, OSTP, and others. The object should not be total national self sufficiency so much as simple retention of industrial freedom of action sufficient to support

9 Such as RCA's retreats into financial services, carpets, rental cars, and ultimately cash.

a full range of entrepreneurial initiatives without firms being obliged to seek essentials from vertically integrated competitors[10]. The problem is that such supplies, tools, or technologies may not be available so soon from competitors, or on terms so favorable, as they are within the competitor's circle of enterprises, and accessing them may require surrender by U.S. firms of critical competitive information.

Antitrust laws act to help protect U.S. firms from the excesses of such dangers within the U.S. economy, but they offer diminished protection from similar practices by global competitors operating offshore. This weakness of our antitrust laws follows from the sovereignty of other nations and from the difficulties of discovery abroad in pursuit of U.S. lawsuits.

A key technology in the information and communications infrastructure is high definition systems. Are high definition systems "critical"? What happens if we vacate this industrial sector? First, both military and civilian customers would be dependent on non-U.S. suppliers who could slowly extend at will this technological monopoly into adjacent industrial sectors, such as computers, telecommunications, software, and movie production, and who could establish high prices because the cost of re-entering a complex and difficult abandoned technological area can be prohibitive--such high costs of re-entry are another feature of a critical technology. Semiconductors and advanced machine tools are two other often cited examples. The U.S. is not yet in this desperate situation because we still retain substantial relevant technical expertise within our firms, universities, and national laboratories, but all of these are slowly losing their edge as related manufacturing capacity and ownership move offshore.

B. Summary of the Problems

These opportunities and challenges can be reduced to two immediate questions:

1. How and by whom should our future information and communications infrastructure be designed?

2. How might this process be shaped so as to best ensure our continued national economic health and independence?

C. The Problem of Infrastructure Architecture

10 Although such transactions are sometimes successful, the risk for abuse is great.

The importance of this infrastructure and the need for flexibility, interconnectivity, modularity, and extensibility have been described. The reason such objectives are elusive is less clear.

For several decades the computer industry was largely dominated by IBM architectural thinking, and AT&T played a similar architectural leadership role in defining our national telecommunications network. In both cases most smaller firms simply adopted these standards. RCA played a similar role in the definition of our NTSC-based television broadcasting system, a role which was enormously enhanced by its vertical integration within the consumer and professional electronics industry, by its strong research and development capabilities, and by its link to NBC. This degree of vertical integration exists today principally in large offshore corporations.

U.S. antitrust actions, foreign competition, and other factors have now nearly eliminated U.S.-owned firms manufacturing consumer electronics, they have separated AT&T long lines from local telecommunications, U.S. software and hardware firms are not vertically integrated, and broadcasters face economic pressures which could undermine the health of our independent free broadcasting system. Unfortunately, the use of government bodies to resolve complex architectural issues has little successful precedent, nor can we readily select one or two strong firms to perform such a service because of the cross-industry nature of our information and communications infrastructure and the conflicting competitive aims of various firms.

If we do nothing, or proceed inadequately, the consequence almost surely will be that large vertically integrated non-U.S. firms will not only effectively become our architect, but they ultimately will be in a position to control our entire electronics industry, as they now effectively control consumer electronics. The risk here to U.S. industrial (and therefore military) independence is enormous because of the strong and growing role of electronics in all industrial sectors. Its links to the software and media industries are also noteworthy. With respect to media, most large "U.S." record companies are already non-U.S. owned[11], and in only the past few years a significant fraction of all U.S. movie assets and production capability[12] has followed. Architectural decisions involve concurrence by both media and electronics producers, and already some U.S. independence in these areas has effectively been lost.

11 Such as CBS Records and RCA Records.

12 Such as Columbia Pictures and MCA (Universal Studios).

D. The Problem of Economic Health and Industrial Integrity

The essence of industrial integrity and independence is the ability of national entrepreneurs to access in a timely way world-class technology, supplies, and personnel beyond the control of external entities. Such access is needed by any major power in all areas vital to its civilian economy and military integrity. These qualities need not conflict with similar desires of other nations because integrity and independence does not require total self sufficiency, but only the ability to supply national needs sufficient to ensure reasonable domestic prices and that domestic entrepreneurial creativity and skill can be fulfilled in the market.

IV. Remedies

A. Remedies Promoting Infrastructure Architecture

The cross-industry nature of the telecommunications, computer, and broadcasting sectors individually, and certainly collectively, mandate cross-industry architectural efforts. The first objective of these efforts should be to define simple, but highly flexible, extensible, modular, and interconnective interfaces for information linked between the products and services of different industries, so that existing architectural efforts can better proceed with confidence that cross-industry synergism and future opportunities will not be lost.

I believe the best vehicle for accomplishing this task would be a tightly organized and focused consortium of industry, academia, and private entities, and perhaps even a "consortium of consortia." The fragmented nature of our industrial skills mandates corporate cooperation, but such cooperation can benefit from additional intellectual catalysts that question positions without the pall of commercial interest. Universities, in particular, have a strong track record in stimulating innovation and providing trained young people to industry to ensure that new technology and paradigms are widely dispersed[13].

The role of government in promoting such an approach would be crucial, but not demanding. Most importantly, key technical decision

[13] Universities, for example, have played strong roles in catalyzing the evolution of our national computer industry, including the key contributions to the development of magnetic core memories, solid state computers, time sharing systems, artificial intelligence, and many other areas. Strong research and personnel contributions to video signal processing and broadcastir technology have also been made.

making would be left largely to the private sector. This role would include assistance in ensuring that antitrust laws were not used to inhibit or slow such well intended efforts, and continuation of modest financial support to facilitate the initial participation of critical non-industrial partners. Such financial support could also have important symbolic value to corporations not used to operating in such cooperative modes or in areas subject to intense foreign competitive pressures.

It has also been suggested that government should help fund one or more significant infrastructure demonstration efforts in this area. I believe such demonstrations can be a critical step in the development process, once the objectives are known, and could accelerate this process of cooperation and architectural development. However, such funding is not nearly so critical as is immediate support to catalyze formation of joint activities to develop a more widely shared technical and architectural vision.

B. Remedies Promoting Economic Health and Industrial Integrity

Remedies here can be divided into three groups: those I recommend now and those I would not, plus those which I believe should be studied for possible implementation later.

1. Remedies I would recommend pursuing now with greater vigor include:

a) Facilitate the formation and operation of consortia formed for pre-competitive purposes in critical technology areas. Competitively fund selected non-industrial partners in such consortia.

b) Same as remedy (a), but additionally provide matching funds to selected industrial firms joined in especially long-term high-risk efforts. High definition displays is a representative critical technology of this sort where cost sharing by government is having a remarkable catalytic effect well beyond the modest funds involved.

c) Provide stable research and development tax credits that promote long-term technology investments.[14]

d) Continue active support of technology development in universities and other leading laboratories which are precompetitive by nature and

[14] Restricting such credits to critical technologies could entail major bureaucratic costs associated with resolving their definition within countless firms, and should be avoided.

which are successful at technology transfer through education of world-class employees and other means.

e) Ensure regulatory powers are not used to weaken U.S. industry. One useful positive example is the FCC search for a new HDTV broadcasting standard, which has produced more creativity and enthusiasm in U.S. firms in this market than has been seen in years.[15]

All of these remedies have the advantage that government is not making detailed product, process, or long-term corporate selection decisions, but is only taking generic steps within sectors known to be vital and suffering.

2. Remedies I would not recommend include:

a) The option of doing nothing. Trusting other nations to unilaterally limit their industrial policies and associated market expansion and profit maximization is a policy which risks sharp, and ultimately nearly irreversible, national industrial, economic, and military decline.

b) Systematic and continual long-term subsidization of threatened firms, with much detail decided or approved by government, is also a formula for industrial decline, characterized by increasing bureaucracy, political maneuvering, and industrial uncertainty. Provision of substantial credit to critical but temporarily insecure firms, such as Chrysler and Lockheed once were, is different and can be warranted on occasion, however.

c) Substantial reductions in capital gains taxes for all classes of investments. Although such across-the-board reductions would be desirable, they are less efficient economically because they include many expenditures which, like vacation condominiums, might actually be considered consumption oriented. Restriction of such tax reductions to investments in firms classed as manufacturing, or establishing an additional lower capital gains tax rate only for such assets held longer than five years, for example, could be very helpful in leveling the cost-of-capital playing field without significantly reducing tax revenues.

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[15] My primary concern here is that due to inadequacies in the presently defined HDTV testing process, it may not fully reveal the superiority of progressive scanning, as proposed by some U.S. firms, and that the evaluation process does not yet include adequate criteria concerning interconnectivity, modularity, flexibility, or extensibility.

3. Potential remedies which should be studied more aggressively and promptly include:

a) Limiting to reasonable levels certain present lottery-like legal liabilities, particularly in critical industrial sectors. Open-ended punitive damages are most suspect here.

b) Develop a new globally acceptable rationale and method for tariffing imports in critical sectors where national industrial integrity is at serious risk. It has recently been argued that the societal costs of such selective tariffs can be quite modest.[16]

c) Legislatively reducing risks associated with potentially unlimited patent liabilities resulting from rights assigned or recognized in an untimely or unpredictable manner[17].

d) In past decades numerous antitrust consent decrees increased competition through effective mandatory fair licensing by dominant technology owners such as RCA, AT&T, IBM, and many others. Because U.S. antitrust law is a weak international tool, new more limited legislation to achieve similar licensing results within the U.S. market might be desirable, and should be studied. Other nations have already addressed this problem in a variety of ways.

e) Lowering the cost of capital in threatened critical technology areas by means of low-cost patient government capital. Such loans could be provided, for example, through qualified investment groups rewarded only if they retain their investments to the end, and if they prove profitable for the government.

f) Develop a new globally acceptable rationale and method for limiting foreign ownership within critical categories of national assets. Other nations have established a wide diversity of precedents in this area.

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16 See, for example, Paul Krugman, The Age of Diminished Expectations, MIT Press, Cambridge, MA., 1990.

17 This is a greater concern for small firms without the financial or managerial resources to pursue even a just cause: the legal costs for large firms can also be substantial, as in the dispute between Polaroid and Kodak. The recent tardy award of a key laser patent further illustrates these risks.

Mr. VALENTINE. Thank you, Dr. Staelin. Thank both of you. I want to ask just a few questions and then provide most of the time for the other members of the subcommittee.

I don't want to interject anything that is going to take anybody by surprise, or get into something that is unnecessarily controversial, but I have to ask you if you would care to comment on what we have heard from your testimony and what we hear from testimony other witnesses about the obligations of American business leaders to the shareholders in a corporation.

I think we understand that the boards of directors and the chief executive officers have some responsibility to see to it that the investors, first of all, their capital is well-protected, and that they make an income—that they earn a little money now rather than a promise to be earned 10, 15, 20 years ago.

What I want to ask you is how does that type of thinking fit in with the ten top, highest-paid executives, chief executive officers in the union receiving an average of $20 million each in salary? Is that really part of the problem? Is that an indication of some disease of greed that is always going to be there to affect us when we combat the Japanese and Germans?

I'm not suggesting they give that money back to the Government. If you don't have any comment, I can understand but it seems to me in all the talk about what we need to do in the country and about innovation and we're falling behind. I daresay that some of these companies have lost their positions of leadership over the past years, have really been losing ground while the pay of their executives goes up and up. You don't want to comment on that, I don't think?

Dr. STAELIN. We find it inexplicable.

Mr. VALENTINE. Good for you. It is a shame. In view of that, Dr. Kahn, what do you mean by a restoration of national leadership in this area? Are you talking about a leadership in business and industry, or is it all the Government's responsibility?

I bet you these guys that we're talking about now—I won't call their names—would say oh, well, any problem we've got with our company, that's the fault of the Government.

Dr. KAHN. I think the issue here is how one gets multiple organizations to work together toward a common objective that is clearly more than what they can do all by themselves. You're talking about situations where no one organization has all the wherewithal, they may not be able to afford it all separately, where there are no established procedures for dealing together, where no one can obviously take the lead—if anyone does take the lead, it's in some sense a threat or a challenge to the other parties. This is particularly true when there are multiple industries involved.

It seems to me that historically these kind of areas have been ones where only the Government has been able to somehow enable progress in the form of either seed funding or an imprimatur of some sort and I think it's going to turn out to be especially important in this infrastructure area.

The leadership really comes about from the essential need to have a vision of what this architecture can look like. That's really what this session is all about. It's been my experience that when you're putting together complex systems, it's usually either one person or a very small set of individuals that have to somehow get the concept in their heads in order to make sure that the pieces all play together; but that can be done in a way that gives all the participants the opportunity to do what they do best, and in the most effective way.

That's why you hear terms like interfaces come up all the time and protocols because those are really the life blood of these systems, so I think you need a leadership role from the Government to be an enabling factor to get the process going. You need leadership from individuals who can gain the trust of all the parties and essentially make sure that the standards, these interfaces, these protocols are developed with everybody's interest in mind and that the system can then have a chance of emerging with sort of arms length arrangements with all the parties.

Mr. VALENTINE. Dr. Staelin?

Dr. STAELIN. I think we want to be our own architect because we have a national culture and tradition that may not be the same as if somebody else becomes our architect. I could imagine if we let somebody else be our architect, our highway system, so to speak, might look like a network of interconnected toll roads, and we may not be the toll collectors.

In other words, we want an architecture for our information system that's open and flexible and permits our entrepreneurs, small ones, to compete. That is not the way these other parts of the world are organized. I think that will be reflected in their architecture. I think we can be leaders in this area and bring a fresh technological vision to this opportunity.

Mr. VALENTINE. What do we say to those who say—what should the Government's obligation to U.S. consumer electronics industry be in addition to the support which the Government gives to Sematech, for example?

Dr. KAHN. I think you have to make a distinction between the building up of the supporting mechanisms, whether they are cost of capital considerations, depreciation scale considerations, the building of infrastructure considerations, and the ability of any one industry or parties in that industry to compete effectively. It seems to me they are both important concerns.

One is one that the Government can get very directly involved in and has in the past, particularly in the road system. Having a first class highway system in the United States does not guarantee that the U.S. auto industry is going to be the lead manufacturer of automobiles. Historically that was the case, it's increasingly under challenge, and it seems to me it's a separate set of concerns that really ought to address the ability of our manufacturing sector and service sector to really compete effectively in what's now increasingly the international marketplace.

It seems to me that if we can keep those two separate, then we have a chance of understanding how to proceed accordingly.

In the case of Sematech, I've talked with Bob Noyes many times before he passed away recently and his view of Sematech — which I think I can say fairly accurately—was that he saw it as a placeholder. He was holding a candle, a lit candle hoping and praying, I think, that the United States Government would figure out something to do to put the U.S. semiconductor industry back in a competitive position on the map.

I don't think he had the answer for that and just how one goes about debating and deliberating what that answer is, is an interesting question in its own right. I know that Sematech has not declared its mission over as this point in time and in fact, they are looking to play a significant role as the 1990s move on.

Dr. STAELIN. You ask an interesting question. You cited consumer electronics and Sematech and semiconductors. What's the essence of a critical technology? What is it that makes one thing critical, or more critical, than another?

I think our objective here, our national objective is to insure that we maintain a free enterprise system where our companies, large and small, can develop concepts to meet a market, move out and develop it, and sell it competitively. This requires that they have access to state-of-the-art technology and other resources.

If a technology is basic to a large number of potential entrepreneurial initiatives, as is semiconductors, semiconductors are going to be a key part—already are—of everything from toys to refrigerators, to stoves, to anything you can think of, they are vital to computers and weapons, you cannot have a situation, a free enterprise situation, where the technology and the control, so to speak, of the technology is in principle outside your direct reach. In the attitude of industry that that's outside, or it might move outside at somebody else's will, randomly outside their control, is a very inhibiting thing. It's like dominoes.

A critical technology is a technology where if you lose it, there is high probability of a domino effect, and certainly semiconductors in that category.

What about consumer electronics? What's the essence of consumer electronics? I think of that not so much as toys we use at home. I think of it as the manufacturing base capable of manufacturing low cost, sophisticated electronics. That includes telephones and so on.

I think a technology like that, the manufacturing perspective of it, is a critical technology, but I don't think one has to manufacture, or be, in all sectors of the business to make our entrepreneurs free of being held hostage to somebody else's decisions. In other words, it's not necessary for us to manufacture in every category of consumer electronics.

What we want is, if a manufacturer has a concept or product he wants to develop that needs that technology, there should be in our industrial base the resources he needs to do it.

Dr. KAHN. Mr. Chairman, if I could just make one other comment along those lines. One of the attributes of Sematech that I think is a rather interesting counterpoint to the infrastructure discussion that we're having today is that one of the methods of attracting semiconductor participants into Sematech is that they have unique access to the results of the Sematech work during the time that they are members, and the technology is moving so fast that if somebody were to wait a year or two or three, when it becomes available in the public domain, then it's fundamentally been overtaken by events.

It's sort of like saying that if you want to pick your raspberries in my raspberry patch, you can do so for the first two years and after two years, anybody can pick in the raspberry patch but there are no more raspberries left. So there is an incentive to join this organization in the first few years simply because the raspberries will be gone.

On the other hand, the infrastructure is very different. Somebody can afford to sit on the sidelines for a year or two, let somebody else pay for that infrastructure and then simply get on this highway that flows behind your house and simply pay the tolls. So we need to think creatively about mechanisms that will encourage all the parties that have interest in this, and that's many industrial firms, to have an incentive to become part of the process of creating this infrastructure. It's very different than the situation facing the consumer electronics folks.

Mr. VALENTINE. Before I yield to Mr. Ritter, this is, at best, the free enterprise system and a different facet of it, isn't it, because usually the free enterprise system, business says to Government, let us go, release us, we can do it, but here this edition of the free enterprise system says, we need the Government to tell us what to do. We need the Government to help finance this. We need the Government to reduce our taxes. We need the Government to cut the shackles of all this antitrust stuff, let us go. If we consume somebody else along the way, that's tough.

Isn't there some element of truth in that statement and then regardless of that, we come to Government and we say to do this we've got to have billions of dollars of tax money. We put that tax money into research and development and that gives mankind all these fancy new conveniences, and the next thing we know, the crown jewels are sold to the Japanese. And they are manufacturing all this stuff that was developed by American taxpayers, their dollars. Is there any cure for that sort of thing?

Dr. KAHN. I think that no one has said on the panel here, and I guess I don't believe it myself, that what's needed is for the Government to tell industry or the research community or the public what to do. What I think is needed is a very fundamental role from Government.

First of all, I believe that Government can provide the seed funding to catalyze some of these developments by simply staking out an area that you feel is worth investing in, even if it's at a fairly low level, it often can catalyze very much larger investments from the private sector because they can get on that horse.

Second of all, many of these activities require an imprimatur of some sort. Nobody can stand up and say, I am the leader. It needs to somehow be blessed from somewhere and the Government can do that.

Third, I might point out that many of these activities are ones that—especially the large organizations who can most afford to do it—may not understand what exactly the antitrust implications might be from getting together to proceed in these areas. So some notion of precompetitive collaboration in areas that start to border on infrastructure development or go beyond pure research may be appropriate for the Government to be party to.

It seems to me that also the issue of us building our own infrastructure tends to strengthen the idea that it won't come in from abroad. If we can control our own infrastructure, we really have control of our own destiny in this area, and nobody is going to sell the infrastructure abroad if we build it here in America.

Mr. VALENTINE. The Chair recognizes Mr. Ritter.

Mr. RITTER. Thanks, Mr. Chairman. You certainly asked some really tough, far-reaching questions. Those questions keep coming up, those really important questions about how come we can't do it and they are doing it.

I just recall the last time I was at the Electronic Industry Association conventions, it was in Las Vegas and they had just completed the Mirage Hotel to the tune of $650 million, a couple of years ago at a time when we were desperately trying to get some critical mass together for HDTV or high definition systems research. It was a lot easier to build a quick ROI, return on investment, gambling casino than it was to invest in these other things which are much longer term and take many, many years and very high risk and may never pay back a dollar.

But you build a gambling casino and there's kind of a secret formula—you just put the money in and it starts coming back at a certain—it's no secret formula, it just starts coming back real quickly.

That aside, I talked in my opening statement about a kind of national fiber network, tomorrow's infrastructure for telecommunications in the information age. I take it you are also talking, Mr. Kahn, about a similar kind of infrastructure, a fiber optic network?

Dr. KAHN. Certainly. The work that we've been doing has been based on the assumption that fiber optic networks would be the backbone of this whole activity, except I might point out it's not the only communications technology that's applicable here.

Satellites probably have an important role to play. I think ground radio transmissions will have an important role to play, especially in the portable environment.

Mr. RITTER. I was just picking up that one, but that is, in your opinion, part of the overall infrastructure consideration, is that correct?

Dr. KAHN. Absolutely a crucial piece, but I might point out, not only is it essential, it's also the lowest level piece in the whole structure because just putting a wire into an organization and saying here, there's a billion bits a second or a trillion bits a second, or whatever, flowing out the end doesn't mean that they will be usable to that end party.

Mr. RITTER. With the explosive growth in chip power and computing power and the billion circuit element chips perhaps with some of these new technologies for combining chips on one wafer, on the horizon we might have some of that power. By the time we get the network out, we may also have the power to deal with it?

I made the comment that out there are phone companies, cable companies, and long distance type companies and technology producers, and corporate users, and research networks, and the Government serving as kind of a coordinative body to put these jigsaw puzzle pieces together. Then you also have 50 States with 50 utility commissions.

Do you envision the Federal Government as a potential player here, a kind of adder of cohesion to this otherwise fragmented system?

Dr. KAHN. It seems to me the Government has to play an oversight role, especially if it's a major funder of any of the infrastructure. That oversight role should very carefully crafted. People come in and go out of the Government and I think there's a technical component to this that's going to need continuity over a long period of time.

Also, I think that many of the issues that need to be addressed may very well turn out to be legal—

Mr. RITTER. When you say oversight, let me just into that a little bit. It seems to me that what you need is—if you want to synergize this whole to be greater than the sum of the parts—you need more than a responsive which I view oversight, something happens and you respond. It seems to me you need a kind of proactive provider of cohesion along with these different players which I mentioned in the private sector and try to manage a process whereby the interfaces start matching up whereby the economies of transmissions interstate become rationalized and the utility commission impediments become reduced.

Isn't the Federal Government, in a sense, the only referee out there for such a process?

Dr. KAHN. No, I don't believe that's the case.

Mr. RITTER. Who is the other referee?

Dr. KAHN. I believe that what the Government can do is essentially carefully represent their own interests. By virtue of doing that, they will become a heavyweight player in the process.

Mr. RITTER. What do you mean by carefully represent their interests?

Dr. KAHN. They can represent their interests in the defense arena, they can represent their interests in the space arena, in the energy arena, in the medical areas, and they can also be an appropriate body to think through the long-term R&D implications of what's going on.

Mr. RITTER. Who's out there to proactively cement these jigsaw pieces together?

Dr. KAHN. I actually think that the private sector has the wherewithal to do that if the imprimatur comes from somewhere and I think that imprimatur has to come—

Mr. RITTER. You give me a definition of imprimatur and what does that mean?

Dr. KAHN. I think for example the current INTERNET and NSFNET is a very good examples of how that might work. Here is the case where the Federal Government really plays a very important role in insuring that the direction of networking is headed in the right direction, that the facilities and capabilities that the research community needs are being sought, being met, but the actual development of the network, the structures, the protocols, are all being done in the private sector.

Mr. RITTER. I think you and I are probably saying the same thing. I don't envision the Federal Government developing technology. I don't envision the Federal Government creating structures, but I envision some body that gives cohesion to the myriad players who constitute the system. After all, NSFNET or NREN in the future is really just composed of research institutions and you call it a federal imprimatur. There is a coordinative role played by the Federal Government to keep these parties at the table discussing with one another what the interfaces should be and how to optimize the overall impact of the system.

Dr. KAHN. I think we are probably in close agreement. I would call that an oversight role because they are generally not involved in the day-to-day details of developing the technology.

Mr. RITTER. I have also proposed that when there are gaps between these various players they need to be filled or need to be glued, that there is capability for financing between the different elements of structure and interface capacity, and that somehow we would devise a system whereby tolls could be paid once the network was up and running, or maybe we could use new spectrum, auction new spectrum which seems to be gaining—I have a bill in on that but it seems to be gaining credibility in recent months given the wild and crazy lottery system of auctioning off spectrum today where you make multi, multi millionaires out of people who speculate on picking numbers from ping pong balls in a standard lottery situation.

That's another role, isn't it, where we have got holes or gaps systemically between these myriad providers and sometimes they don't even cooperate, they are not talking to each other and they are fighting each other, as a matter of fact. You have to have somebody to kind of bring them together.

Dr. KAHN. Well, this is an area that I've actually be involved in, one way or another, for several decades now, having been intimately involved in creating the ARPANET which was the first of the packet switched nets and being one of the architects of the protocols for the INTERNET which is what glues together all the different components that exist in the network of networks today.

I would be inclined to envision an NREN, for example, that is not a single network where there is one party collecting the tolls, but rather it is an integrated collection of networks that parts are provided by various parties that are in the business. You'll have the long distance carriers, you'll have the telephone company, the regional telephone companies, you'll have the various cable— various providers will all somehow get together and they have the wherewithal within those organizations to resolve the kind of problems you're talking about if they can.

Where the Government is needed is to come in and resolve the problems that they are unable to resolve by themselves. I think the Government funding to the extent that it is required, and it is crucially required for the research and development phase, can in fact go right to the end users who hopefully will make a choice from among the different alternatives that are there, but it will be one, cohesive, integrated system.

Mr. RITTER. Dr. Staelin?

Mr. STAELIN. I'd like to add to that simply that I believe there's a distinction here between the generation and the creation of the vision—which is a technically very complex task; it's a cross industry task, involves a lot of creativity and careful work—

Separate that from the implementation of the visions and I think you're absolutely right. There's a problem here between 50 State regulatory agencies, a federal system which is a crosswork of television, FCC regulation, and other regulatory bodies of all types. How do we move into this new area and straighten things out, so to speak?

I believe that first we have to articulate that vision. I think the job of Government here is not to, itself, articulate the vision—it's a very challenging task—but as I suggested, to be the spark plug, a critical spark plug in stimulating this step forward in the private sector, which is very difficult to initiate because it's counterculture, getting competing companies looking at market share issues in a very profound way, to collaborate and cooperate and create an open structure. I'm sure the legislation will be required here if a good vision exists. I think it's for Congress and Government to be the spark plug, for the private sector to respond, and then for legislation from Congress to bless whatever vision or combination of visions they wish, to resolve this regulatory transition into what may be a new era.

Mr. RITTER. Our legislation envisions a Coalition for Fiber Optics in America. I want to thank you for your excellent testimony and hopefully you can join with our Coalition for Fiber Optics in America and join some of these players in this high stakes game. I'd like to take advantage of your in-depth knowledge in the future.

Thank you, Mr. Chairman. I yield.

Mr. VALENTINE. The Chair recognizes the distinguished gentleman from Arkansas.

Mr. THORNTON. Thank you, Mr. Chairman.

I would like to pick up first on a general thought that what you're calling for in this particular instance is the development of a strategy, developing a consortia of private industry, academia and Government, a new way of thinking about improving American competitive position in high definition systems.

It occurs to me that the need for that strategy may indeed be broader than only in high definition systems, but that the remedy which you both are suggesting might have application to a wider fabric of economic development in the interest of our national security as far as being competitive economically. How do you react to your suggestions as being a model for further use, either one of you?

Dr. STAELIN. I think it would be a reasonable model for a number of areas, for manufacturing—for example, the relationship between the machine tool manufacturers and the technology developers there and our manufacturers like the automobile industry, which is vanishing, seemingly, almost before our eyes if we look at their deficits each quarter.

However, I think one doesn't want to do too many experiments in parallel. I think we should think of this as an experiment, although I'm reasonably confident of its success. I think you're right, it could well be a model for other areas.

Mr. THORNTON. One thing that concerns me, I was impressed with your suggestion that we need to maintain our free enterprise system and indeed the free enterprise system, regulated as it has been, is still considered by many people in the world to be a very splendid method of approaching markets.

I would like to suggest that maybe it is not as free as your statement implies. I have on occasion suggested that our great free enterprise system might be a bit like Gulliver on the banks of Lilliput, tied down by thousands of threads, many of which don't have a reason anymore, but which do inhibit both by culture and by law the development of the strength of our economic power to meet national needs.

I think not only your allusion to antitrust laws but the culture itself may be at fault. We have been told in other committee meetings that an American manufacturer will be reluctant to walk down the street to someone who thinks of as being potentially a competitor in order to buy some products from that person to use in his further manufacturing but has no hesitation in going across an ocean, either east or west, to purchase from overseas suppliers. Do you think there is a cultural problem here?

Dr. STAELIN. My experience has been that if he's going overseas for something that's exactly identical to what he can get down the street, he probably views the people overseas as less serious competitors.

Mr. THORNTON. As less serious competitors.

Dr. STAELIN. Exactly.

Mr. THORNTON. And yet that does not seem to be borne out by our recent experience with foreign trade. What I'm wondering about is, it seems to me that we have recognized in this Nation that our national interests, the interest of all of us, can affect the direction that our policies take and not always at the disadvantage of the free enterprise system.

Rather than the free enterprise system, I'd suggest we have a regulated, short-term, profit-driven, selection process that is influenced both by concerns and fears of litigation, that has really damaged the ability of American companies to remain on a level playing field. I see you shaking your head, yes. Do you agree with that?

Dr. STAELIN. I certainly do. That's one of the items I suggested for study, is this lottery-like, legal liabilities.

Mr. THORNTON. Let me take it another step. If you agree that the intervention of the national interest justifies making some changes of direction providing maybe vision, leadership and direction to the way we take, can you not find an illustration of that intervention in something we're all very proud of recently, and that is the purchase of the military of high technology hardware which had such a tremendous beneficial effect in the Persian Gulf.

Did that damage free enterprise to have that intervention of the national interest in the selection of systems that were important to our country?

Dr. STAELIN. I'm afraid I have an interesting view on that.

Mr. THORNTON. Let's hear it.

Dr. STAELIN. My view is that our federal procurement process is seriously deficient. It is one of the greatest handicaps this country has. I think the opportunity lost because of that system is enormous. It's tens of billions of dollars per year equivalent waste because that system is so inefficient. There is overlay upon overlay of regulatory oversight to the point that we have lost track of where we are going.

So I believe that we have a tremendous opportunity here, as we did in the past, to actually achieve, to incidentally accomplish a great deal of forward movement in technology efficiently. Today that is much less efficient.

Mr. THORNTON. And in a much better way than by having the Government become the market for the high definition television, for example. Is that what you're saying?

Dr. STAELIN. No, I was speaking strictly in terms of military procurement in the FAR. The Federal Acquisition Regulations are a tremendous burden on the efficiency of our whole enterprise.

Mr. THORNTON. And what you're suggesting by means of a consortia, leadership, stimulation of an orderly plan of getting a longer term look at products is a contrast to that system, is that correct?

Dr. STAELIN. It's in a totally separate sphere. One is federal acquisition for federal use as a military system, for example. The other is support of the national industrial infrastructure where there is no hardware deliverable. It's essentially a vision by which our free enterprise system, companies in competition, and collaboration, can move forward. It's really quite separate in my view.

Mr. THORNTON. Dr. Kahn, do you have some comments?

Dr. KAHN. Yes, Mr. Thornton. I was just going to say that many of the things that we've been talking about today that we'd like to see come about in terms of an infrastructure do not exist today. The components are there, but the methodologies for putting them together, the agreements, the standards, those capabilities don't really exist and I think they can't be created from on high.

That is, somebody cannot sit down in a room, stare at the ceiling, write them down, as would be the case, and have everybody march to those orders. I think it's got to be done in a more interactive fashion, it's got to involve the participation of the relevant parties, and I think—

Mr. THORNTON. It requires a dynamic process.

Dr. KAHN. It requires a process—I'm particularly enamored by this testbed process that we've been able to put in place in the country because we've got almost three dozen major organizations—the biggest in the country in some cases—participating with us in trying to develop some of these capabilities, many of the leading universities, some of them are represented here today.

Having the research participants, having the industrial participants, having the eventual providers of these services work together collaboratively in some of these activities which can be done in an arm's length fashion, doesn't require tight consortia. It can be done in reasonably loose consortia. I think it is a very attractive way of underst ding how to make progress in these areas.

Mr. THORN It seems to me to be important to take lessons from the past to see the importance of strategies and pulling together groups of people who have a variety of view points in order to develop a plan of action that can be effective.

I've been referring frequently to the difference that happened right after World War II. For two-and-a-half years after World War II, the United States poured over $11 billion into Western Europe in an uncoordinated, unplanned relief effort to address the tragic circumstances that both friends and enemies were facing in that arena, and the same thing in the Pacific realm.

Then came an idea of a comprehensive, coordinated plan and we applied about the same amount of money, $13 billion, which was incidentally about 2 percent of our gross national product, to rebuilding Europe. We took 8 months of bringing the finest minds in America and in Europe, and in academia and in Congress, and in the Executive Branch together to formulate a coordinated, comprehensive plan of action which we called the Marshall Plan for Europe.

Before the first dollar flowed, the recovery was already taking place from the act of developing a strategy, and in the next 3-1/2 years an expenditure of $13.5 billion, about the same, accomplished amazing results. A number of my colleagues and I have been saying that we need today to have a Marshall Plan for America and to approach it just as carefully and with the same intensity that we did in allocating 2 percent of our gross national product to Europe after World War II. Do you have any comment on that idea?

Dr. KAHN. I have sort of a tongue and cheek comment. I think we haven't quite succeeded in defeating ourselves at home, so it seems to me the parallel isn't quite—

Mr. THORNTON. I saw a recent cartoon that during the Persian Gulf conflict where one of the generals said we have just about destroyed the Iraqi infrastructure of roads, bridges and highways, and another one said, that makes us even. Our infrastructure is in pretty bad shape, both in roads and highways and also in manufacturing infrastructure. We have, indeed, abandoned to the short-term market drives a good bit of our productivity.

Dr. KAHN. Let me give you a serious answer. I actually think that the wherewithal to create some of these in the United States is latent. If you look, for example, at the pension funds, you've got trillions of dollars in the pension funds. Those are funds that are really intended to deal with our long-term interests in the United States.

To the extent we have a strong economy in the country, those funds could be invested. It seems to me that the economy in this country is going to remain strong only if we're able to make the long term investments. If industry can't do it, may be we can find a way, may be the Congress can help, to get some of those pension funds invested in the long- term interests which may help retirees more than just leaving it in industries that are no longer competitive.

It seems to me there are literally dozens of possibilities that could be looked at. I'm not the expert in knowing which one of those is going to play the best and every one has its own pitfalls, I'm sure, but it seems to me that the resources are here, the wherewithal is here. We certainly are doing our part to try and provide a leadership role, but just who is it that can provide the imprimatur. It's got to be the Government that says we want this thing to happen and we're willing to take the steps to enable it.

I suspect out of the diverse set of resources in the country, whether it's the universities and the nonprofits, the industries or the Government itself, it will get itself organized if the Government simply makes it clear that it would like this to happen.

I don't think we need a Marshall Plan with the same level of detailed planning to deal with our problems. I think we have the wherewithal to deal with it in a more culturally acceptable way.

Mr. THORNTON. Certainly. I'm not suggesting that we should apply the Marshall Plan, but the suggestion is, is it time to develop the kind of strategy, the kind of thinking that led to the development of a Marshall Plan approach?

Dr. STAELIN. I would be inclined to think that our problem today is different. I think what's broke today is not our factories rundown and rusted, so much, things like that; it is our intellectual understanding associated with our moving from national economies into a global economy.

Mr. THORNTON. So that's what we need to fix, isn't it?

Dr. STAELIN. Let me give one example of an issue that I think is absolutely essential to all that we've been discussing here today. In the last century we had a free enterprise system, and toward the end of that century we saw the growth of large monopolies, trusts, and we saw that as being inimical to free enterprise by smaller entrepreneurs the myriad ways that successful, large firms could undermine their competitors until in fact there was one U.S. Steel. We said that's not good for free enterprise, it's not good for economic efficiency, and we enacted antitrust laws.

What's happened today? We've gone to a global economy. That antitrust law fix worked when we had a national economy. That fix doesn't work in a global economy because other nations have sovereignty. We need a new vision that stabilizes that old instability because what's happening, very clearly, is we are moving back to the patterns of the previous century—very large companies, Thompson, Philips Electronics, and many large Japanese companies, vertically- integrated, powerful, overseas, beyond our reach, and the only thing we can do to stay in business, in competition, is maybe we create a few of our own giant companies. IBM maybe can stand the heat for a little while longer, General Motors, Boeing, but the smaller companies essentially are still in business, but really in business at the sufferance of larger companies who could change their policies at any time.

Mr. THORNTON. I have used my time, but I would like to say that I think we are in agreement that what we need is new strategies to meet a changing world and that we should adjust our strategies to the circumstances in which we find ourselves.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you.

The gentleman from California, Mr. Rohrabacher?

Mr. ROHRABACHER. Thank you, Mr. Chairman. I'll try to be brief, just one note about pension funds.

This also ties into the Chairman's comment about the inexplicability of people running our corporations paying themselves enormous salaries at a time when our corporations really aren't doing that well.

I am personally a supporter of ESOPs, employee stock ownership plans, which I believe would make business leaders a little bit more responsive to their stockholders, especially if the stockholders are part of their own company, and it would also provide that pension funds which today basically are invested through institutional investors who have the most limited, long-term views—in fact they are only interested in quarterly dividends and that is it. If you don't get a quarterly dividend, they are going to pull their money out of a company and that is as short-term as you can possibly get.

I believe under ESOP programs where people own their own company, they do have a longer range of interest in terms of investment in the company because they want that company 20 years from then to be a viable entity, but that's another area.

I think this type of fundamental reform when we're talking about the technological challenges which this hearing is all about, I think we've got to look at some of the fundamental issues. I think you touched on the whole antitrust area and your last comment was right on target.

These antitrust laws basically were set up in another era, another time. Just as I believe we need to have some fundamental reform that makes sure the pension funds in this country are actually allocated in a way which will have a long-term effect rather than a short-term effect, and I believe ESOPs are part of that answer.

It's clear for us to be competitive in this coming technological age, we are going to have to have major changes in the antitrust laws. Antitrust law is the highest technology I think that was available at that time. You talked about U.S. Steel, but we were in an era when railroads, that was the ultimate technology.

One note on the Marshall Plan. I studied the Marshall Plan and I found that one of the reasons the Marshall Plan was very successful was not that we were pumping money into Europe but that what we insisted on, for the Europeans to get that money, they had to tear down many of their own economic barriers that at that time prevented Europe from progressing. Some of the trade barriers, in particular, in order to get that money had to be torn down. Some of the tax structures had to be changed in order for the Europeans to get that money.

It seems to me that some of our emphasis in looking for a plan for how we can meet this technological challenge of the future, if it is a Marshall Plan, it should be aimed at tearing down some of the impediments making some of the changes that will be necessary for our own corporations to succeed.

Rather than just looking at it as a means of pumping money into some area, which leads to my first question, we have limited amount of money and both of you have suggested that perhaps we could target technological areas in which to make available funds to make sure that we can compete, maybe perhaps in the form of loans.

Instead of asking you just where you think the money should go, what I want to ask you is, what areas should the Government neglect? If we have choices to make, what areas in technology should we just write-off and say we shouldn't put money in these areas, this is not something that's worthwhile for the Government to invest its time and resources in. Could you give me just one or two examples of things you think just forget it for the Government?

Dr. KAHN. It seems to me that the area where the Government's money is best leveraged are areas where there are new opportunities that wouldn't normally arise within the private sector on their own. That's why I think the Government's target investments in research and development are broadly in that community to seed new areas is a first order imperative and their ability to support users in using infrastructure in the R&D community—universities in particular.

Therefore, it would seem to me if we have some of the so- called sunset technologies, sunset industries which are using old technologies but are phasing out, it seems to me inappropriate for the Government to choose as a major focus area to try and prop up areas that are just no longer the wave of the future.

I can easily imagine that people may come up with more and more innovative ways to use horse drawn technology or coal resources.

Mr. ROHRABACHER. That I concede. There is a lot of people who believe we should use our funds to subsidize businesses just to keep them running. I understand that concept and that was well spoken that we shouldn't.

What about some of the new technological areas? What shouldn't the Government get involved in?

Dr. STAELIN. The history of the consumer electronics industry is interesting. If we look at the way the Japanese—who are the most successful entrepreneurs in this area— moved ahead of the United States, there are some very interesting lessons.

They put their money by and large into the next generation. They put a lot of money into developing transistor television sets, first at the black and white level, and then in color. They put their money into the next generation of manufacturing technology. So, echoing Mr. Kahn, one of the things we do want to do is the next generation, which implies that there is a last generation, and there surely is.

It's generally from the last generation that you get the strongest pleas for support—because they are suffering anyway, and so that's one distinction, next generation versus last generation.

The next criterion I think one can use is: when we look at the entrepreneurial opportunities on the part of both large and small firms, where are they, what do they need as ingredients in order for them to succeed in a polytechnology product? Some of those areas are in fact going to be well free traded. There may be multiple global regions which provide competition, it may be a true competitive market. There are other areas which are not truly competitive, where in fact some region of the world, there may be some one company controls it. So again, it's in those areas where your risk of freedom loss is greatest that I think should receive greatest emphasis.

Those areas where we have suppliers competing, say in Europe, suppliers competing in East Asia, and other parts of the world, those are less important. They may be just as critical as technologies but they are less at risk.

Semiconductors is certainly one of the areas which clearly is at risk. Advanced machine tools is another area which clearly is at risk because of the national competitive market situations in those areas.

Mr. ROHRABACHER. Thank you very much.

Mr. Chairman, thank you.

Mr. VALENTINE. Thank you, Mr. Rohrabacher.

Thank you gentlemen very much. We appreciate your sharing these words of wisdom with us.

Mr. VALENTINE. We go now to the second and last panel, Mr. Clark E. Johnson, Dr. William E. Glenn, Dr. Robert Sanderson, and Mr. Alan R. Blatecky.

The Chair would appreciate it very much if you would summarize and if you could possibly limit your summaries to 5 minutes each, we will see to it that your prepared remarks appear in the record as presented to us.

Mr. Johnson?

STATEMENT OF CLARK E. JOHNSON, CONSULTANT, DENVER, COLORADO

Mr. JOHNSON. Thank you.

I'm Clark Johnson, an independent consultant. I have no affiliation with any company involved in the whole area of high definition television except I'm a founding member of COHRS which is the Committee on High Resolution Systems, which is an outgrowth of the Ad Hoc Committee on HDTV that Congressman Brown alluded to.

Because people believe that there is an inexorable convergence of computers, communications imaging, information technology and consumer electronics, the Nation's ability to decide how we as a Nation participate will depend upon how well this convergence is anticipated, developed and managed by American companies and the Government.

We've heard today from a number of people on a number of very good questions on how this is all about to happen. Let me make a couple of remarks in addition to my written text.

I think Congressman Ritter is right on. The bidirectional, fiber optic, super highway is certainly the wave of the future and it can be compared to the building of the U.S. super highway system, the freeway system that we all use.

That was originally conceived in 1939. It took 25 years before it was legislated into action and another 15 years to build. We might hope it won't take 40 years for the fiber optic network to be in place.

It is estimated that about $200 billion will be spent building this network. It's hard to conceive of how that much money can be spent by private industry and I have a suggestion for a way of funding this that was slightly alluded to before.

Suppose, for example, we were to take 1 percent of the social security collections every year and put it into an equity fund to make loans and buy stock in these companies that are developing these next generation products. There is no better opportunity for the future of America than it take some of these funds to help build the country's future.

It strikes me that the money spent here would probably come back by a factor of 10 if the history of the venture capital world is any indication.

The super highway analogy to the fiber optic network is kind of interesting because in much the same way that every car is unique as it goes down the highway with its own license plate, the information being sent down the fiber optic network will have its own header and will have its own direction and identification and destination.

There will be the same sorts of problems as cars stolen, so information security may be breached.

Each of us in our own homes when the fiber network is installed will need a place to park our information and it is in this area I'd like to spend a couple of minutes. I spent most of my life in the magnetic recording industry. This is the industry which very few people know much about.

It is presently in the United States a $50 billion a year industry, yet it is not looked upon as being a leading edge technology. Since its commercialization in the early 1950s, the amount of storage per unit area on a piece of magnet media — tape, discs or rigid discs, what have you—has gone up by a factor of two every 2-1/2 years.

That means at the present time, commercially you can store 200 million bits on a square inch of magnetic media. In order to handle all of this information coming over the fiber optic network, we are probably going to need in our homes a low cost means of storing up to a terabyte of information. A terabyte is an 8 followed by 12 zeroes. This was the entire world's storage capacity in 1960.

We have lost a good share of the magnetic recording technology in this country. We no longer make audio tape players, we no longer make video cassette recorders, we no longer make floppy disc drives and the reason we don't is because they have moved offshore basically to the Pacific rim.

I want to address the whole business of video cassette recorders or video tape recorders because those are the basic technology that's going to be required for our digital information coming over the network.

I might say in the 22 critical technologies, information storage was listed. I also noticed in yesterday's Wall Street Journal the fact that even though the Administration claims not to be choosing winners and losers, there was a list of winners and losers and high definition television was listed as one of the losers.

We have lost the infrastructure and I think this is an example of the problem. We have lost the infrastructure necessary to support the United States manufacture of video cassette recorders. We lost this because in the 1960s, the Ampex Corporation who holds all the basic patents on video recorders decided that there was no market for consumer video recorders. There have been 50 million home video recorders sold in the United States since the Japanese commercialized the product in the early 1970s.

The total dollar volume is about 100 times that of all of the studio video recorders that have been built in the United States.

One of the technologies that has gone away is the little heads that are used to put the information down on tape. These are basically made from single crystals of ferrite. There is no longer any capability in the United States for growing single crystals of ferrite. This has all moved offshore.

If you go out and try to buy some of these heads made from single crystal ferrite from the Japanese who are virtually the only vendors in the world, they will not sell you the select material. They keep that for themselves. This is just an example of what we were talking about earlier but a specific example.

I'll end my remarks with that and take any questions.

[The prepared statement of Mr. Johnson follows:]

TESTIMONY OF

Clark E. Johnson, Jr.
Technology Consultant
Denver, Colorado

Before the

SUBCOMMITTEE ON TECHNOLOGY & COMPETITIVENESS
Committee on Science, Space & Technology
United States House of Representatives

HEARING ON

High Definition Systems

14 May 1991

I am pleased to have this opportunity to participate in this extremely important hearing on High-Definition Systems. Let me state that I am not a representative of any company, affiliation of companies or other special interest group. My sole interest is in seeing the United States play a significant role in determining its own destiny in the design and implementation of a nation-wide, interconnected, high capacity communications system. Such a system will surely change the way we live.

There is an inexorable convergence of computers, communications, imaging, information technology and consumer electronics. The nation's ability to decide how we as a nation participate will depend upon how well this convergence is anticipated, developed and managed by American companies and the U.S. government.

The vision is that we will all be connected together by the "digital superhighway" a fiber-optic, bi-directional link to every home and office. In much the same way that the interstate highway system changed America, so too will the construction and operation of the digital superhighway. I should point out that it took 25 years from when the Interstate Highway system was proposed in 1939 until the enabling legislation was passed in 1956, and then another 15 years for construction. Hopefully, we won't have to wait 40 years for the digital superhighway.

The highway analogy is compelling in a number of ways. In much the same way that each highway vehicle is uniquely identified by its license number, so will the information packets be uniquely identified. Just as cars are occasionally stolen, so to will data security be occasionally breached. It is for these and many other reasons that we need to establish standards for this network.

The mission of the Committee on Open High Resolution Standards, COHRS, an informal, volunteer group made up of representatives from concerned companies and industries states that the current process is uncoordinated, chaotic and often redundant. Individual companies and even industries cannot bring about convergence on their own. Cross-industry cooperation, which brings about coherent standards, reduces risk and cost for all providers of products and services. The success of this effort will deliver substantial social and economic benefits to the United States.

It is here that government needs to become involved, to provide a nucleus and a forum around which the participants can coalesce. The present and past Administration have looked upon any sort of industrial policy as an anathema, avoiding the urgent need to address the issue by calling such policy "choosing winners and losers." Without some sort of centralized coordination it is my view that there will be neither winners nor losers, as the technologies will be commercialized by our Far East trading partners, costing not only control but many thousands of jobs.

There have been few times in history when several different technologies have matured simultaneously and then have synergistically cooperated to totally change the paradigms of the culture. Such is now happening with the technologies supporting high-resolution systems and these technologies together will usher in the "information age."

What are some of these essential technologies? They include fiber optic communication links, advanced semiconductor development that makes low-cost ultra-high speed computing and storage possible, flat-panel displays, software, and very high capacity local storage.

Ultimately the products of this communications infrastructure will be accessible to all at low cost. In fact, ordinary telephone service since it requires only minuscule bandwidth will be almost free. Information will flow in both directions making home-based teleconferencing with high-resolution images of the participants, documents, drawings, models and the like possible in real time. The merging of pictures with text, entertainment including movies "on demand," will be parts of this information revolution.

While all of the parts of the system are crucial, my purpose today is to focus on information storage technologies. I have spent the last 35 years working in this area, predominately in magnetic recording and I would like review the history of the video tape recorder as an example of how easily a technology can slip away.

There has been a great deal of discussion over the past few years on the status of the semiconductor industry and the loss of the majority of the DRAM business to overseas, primarily pacific rim manufacturers. There has been some effort to revive this solid-state memory business in the United States through the creation of industrial consortia (e.g. U. S. Memories).

Unfortunately we have probably lost this war, but there is some possibility of revival as high-resolution television sets are developed and are accepted by the public. When they become as ubiquitous as the television set of today, these high-performance sets are expected to consume the majority of DRAM production. Why? Because to take full advantage of the digital imaging techniques that will be used in tomorrow's high-resolution displays, an enormous amount of signal processing is required, much of it at the receiver itself. The Japanese have realized for some time the thirst high-resolution displays have for DRAMs, and have ben busily building DRAM factories--even in view of the present supply glut.

Compared to semiconductor memories, most are unaware of the data storage industry. At about $60 billion in sales, the semiconductor industry represents about 15% of the information processing industry sales. However the data storage market, which includes magnetic tape, rigid and floppy disks, disk drives, tape transports and optical storage products was just over $50 billion.

Data storage is essential to the computer industry and is a vital component for the implementation of the "digital superhighway." The cost of magnetic storage is about one percent of that of solid state memory. Yet it is fully archivable and reusable.

An astounding feature of magnetic storage is its continuing growth rate and storage capacity rate. From its commercialization about 1950, the areal storage density of magnetic media has been doubling every 2.5 years and continues to do so without pause. At the present density of about 200 million bits per square inch, magnetic media is still several orders of magnitude from the ultimate, physical limit set by atomic dimensions.

Yet magnetic recording technology has often been the poor sister in receipt of research dollars. In 1965 the Vice President of Research of one of America's preeminent computer companies refused to support basic research in magnetic recording stating that it was a mature technology and that everything was known about it! Since then, areal densities have increased by a factor of 250.

It is estimated that the capacity required for a home data recorder in the information era will be about one terabyte--that's an 8 with 12 zeros after it--of binary bits. One terabyte was about the total world storage capacity in 1960!

The data storage industry has kept itself well-hidden from view. Not intentionally perhaps, but rather because it is highly fractured into a number of different components: media manufacturers, drive builders, specific component manufacturers such as magnetic heads, and the like. This fractionation has become a serious problem for the industry because as storage capacities increase, the need to work together to solve problems (such as the head media interface) becomes paramount.

The Japanese with their vertically structured companies have an easier time of it as one company or closely controlled group of companies can work cooperatively on the problems. In Japan, the same company that makes drives also makes recording heads and has an intimate affiliation with a media vendor.

Magnetic recording was not invented in the United States. Rather, it was originally a Danish invention demonstrated at the Paris Exposition in 1900. It was then used successfully by the Germans for unmanned radio stations during world war II. After the war, a number of these German "magnetophones" found their way to America where many companies developed a wide range of audio, video and computer storage products that we see all around us today.

Initially, virtually all of the developments of magnetic recording devices were made by American firms. Yet today there are no American manufacturers of video tape recorders, floppy disk systems or consumer entertainment audio. The consumer video recorder industry was virtually given away and that is a story I would like to relate.

The Ampex Corporation had a long and successful history in the development of magnetic recording products, devices and media. In the late 1950's it had come up with a fabulous idea on how to dramatically increase the amount of information stored on magnetic tape--enough of an increase to make video recording possible. Remember that before the advent of studio video recorders all television programs were done live. The technique developed by Ampex involved mounting the recording heads on a drum and spinning the drum so that very narrow tracks of information could be recorded across the tape rather than along the tape as had been done conventionally.

The Ampex video recorder was an instant success and within a few years all television stations had several of these very expensive machines to provide program time shifting. A development effort at Ampex in the 1960's for a consumer-type recorder was never commercialized and the rights for a consumer video recorder were sold to Sony. The sale of a few thousand studio video recorders at $100,000 each pales to insignificance when compared to the consumer market that now counts over 50,000,000 video recorders sold in the United States alone.

The techniques for making these quite complex devices at very low cost have been perfected to the degree that many of the critical precision parts are made in virtually automated factories. To re-enter the consumer electronics market with a digital video tape recorder would be a major undertaking requiring a significant capital investment.

Why do we need massive amounts of storage? Going back to the superhighway analogy, we cannot know when information packets destined for us are going to arrive. We need somewhere to "park" them until we're ready to use them. Thus, the recorder becomes our parking lot. And we will need to incorporate security and in/out protocols to protect our data.

Suppose that we wanted to call up a movie for viewing. Instead of going to the local video store, we would simply call up the electronic movie vendor and the film we selected would be dispatched to us over the fiber-optic superhighway, requiring about ten minutes to send a two-hour feature. Clearly we need some means for storing this theatre-quality movie until we're ready for it.

Thus it is clear that a consumer digital recorder is a crucial component of the new generation of digital home entertainment and information systems. The question "Is it possible for American firms to enter this market and if so, how," needs to be addressed.

Unfortunately, many of the component technologies for the manufacture of low-cost video recorders have been lost to us. For example, the heads that are such an critical part of high-performance video recorders are made from single-crystal ferrite. There is only one functional ferrite crystal growing machine in the United States and it is not being used.

Why can't we buy single-crystal ferrite for these heads from Japanese companies that are now the only manufacturers? Because they simply refuse to sell us the highest quality material that is essential for the manufacture of digital video recorders that will operate at the data rates required for use with high-resolution systems.

I would like to address some of the issues raised in the charter for this hearing. It seems almost self-evident that the United States needs a coordinating mechanism to reconcile and mediate for the best interests of the nation the often diverse interests of the various constituencies involved here. Such a mechanism must be provided by government. In Japan it is MITI that provides a such a forum.

The COHRS group has been quite successful in bringing together all of the interested parties to outline means for establishing standards. The COHRS mission is to structure and provide technical solutions to guide the harmonious development and application of imaging, computing, communications, information and consumer electronics technologies; encou aging open architecture, interoperability, scalability and extensibility.

The technologies comprising high definition systems are in varying states of economic health. In image processing, both in the hardware and software (e.g. for image compression), we are in good shape. In the area of flat-panel displays we are behind the Japanese. In magnetic storage some mechanism needs to be developed to lure U. S. companies back into what has heretofore been a low margin business.

There is a critical issue of how to finance this information revolution. Some have estimated as high as $200 billion to "wire" everyone with fiber-optic cable. We need an approach that is analogous to the building of the land-grant railways during the last century wherein the railroads repaid the government for the land grants via reduced rates that continued for 75 years.

One suggestion that has received little attention but might be particularly relevant here is to set aside into a special investment fund some tiny percentage, say one percent, of the social security tax collected each year. These funds would then be used to make equity investments in and loans to companies that are developing technologies and products essential to the success of the nationwide digital high-definition infras ıcture and components thereof. Later, when the loans were paid off and the equity sold, the funds, greatly magnified one might hope, would be retired.

Clark E. Johnson, Jr., a native of Minneapolis now residing in Denver, Colorado, received the bachelors degree in Physics and the Master Degree in Electrical Engineering from the University of Minnesota. He has spent his entire professional life in various aspects of magnetics, most of the time in magnetic recording technology. Until 1985 he was a technology entrepreneur having founded several high-tech companies, after which time he began consulting full-time. He serves on the boards of six companies and is a founding member of the Committee on Open High-Resolution Systems (COHRS).

He is a Fellow of the IEEE and spent 1988 as an IEEE Engineering Fellow in the U.S. Congress. He holds 19 U.S. and several foreign patents. He is widely published and is listed in American Men & Women of Science, Who's Who in the West, Who's Who in Technology Today and Who's Who in Industry and Finance.

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Mr. VALENTINE. Thank you, Mr. Johnson.
Dr. Glenn?

STATEMENT OF DR. WILLIAM E. GLENN, PROFESSOR, ELECTRICAL ENGINEERING IMAGING SYSTEMS LABORATORY, FLORIDA ATLANTIC UNIVERSITY

Dr. GLENN. Thank you, Mr. Chairman and members of the committee.

I think there is no question that high definition imaging will be a very important industry within the next decade. The computer industry as well as the television industry are using high resolution technology. They both use high definition displays. They both use high speed digital processing and in the future, they will both require very large amounts of memory.

In this business, I think one of the most important manufactured components is the display if you include in that the consumer television business. About 80 percent of the cost of a television set is in the display and the cabinet. That business is a very large business.

High definition television is not just a sharper picture on your present television set. If you increase the resolution of your present set, you wouldn't be able to see the improvement at the viewing distance that you normally view the image because it would get to be a higher resolution than your eye can see.

In order to really appreciate high definition television, you have to have a much larger display and at the viewing distance that you view consumer television, it needs to be about 5 feet, and for reading distance which is where you view a computer, it needs to be about 2 feet.

This requires new technology and most people agree that for consumer television sets, a 5 foot display would have to be a hang on the wall panel or possibly a projector.

The Japanese industry is spending approximately $1 billion a year to develop just one type of active matrix flat panel display for high definition use. This is the active matrix liquid crystal display. That can be used for either computer displays or for consumer displays.

Most people are a little bit concerned about what a high definition set 5 feet across would look like when it's turned off. I think that assuming that we have recording technology that has random access and stop frame as I think we will at the time high definition is a consumer product, we could probably display works of art on the panel when we are not watching television.

One interesting observation is if you have a 2 hour high definition recording and you display this one frame at a time and change the picture every 15 minutes, one of those recordings would last longer than your lifetime.

The question is what do we do about the recording business? As was pointed out earlier, we're no longer in the VCR business. One interesting observation is that solid state memory at this point is approximately the same density as magnetic tape memory, using manufacturing techniques that are more like tape than like solid state chips.

I think it's probably possible to do the terabyte memory at a cost that would be affordable. As soon as somebody does that with random access, no moving parts for a large memory of this type, the recording business is all over and I hope we do it.

Of course you need other components for this industry. I think if you look in the short term we should look at the areas that we dominate. At the moment, we dominate program production, we have a trade excess in that area. I think we will continue to dominate that field.

In the area of program production we need professional equipment. Right at the moment, the only source of that is Japanese for high definition professional equipment. This is a huge capital investment. I think that they need some competition.

We're certainly ahead in computer software, we're ahead in digital compression. I think in many ways we are ahead in the possibility of high definition distribution. We're actually the only country that's even considering terrestrial broadcast of high definition television.

I think that we need to encourage the fields that we dominate, but I think we also need to look very closely at the fields where we are behind because these are very closely interrelated to these other fields that we're trying to make businesses of.

The areas that we are behind in are generally in the area of manufacturing. We're behind in the development and manufacture of high definition displays, in real time processing as opposed to offline computer processing. In the area of memory, we're certainly behind and also in the development of cameras. So these are all technologies that support the industry that need stimulation.

I think all of these come in the category of manufactured hardware. We are certainly in an environment where I think that there is not an incentive for companies to make long range capital investments in manufacturing. I think somehow that has to be remedied so that we can get back into the manufacturing of these critical components so that we can have a vertically-integrated industry.

Thank you.

[The prepared statement of Dr. Glenn follows:]

Testimony of the Florida Atlantic University

before the

House Subcommittee

on

Technology and Competitiveness

High Definition Systems

May 14, 1991

Dr. William E. Glenn
Director

Florida Atlantic University
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We are entering a new exciting era in which high resolution electronic imaging will play a key role. The computer industry and the visual entertainment and education industry are rapidly merging. They are both converting to high resolution images with over 1000 Scan lines and are both using high speed digital technology for signal processing, signal recording and signal distribution. The United States dominates the computer software and entertainment software (program production) business. However, our position in hardware production to support these industries is rapidly eroding. This testimony is intended to describe what hardware will probably be developed.

High definition television equipment for commercial and defense uses was first developed in the United States in the 1960's. As the U.S. abandoned the manufacture of commercial and consumer television equipment, it also abandoned the exploitation of this impressive new technology In the 70's Japan started a major program to commercialize high definition electronic imaging products. A complete line of equipment has now been developed The image quality is incredible It now equals or exceeds the quality of 35 mm projected film in the theatre

This current equipment is simply the results of improvements in traditional television technology. It is widely recognized that entirely new devices will be needed before high definition imaging will reach its greatest potential By far the most important development that is needed is a new type of display. Basically three new types of displays are needed: one for computer displays and portable TV sets; one for entertainment viewing, and one for commercial use in the electronic cinema and in aircraft simulations.

High definition television is not just a sharper picture on your present size TV set. If you increased the resolution of your TV set at its present viewing distance, you would not see the improvement. The sharpness would be greater than the eye can see. High definition imaging must be a sharper image on a much larger display. Computer displays are normally viewed at "reading" distance. They are typically about 12" diagonal. A high definition computer display needs about a 24" diagonal. The computer industry is rapidly converting to flat panel displays for this purpose for reasons of portability and size.

Electronic imaging would rapidly replace film in the cinema, if electronic projectors were available with enough light output. Aircraft simulators require electronic displays. Projectors designed for the electronic cinema would be ideal for aircraft simulations.

Consumer entertainment displays (HDTV sets) need a 60 inch diagonal at normal viewing distance. Market studies indicate that only hang-on-the-wall flat panels or possibly small high-brightness projectors can satisfy this market.

A large flat panel display would certainly provide an outstanding viewing experience. However, most people would object to the way it looks when it is turned off. HDTV will undoubtedly have sources of recorded images. Why not display works of art on the panel? If the images in a two hour recording were displayed one frame at a time with the image changed every 15 minutes, we could have an endless art exhibit. At this rate, a two hour recording would provide new works of art for your lifetime without repeating. The panel could also display moving scenes, such as fountains or the waves on a sea shore or even moving works of art.

Economically the display is extremely important. About 80% of the cost of a TV set is in the display and cabinet. About 20% of the cost of a computer is in the display. There are several new technologies that can probably satisfy the requirements for high resolution displays. Active matrix liquid crystals can be used for both small projectors and for direct-view flat panels. Japanese industry will spend over three billion dollars from 1990 thru 1992 on this technology alone. They will get a very good return on their investment. It is too early to decide between display technologies at this point in their development. As an alternate to liquid crystal panels, plasma panels and electroluminescent panels could be the best technology for large area displays Solid state laser scanners could be a good alternate for projection displays. U.S. scientists are leaders in all of the technologies except for the active-matrix liquid crystal display. The basic question is - will U.S. industry make a profitable business of the developments?

High resolution imaging will undoubtedly be distributed and stored in digital form. It would require more bits than fiber, cable, satellite and terrestrial broadcast can transmit However the U.S. is leading the world in digital image compression techniques. These techniques will undoubtedly allow us to have a digital quality image (CD image quality) but with transmission and recording capacities that are now used for standard television. There is no doubt that distribution and recording of high definition images in digital form will be commonplace within the next decade

The United States is the only country considering digital terrestrial broadcast of HDTV This effort should be strongly supported The three leading proponents for a terrestrial HDTV broadcast standard are digital. The techniques used by these three systems have much in common. Progress in this field is moving very rapidly The system that finally emerges will probably be a combination of the novel contributions of dozens of researchers in the area. The question has been asked about the importance of standardization. It is no longer necessary for there to be general agreement on a common standard for all forms of program distribution Terrestrial broadcast, for example, could use a different standard than direct broadcast satellite. Some form of industry agreement on transmission formats is certainly desirable However, conversion between formats encoded in different ways has become very inexpensive with digital processing technology. It is important for a signal to have a "tag" that tells what kind of signal it is and important things about its origin There needs to be industry agreement on the format of the "tag" The SMPTE has established a committee to standardize this kind of designation. Once this has been done, many distribution formats can be used that are specialized for the transmission or recording medium. Even the number of scan lines used can be flexible. As cameras, displays and transmission techniques improve, these can be accommodated by simply changing the designation code. Older equipment will still be compatible with new signals but new equipment will show an improved image.

How about storage (recording) of computer data and high definition video? The United States is completely out of the magnetic recording business and almost out of the solid-state memory business. What is likely to happen in this field?

Solid-state memory is now being produced with an information density as high as magnetic tape (in VCR's) or optical disk. It can be electrically read out without any moving parts. It has instant random access to any information in the memory. A recording of this kind can start anywhere instantly, play forward or backward at any speed or can show our endless art exhibit one picture at a time. Can a solid-state memory be made with a large enough area to record two hours of digital high definition video? This is about a million times the information that can now be stored on a single chip of solid-state memory. By using large area thin film technology with parallel access, this can probably be done. As soon as a low cost solid-state memory of this size is produced, the recording business is all over. If the United States succeeds in this solid-state memory development, the memory and recording business is all ours again!

The last area is the high definition solid state camera. The United States dominates the program production business. This industry will need to invest billions of dollars in high definition cameras and digital recorders (hopefully solid-state). The professional equipment business should be high on our priority list.

A new combined industry is developing that includes: a network for the distribution of high definition images and data; the generation of this information with cameras and computers; the production of computer software and production of entertainment and educational program material; the storage of these images and data; and finally the display, using new exciting display technologies. All of these components are interrelated and strongly dependent on each other.

We can't afford to abandon large parts of this industry (such as the manufactures of hardware) without risking the loss of the total. If industry is going to invest in research and in manufacturing plants, it must have strong incentives for long-range investment in these fields. These could be a combination of tax incentives and a subsidy that makes capital available at a low interest rate for investments that can stimulate our economy. The savings and loan associations have made 500 billion dollars worth of poor investments and left us "holding the bag". One percent of that invested wisely could make the United States very competitive in the information age

Mr. VALENTINE. Thank you, Dr. Glenn.
Dr. Sanderson?

STATEMENT OF DR. ROBERT SANDERSON, TECHNOLOGY ASSISTANT TO THE DIRECTOR, EASTMAN KODAK COMPANY

Dr. SANDERSON. Thank you, Mr. Chairman. I do appreciate the opportunity to address your committee.

The first section of the written testimony I've cited my relationship with Eastman Kodak, Kodak being a major supplier of imaging products. In the past, these have traditionally been photographic and film but in the present and future, these will tend to be more electronically based and often involving non-silver media.[1]

Kodak also provides image products that operate over present and anticipated networks including telecommunications.

Things that endure generally play to fundamentals and I would submit to you that as humans, we are visual beings and our visual imaging environments have been limited always by available technology but there is a steady evolution in these environments over time that's been marked by things like the printing press, photography, television, even facsimile machines.

Each major step of these changes have touched every aspect of our lives, the way we work, our entertainment environments, education, medical. They often change the way we do our work and generally even the way we lead our lives. We're standing basically now at the threshold of another major imaging evolution or revolution. This one is stimulated by technology advances in electronic signal processing, computer and communications technology which make available environments that again play to other fundamentals that we enjoy as human beings; that is, the desire for image rich information customized to individual interest, available when we want it, and in a way that we can interact with the information source.

High definition television is an important step toward these new richer image and information environments but that will only be true if HDTV converges with advances in computing and communications.

Major future growth will often be not in the broadcast paradigms that we know today but in the nonbroadcast areas, be these in television or video production or publishing. So the growth environments will be in these new areas that are enabled by the new technologies.

We can't always predict accurately these new applications and how they will develop, but we do know that they will serve fundamental needs and interests and that these will be basically in all areas of business, manufacturing, publishing, advertising, health, education, so on.

Technologies needed to realize this future are becoming available or are predictably going to become available. So it may be less a question of technology than in creating an environment where products are available, satisfying our needs and interest, that we can buy, confidence that they will interoperate with each other,

[1] Refers to non-photographic, i.e. non-silver halide media. Examples include electrophotographic, thermal, dye transfer, ink-jet printing.

and other related products so that manufacturers can produce confident that markets will exist that provide a range of performance and cost options for the consumer, thus benefitting basically the broadest array of consumers as well as product and service providers.

Such a condition is generally achieved through standards. This has been mentioned many times today. In this case, we're discussing standards that must reach across industries, however. These include communications computing, consumer electronics and imaging. This is a difficult problem because while the standards must reach across industries, they also must accommodate current valuable applications. This is, indeed, a difficult problem, but the benefits will be substantial to the Nation or society that develops this solution and I believe the United States' is in the best position to develop that solution.

We have submitted some preliminary work to the CCIR, international standards body. A couple of exhibits are included that give indication of some preliminary definitional work in the standards and architecture area.

In my mind there is no clear shared articulated vision in the United States. Some other countries seem to have a vision. Separate visions are being developed within the United States. These are often from industries or from combinations of industries and in fact, another attempt is included in the materials submitted. This one was developed as input to a joint meeting of the Advanced Television Systems Committee and the Institute of Electrical and Electronic Engineers.

It's in the exhibit and possibly combined with other similar initiatives—for example the National Research Council might become the basis for forming a national vision. It's my belief that having that vision is critical to developing a national strategy.

The very last exhibit in the testimony includes an exhibit that refers to our homes and it attempts to demonstrate that there are at least three separate evolutions in the home that relate to what we're talking about and exemplifies the issues we are dealing with.

The first evolution is in the television area, television evolving from a simple receiver with an aerial or rabbit ears up to cable ready and possibly now advancing to high definition television. We use existing telephone channels now with facsimile machines to move images around and computers and modems for data communication. We have the promise of wider bandwidth with ISDN and fiber optic in the future.

At the same time, we're accumulating a variety of new and nontraditional image and information sources in our homes. These are in the form of video tapes, video laser discs, computer discs, compact discs, making basically a broad array of multimedia available through the appliances that we have in our homes—televisions and computers.

What's not clear is whether these three separate evolutions that we already see there can converge to a richer environment that would serve us better. Would we in some future time be able to transport videophone images of the daughter away at college onto a large screen in the living room so that we could all interact as a family with this person away from home.

We're on the verge of great new opportunities that offer to enrich our lives as a source of new economic opportunity and are critical to our national security. No company or even industry can accomplish this alone and finding the common vision and solutions will be difficult.

Government help is needed to create an environment for cooperation and to stimulate infrastructure creation. Competitive market forces should then work drawing private investment to the resulting opportunity to create the technology, products and services needed to reach the shared vision.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Sanderson follows:]

Testimony
Committee on Science, Space and Technology
Subcommittee on Technology and Competitiveness
U.S House of Representatives
May 14, 1991
Robert L. Sanderson, PhD
Eastman Kodak Company

Biographical Information.

Biographical data for Robert L. Sanderson is included as Exhibit I.

The Eastman Kodak company is a major provider of imaging products. In the past these have most often been in the form of photographic and film products. Presently and into the future the company is broadening its participation to include imaging products in a wide range of technologies including, for example, solid state image sensors, optical disk image capable storage, hard copy printing by electrophotography, thermal dye transfer and ink jet.

Eastman Kodak takes an active interest in the issues of the present hearing, being an active corporate participant in the motion picture and television industries, as well as the professional, business, commercial and consumer imaging industries. Particular to motion picture and television, Kodak is a leading supplier of motion picture film. Also, we have announced product developments anticipating the HDTV market; an HDTV Telecine (35mm motion picture film-to-video conversion) and a High Resolution Electronic Intermediate System (high performance system for electronic manipulation of 35mm motion picture film images and a high resolution laser film recorder).

Eastman Kodak has also announced PhotoCD, a product for broad use in the still imaging markets including consumer. In this product system, 35mm film images are scanned, digitized and recorded on optical disk (CDROM) such that the recorded images are accessible for both television and computer presentation and/or manipulation. This product supports the notion of interoperation between television/video and computer environments, in this case for digitally recorded, color, still images.

Why is HDTV so Important?

First let's explore why there is so much energy about high definition television or the more broadly defined; high resolution systems, high definition systems, high resolution imaging, or whatever your favorite term.

Fundamentally, we are visual beings. However, our visual or imaging environments are limited by available technology. These environments have evolved steadily over time. But there have been major steps in this evolution. These include, for example, the printing press, photography, television and probably also the now ubiquitous facsimile machine. At every major step of this evolution, the changes touch every aspect of our lives. They affect our work, business, medical care, education, entertainment environments. At the same time, they most often change the way that we do our work and in general lead our lives.

We stand on the threshold of another major imaging evolution or revolution.

This one is stimulated by technology advances in electronic signal processing, computer and communications technology. These advances make possible the creation of environments which again satisfy fundamental human interests — to have image-rich information, customized to our individual interests, available when we want it and in a way that we can interact with the information source.

HDTV, as a next evolutionary step in television and video presentation, can also be an important step toward new and richer image information environments. But this will only be so if HDTV evolves in convergence with advances in computing and communications.

Strategy toward new opportunities.

Even as future environments evolve, we will continue to broadcast information in many of the ways we do today, for example radio, motion picture, television, newspapers and books. However, major future growth and opportunities will be in the non-broadcast applications that will become possible. We can't predict accurately the applications that will develop, but we know that they will serve our fundamental needs and interests in, for example, business, manufacturing, publishing, advertising, health, education, training and entertainment.

In many ways, the technologies needed to realize this future are becoming available or we can predict their availability. So it may be less a question of technology than creating:

- an environment where products are available that satisfy our basic needs and interests, and that we can buy, confident that they will interoperate with other related products

- an environment where manufacturers can produce products confident that a market exists

- an environment where products provide a range of performance and cost options, thus benefiting the broadest array of consumers as well as product and service providers.

This condition is achieved through the creation of standards. In the case we are discussing, however, these standards must reach across industries such as communications, computing, consumer electronics and imaging. Further, they must be open to accommodate current applications (for example broadcasting) while at the same time enabling new, image-rich and interactive applications. To the extent that effective standards can be developed within the US, these can be advanced (along with products and services) in the international arena.

The cross-industry nature of this issue, as well as the need to accommodate current valuable applications, makes this problem difficult. Nevertheless, the benefits will be substantial to the nation or society that develops the solution and the US is best positioned to develop this solution. Preliminary considerations have been documented in inputs to the international standards body CCIR (International Radio Consultative Committee), two of which are included as Exhibits II and III. Here the characteristics of imaging in many important industries are recorded as input to the definition of architecture and standards. Also, architecture and standards concepts that are proving effective in the computer and communications industries are set forward for advanced television or HDTV consideration.

"Is there a vision or how do we develop a national strategy or vision for high definition systems?"

There are really two issues here. First — is there a vision, and second — how to get there or a national strategy.

On the first point, there is no clear, shared and articulated vision in the US. There are examples where other countries appear to have such a vision. Separate visions have been and are being developed, often by industries or combinations of industries within the US (e.g., television broadcasting, computing, communications, computing and communications, etc.). But the vision needed is broader than any of these individually created visions. In that regard, one attempt at such a vision was developed as input to a recent series of joint ATSC/IEEE (Advanced Television Systems Committee/Institute of Electrical and Electronics Engineers, Inc.) meetings and is included as Exhibit IV. This, augmented by other similar efforts, (e.g., by the Computer and Communications Industry Association, the American Electronics Association, the National Research Council, the Electronic Industries Association) might form the basis for defining a national vision. This is a necessary step to defining a national strategy toward realizing the vision. In all likelihood this strategy will need government action to encourage cross-industry cooperation and in the infrastructure development/deployment critical to achieving the vision.

What's happening in our homes?

Let's consider the image/information evolution going on in our homes today because it illustrates the issues. Exhibit V depicts the home, noting three separate evolutionary processes under way there; television, telecommunications and media. Television has evolved from simple terrestrially received television to cable and satellite delivered signals, and we now stand at the verge of a next step called high definition television. In telecommunications we have seen new uses of the available telephone channel through the use of facsimile machines for image transmission and computers and modems, most often for data communication. There is now also the promise of wider bandwidth, interactive communication channels through ISDN and ultimately fiber optic channels. At the same time, in many of our homes we are accumulating non-traditional media, image and information sources. These include video tapes, video laser disks, computer disks, compact (optical) disks. These make available multimedia information containing text, images, video and sound, which is variously accessible by the television and computer "appliances" in our homes. What is not clear is whether the three separate evolutions we observe are convergent toward a richer environment or will continue to evolve separately. For example — in some future time will we be able to present the videophone image of a daughter away at college on our large-screen television display so the whole family can interact?

I've taken the example of the home for illustration. However, the situation is even more acutely evident in our professional and business environments where we often desire a greater degree of interoperability between the image, information and communications systems that we use there.

On the verge of new opportunities.

We are on the verge of great new opportunities that offer to enrich our lives, are the source of new economic opportunity and are critical to our national security. Realization of a "digital highway" infrastructure and high resolution systems, can establish the possibility of new and rich, interactive, imaging and information products and services. However, this will require cooperative effort across industries. Government help is also needed in establishing an environment for cooperation and in stimulating infrastructure creation. Competitive market forces, if allowed to work, will then draw private investment to the resulting opportunity, to create the technology, products and services needed to realize the ultimate vision.

EXHIBIT I

ROBERT L. SANDERSON

TECHNICAL ASSISTANT TO THE DIRECTOR ELECTRONIC IMAGING RESEARCH LABORATORIES EASTMAN KODAK COMPANY

Dr. Sanderson began his career with Eastman Kodak as a co-op student in 1957. He joined the Kodak Apparatus Division Research Laboratory in 1968 as a project engineer. During the interval 1975 thru 1985 Dr. Sanderson held various positions in supervision and management in Kodak's Ektachem clinical analysis products development. He was appointed Director, Advanced Technologies in the Photographic Technology Division in 1985.

In 1986 Dr. Sanderson assumed his current position as Technical Assistant to the Director, Image Information Systems Group Research Laboratories. In the same year he initiated and managed the Kodak Boston Technology Center, a Kodak research laboratory in the Boston area emphasizing electronic printing and publishing technology.

In 1990 the Electronic Imaging Research Laboratories formed and Dr. Sanderson continued as Technical Assistant to the Director, paying particular attention to high resolution systems and image telecommunications.

Dr. Sanderson earned a B.S. degree in Electrical Engineering from the Rochester Institute of Technology and a Ph.D. in Electrical Engineering from the University of Rochester. He is a member of the IEEE and on the Microelectronics and Computer Technology Corporation Board of Directors.

EXHIBIT II

Documents
CCIR Study Group
Period 1990-1994

Document IWP 11/9-67
USA 11/9-2
5 September 1990
Original: English

Received:

Subject: Decision 91

United States of America

IMAGING CHARACTERISTICS ACROSS INDUSTRIES

In the past, imaging has often taken distinct forms in different industries.The television broadcast industry has used magnetic tape, motion picture film and video; the movie industry used film; the medical industry used x-ray film; and computer graphics used synthetic image generation. That characterization is changing. Indeed, different industries now use a variety of imaging technologies. These industries could benefit from cross-industry harmonization of standards. Benefits would include reduced cost and increased ease of conversion among formats with less loss of image quality. Further,appropriate standards would enable the growth of high resolution applications across industries and at the same time can permit the participation of many product and service providers. To develop these standards it is necessary to specify as clearly as possible the characteristics of various uses and applications for different industries. Only in this way can new standards be developed that will effectively facilitate widespread but coordinated component and system development for a long period of time.

Following is a list of application characteristics for selected industries.

The Industries include

broadcasting, consumer, defense, education, medical, health, computer and, communications.

<u>The applications include</u>

Television — color motion video; synthetic graphics and animation; signal encoding
Motion Picture — color motion pictures; synchronized multichannel sound; film; large (25m x 15m) projection displays
Medical Imaging — large film radiographs (30 cm x 45 cm); mostly B&W; high spatial and intensity resolution; archival and legal requirements; aversion to compression
Graphic Arts — large, color, high spatial and color resolution; color reproducibility and matching throughout production process; both continuous tone and screened; text and graphics composition, layout, and manipulation
Computer Graphics and Visualization — 2 and 3 dimensional representations; interactive modeling; photorealistic synthetic image synthesis; simulation data and sensor data modeling and display
Interactive Desktop Multimedia — coordinated use of multiple datatypes (text, graphics, image, video, audio); low cost platforms; high volume, broadly available tools; ease of use; interoperability among tools, applications, and communications
Videoconferencing — full motion, color; synchronized sound; significant data compression; multiparty interaction
Education and training — interactive multimedia applications; indexing for search and retrieval; multiple distribution channels (classroom, public library, work, home); multiple distribution media (paper, tape, disk)

A more detailed summary is presented as Attachment I. The table is a summary of image characteristics that differentiate the cited markets and applications and define the nature of the applications. The table is also divided into two categories; the present (NOW) and a look into the future (TRENDS). This dual view is important since the rapid advance of technology makes possible imaging and information applications that in the past have been impossible or at least difficult. Further, trends in applications and markets generally represent products or services valued by end-users and are an important expression of the way that the future will unfold.

	TELEVISION	MOTION PICTURE	MEDICAL	GRAPHIC ARTS	COMP GRAPHICS	DESKTOP M-MEDIA
NOW	color (rgb) natural images electr. special effects motion (25/30 Fps) interlace (30/60fps) 525/625 line res. video encoding elect. xmit. & display 6Mhz terrest. channel displays 5cm to 65cm proj. to 4.5mx6m compressed color synchronized audio stereo audio consumer cost sens. multi element env producer broadcaster transmitter receiver	color natural images film special effects motion (24Fps) 16, 35 mm film 4000 line + res optical projection proj. to 15mx25m telecine to video synchronized audio	B&W natural images mostly still some video high density res (12 bit) direct viewed images 30x45cm x-rays largest fine detail critical very little compression legal/arch. req'ts	color (cmyk,rgb,uvl,...) natural images still images contone & halftone high res (spatial) 10KX10K scanners high res (color) 36 bit color large images 35x43cm common page descr. lang's	color (rgb, uvl, ...) synth. & model images still images animated images 21/2-D (rotation) modest resolution 1k to 5k spatial 24 bit color up to 86cm displays (crt) graphics I/F stds. accelerators/chips API stds. file format stds.	B&W and color (rgb, uvl, ...) nat. synth. & model images still & motion video & animation modest resolution 1k to 2k spatial 24 bit color 50cm displays adequate limited audio complex images text, line art & images documents composition page descr. lang's usability critical consumer cost sens.
TRENDS	more lines (1125/1250) non-interlace displays 1m to 2m compression spat./temp. (bandwidth reduction) (bit rate reduction)	65, 70 mm film big screen 15mX25m > frame rates (60Fps) (special applications) electr. spec. effects digital audio improved films (grain & speed)	remote diag. consult. digital radiography alt. image modalities (NMR, ultrasound) model rend. images	electr. image manip. digital color printing designer workstations complex images text, line art, images	3-D rendering & display	multi element env scanners printers displays platforms networks multimedia complex images video audio info linkages distributed publishing distributed comp content & context del. cons. mkt. adoption

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ATTACHMENT 1

	VIDEOCONF.	EDUC.&TRAINING
NOW	B&W	interactive
	some color	multimedia
	low quality (<TV)	more imp. than pic. qual.
	human I/F import.	interactivity
	still - pix or audio	ease of use
	motion comp.	annual cost critical
	data compression	cap. cost less so
		indexing for search/ret.
		multi distrib. channels
		multi distrib. media
TRENDS	cheaper	big screen
	better coders	higer res.
	more bandwidth	text legibility
	higher res.	customized interaction
	more reliable	intelligence
	digital w/ISDN	more graphics
		simulation & visualization

ATTACHMENT 1 (CONT.)

EXHIBIT III

Documents
CCIR Study Groups
Period 1990-1994

Document USTG-11/1-1
Document 11/1-
17 January 1991
Original: English

Received:

Subject: Question 27-1/11
Question 69/11 (SP 27A-1/11)
Report 1223 (BH/11)

United States of America

OPEN SYSTEMS FOR HRI/HDTV APPLICATIONS

This document discusses the concept of Open Systems as applied to high-resolution imagery (HRI)[1] and HDTV. The bases for this consideration are emerging contribution and distribution channels, and a broader range of applications.

The terms "open systems" and "open architecture" are widely used but imprecisely defined. The imprecision arises because different groups mean different things by the terms. From the perspective of the computer industry, open architecture is simply the public specification of an interface. Other industries have long employed similar principles. For example, the broadcast industry has traditionally specified interfaces and made them public (NTSC, PAL, SECAM). It is important to recognize the new significance of open architecture in the context of recent rapid changes in underlying electronics and imaging technologies, whereby programmes can be distributed to a variety of users via multiple distribution media.

The term open architecture, as used in discussions of the harmonization of HDTV production and programme exchange standards with HRI systems, in general, implies more than just the public specification of interfaces. Parameters that may be acceptable today may be inadequate in the future. Therefore, open architecture further implies an organization of system parameters that are scalable and extensible, e.g., resolution, aspect ratio, frame rate, and colorimetry, for digital imaging and communication.[2,3] A scalable system permits the adjustment of parameters over time and over varying levels of cost and technical sophistication. An extensible system

[1] CCIR IWP 11/9 draft new report, "The Harmonization of HDTV Standards between Broadcast and Non-Broadcast Applications," Tokyo, October 1990.

[2] William F. Schreiber, "A Friendly Family of Standards for all Media and All Frame Rates," Proceedings of the 43rd Annual Broadcast Engineering Conference, pp. 417-426, NAB, 1989.

[3] William F. Schreiber, et.al., "Open Architecture Television Receivers and Extensible/Intercompatible Digital Video Representations," IEEE ISCAS '90, New Orleans, 1-3 May, 1990.

permits future augmentation of system features and functions to embrace unforeseen applications and opportunities. Thereby, an open, scalable, and extensible high resolution systems architecture could provide benefits across industries and applications.

Primary examples of these scalable/extensible principles can be found in computer operating systems, page description languages, and communication networks.

Open architecture approaches have found widespread use over the past ten years. The seminal example is the Open Systems Interconnection (OSI) model, adopted by the International Organization for Standardization (ISO), the CCITT, and referenced in a number of CCIR documents.[4] The OSI model specifies an environment where information is exchanged using protocols following a particular layered pattern. More recently, open standards approaches have very successfully been applied to messaging, electronic data interchange, and document architectures. Far-reaching Managed Information Object (MIO) models are now nearing completion by the ISO and CCITT for sharing information among open networks and applications, and have relevance to indexed high-resolution video file structures, compression and coding algorithms, and other header data. Recently, open architecture approaches have also become popular among telecommunication regulatory communities worldwide.[5,6,7,8]

Report 1223 (1986-1990) offers a tentative solution based a direct mapping of the HDTV chain to the OSI model. A more robust solution would be to develop a digital HRI architecture.

An open systems approach could lead to the development of a wide variety of HRI devices and displays that might also be suitable for HDTV applications.

Future HRI applications will use switched broadband communications, digital compression technologies, and a large variety of mass storage systems. The video index (header/descriptor) concept will permit video extensibility so that, for example, multiple shots (tight and wide) of events could be delivered simultaneously over a single channel with sufficient header data. An image appropriate to a given display may be selected and presented (e.g.,

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[4] ISO 7498 (CCITT Rec. X.200).

[5] United States Federal Communications Commission, Report and Order, 104 FCC2d 958 (1986).

[6] 33 CEC Journal L 192 (24 July 1990).

[7] "Measures to be taken in accordance with Article 2 of Supplementary Provisions of the Nippon Telegraph and Telephone Corporation Law," Ministry of Posts and Telecommunications (30 March 1990).

[8] Report of the Chairman, GATT-GNS Working Group on Telecommunication Services (20 Oct 1990).

wide shots on large, wide displays, and tight shots on small, narrower aspect displays). Future display systems may serve multiple purposes: a videophone call may be displayed in a window on a wall-size screen.

The IWP 11/9 draft new report concluded:

"• Widely diverse applications are embraced by high-resolution systems;

"• this diversity results in numerous different requirements with respect to resolution, sampling distribution, dynamic range, colorimetry, image format, temporal rate and aspect ratio, among other attributes;

"• harmonization across this diverse range would be beneficial, and technically feasible, in principle;

"• harmonization requirements should take account of the consumer-cost implication of proposed solutions."

To achieve HRI open systems, it is necessary to define the enabling technologies, characteristics, and parameters, including:

(1) system and signal parameters;

(2) compression and coding mechanisms;

(3) a video index (universal descriptor/header); and

(4) broadband or highspeed telecommunications protocols.

This will require harmonization with related activities underway in other organizations such as CCITT, CMTT, and ISO/IEC.

3

EXHIBIT IV

REFERENCE: ATSC/IEEE JOINT MEETING
WASHINGTON, D.C.
MARCH 12/13, 1991
EDITED BY R L SANDERSON

I'm delighted to be here this morning ... to report for the Future Vision Group ... and to present some views on ... "what it might be like in the year 2020".

The report I'll give summarizes the contribution of many having a variety of viewpoints (Fig. I). We don't all agree on exactly how the future will develop or even when it will arrive. But there is no question that we are on the verge of major and exciting changes.

Most forecasts of the future are wrong. We often overestimate what will happen and underestimate how long it will take. (Fig. 2)The NNN rule is often sobering in this regard. It postulates roughly equal times N ... to create a technology ... to develop initial products ... and for significant business results to be realized. N is often five or larger. Alan Kay, for example, points out that Englebart first demonstrated the notion of an interactive computing environment at Stanford in mid-1960. It took about twenty years for this notion to reach significant market penetration and to become a major business. The good news here is that those things that will form major business successes in 2020 are likely to be known to us today. They are among the research items we so hotly debate.

But at the same time, we can also say that some things catch on and endure while others fade away. The degree to which new developments play to fundamentals is a major differentiator.

We said last time that the reason there is so much energy about HDTV and High Resolution Systems is that they do involve fundamentals (Fig 3). These involve the fact that ... we are visual beings ... and that we desire image-rich information:

-- customized to our interests
-- when we want or need it
-- available in an interactive environment
-- and supporting our free and mobile life styles

When technology, sound architecture and standards combine to satisfy these fundamental human needs and interests ... and at the same time pay appropriate attention to our human capabilities ... the result is explosive. This summary (Fig. 4) from a recent report by Schnee and Tumolillo suggests such a situation ... identifying a 66 to 79 billion dollar opportunity for but one segment of the telecommunications industry.

As an aside ... consider that even advertising becomes valuable and interesting, when delivered on a timely basis and about products and services that are of interest to us.

But our task is to try and envision what it might be like in the year 2020.

I started by asking the traditional question about "how much horsepower" we might have available by 2020 (Fig. 5). Lest you think that we're being facetious in asking about what will be on our our wrists ... we call your attention to this note (Fig. 6) in a recent Business Week edition.

I received scenario responses to my query (Fig. 7, Fig. 8)

I also received a quantitative forecast (Fig. 9) where the prefixes giga and tera in this forecast replace mega and giga in todays parameter measures. Another contributor agrees, stating that computing has advanced a million fold over the last thirty years (1000 X compute power and 1000X in communication) and that we can expect at least the same in the next thirty.

But this alone doesn't foretell the future.

The issue is ... how will the "horsepower" be used? The scenarios hint at more intelligent systems for the future. We shouldn't dismiss this notion as simply for the professional and technical crowd. It's again a fundamental, that products are successful in the broad consumer environment, when they present simple, intuitive interfaces. The ATM machine and a broad array of tone phone accessible services are certainly examples. Here, highly complex systems are commanded through a very simple interface ... to conduct transactions ... even at a distance ... and by ordinary people.

By 2020, computing and communication advances will support more natural interfaces for the products and systems we use every day.

It's not uncommon today to receive responses to our inquiries by computer synthesized voices. By 2020 we should be well along toward systems that interact with us even more naturally by understanding our spoken words and natural language. Further, experimental environments now exist that contain common sense knowledge. This may be a critical step toward the long awaited arrival of artificial intelligence ... in a form with major potential for more natural human interfaces.

And, interestingly enough --- when it happens --- it will be transparent to the average consumer. The products and devices they use will be very simple and easy to use, but they will access truly marvelous environments and services.

The environments accessed will also simply be imaging environments.

Bandwidths will increase with the increasing availability of fiber optic networks. But it will always be desirable to conserve bandwidth or pay for only that amount that a particular task needs. Motion images and video represent major bandwidth consumers. Compression technology now becoming commercially available performs acceptably for some applications, providing 50 to 100:1 compression. Examples include offerings by Aware, Inc, based on wavelet video image encoding ... or UVC corporation's single chip multimedia processor with compression ratios for audio and video up to 500:1.

Others suggest that compression ratios as high as 10,000 to 1 may be possible.These require fundamentally different approaches involving image recognition and model based image synthesis. While much more difficult, the image recognition/synthesis problem has an analog in speech and voice which is now being solved. By 2020 the "horsepower" will be available to support major advances in image recognition and synthesis. We might then do image searches much as we do text searches today. And it will be possible to create virtual environments or realities for a variety of practical applications. If you think this too far out --- just visit a toy store --- some of the Nintendo components are derived from current, virtual reality research.

By 2020 we certainly will be navigating through multimedia, heterogeneous databases ... across heterogeneous networks ... from heterogeneous computer terminals. This (Fig. 10) is an application example within my corporation that is being implemented today. By 2020 we should expect a much broader community ... and including segments of the general public ... to have comparable capabilities.

Getting closer to our interests today --- we can expect substantial changes in creative production and authoring (Fig. 11). Technology advances could enable something in the area of creative production and authoring like "desktop publishing". An environment where individual creativity is enabled and distribution channels for this individual contribution become available. Production centers will continue to exist but these will also change, becoming more distributed. John Weaver even describes an environment where cameras are literally attached to actors to capture their "point of view" in real-life scenes. Even I thought this a rather wild idea until I read last week that the University of Edinburgh has demonstrated a video camera on a single chip of silicon. Although this development is now limited to 80,000 pixels ... by 2020 we can expect this to advance beyond the anticipated first applications in toys and surveillance.

By 2020, the television receiver will take a different form than today (Fig. 12), although the migration path from here to there is less than clear. Analog and NTSC television will disappear by then. The digital video terminal, receiver or teleputer as some call it, will certainly support higher functionality than has been our experience. These digital video devices will support multi-resolution and will provide access to an array of information, programming and services ... and operate across interactive networks. These devices will likely also be adaptive. They will present received image data appropriate to their capability and conserving of channel capacity. We mentioned at our last meeting that future architectures should be chosen to accommodate the broad range of film and electronic ... motion and still ... images that will exist and be generated. The "source adaptive" digital video receiver ... at the end of an HDTV channel will ... in today's terms ... display (Fig. 13, Fig 14):

-- one HDTV program
-- two HDTV resolution film motion pictures
-- four NTSC resolution programs or views
-- or very high resolution still images at a useful frame rate.

Thus increasing consumer television viewing alternatives and choices ... and at the same time providing benefits for non-entertainment applications like education and training where higher-resolution still images are of significant importance.

This future will require a generation change in the design/development approach taken by digital video product suppliers. But ... that the TV receiver will evolve, driven by enabling technology and fundamental human needs and interests should be no surprise. The TV set as we know it today has already gone through a significant evolution (Fig. 15). It now connects to multiple delivery systems, accessing a multiplicity of services and in a variety of applications. This evolution has been driven by the availability of alternatives in delivery channels... services ... and applications that support user needs and interests. With appropriate attention to the user interface ... there is little doubt that the availability of new and richer delivery channels ... services ... program content ... and interactive access ... the end-point terminal will once again evolve to support user interests and needs.

This view (Fig. 16) of a future architecture which includes both broadcast and interactive modalities is central to the 2020 future vision.

Broadcasting (Fig. 17) will continue to be an important information delivery method and in 2020 will be working across multiple delivery systems. Delivered information and images will intermingle with those from diverse sources including videophone, computer, interactive video, etc. There will be extensive use of fiber in the television broadcast plant . Cameras will be CCD based. Recorders will be all digital, small and often solid state.

Dick Iverson of the AEA summarized our 2020 vision in the simple statement:

"high definition and wideband in <u>every place</u> you <u>want</u> to use it"

The underline for emphasis is mine but I don't think Dick will mind.

But there is always a gap between what can be done and what is broadly available and accepted. Economic and political feasibility has a lot to do with this. Bob Cohen contends that major near-term opportunities will be in commercial market segments rather than consumer. This to some extent is based on the need to put in place ... infrastructure ... services ... program content ... for the consumer to access with simple and low cost devices.

Digital implementations are an important step for the future. Digital is a key enabler to cross industry applications and common use components. At the same time, digital HDTV potentially creates a new game ... one where US strengths and technology can be an advantage. Digital HDTV seems in fact to be coming to us. We can and should assume a leadership strategy ... building on our technology and product strengths in computing and communications and on the fact that we have more fiber deployed than any other nation.

Appropriately based standards are important. They can facilitate US participation in this future. They can also help establish environments conducive to individual creative contribution and participation.

But our products must really work ... they must have high value and quality ... in the final analysis the consumer always chooses among alternatives.

But we also know that important consumers are beginning to choose open systems and standard platforms in many important areas when this alternative is available.

In addition ... for this opportunity to develop within the US ... many feel that change will need to take place in the regulatory environment. Something also needs to be done about our cost of capital to re-establish a competitive financial environment. And we may even need a national vision and plan to get to the kind of future we've been talking about.

Just in case we haven't already said enough to stimulate discussion in this two day meeting ... let's end with one last point. Several of our references point out that television and broadcast have played to the lowest common denominator. To that point some suggest that this has driven programming to satisfy lowest common denominator human interests ... those dominated by our morbid fears, anxieties and prurient interests. Narrowcasting and direct marketing are now providing important alternatives and models for the future.

And we might consider that the future we've discussed this morning offers opportunity to move further up in the architecture.

Lets build advanced interfaces and products that:

- -- play to lowest common denominator human capabilities
- -- enable new levels of creativity and expression
- -- satisfy higher-level human interests and needs
- -- with the expectation that this will lead to new products and services
- -- and in the process produce new wealth.

CREDITS

ARPAD TOTH
JUDITH PREWITT
JOHN V WEAVER
TONY UYTTENDAELE
BOB GORDON
TONE KELLY
ALAN McADAMS
BRUCE FIELDS
MIKE LIEBHOLD
MARK GRANIC
PAUL DOERING
GEORGE GILDER
DAVID TRZCINSKI
BOB COHEN
RICHARD IVERSON
BOB HOPKINS
CHARLES FENIMORE
WILLIAM ZOU
DOUG LENAT

OTHERS THAT WE KNOW, HAVE HEARD AND "READ"

REPRESENTING THEMSELVES

BUT WITH EXPERIENCE IN BROAD AREAS ---
INCLUDING BROADCASTING, CONSUMER ELECTRONICS, MEDIA PRODI ON, GOVERNMENT, ACADEMIA, COMPUTING, IMAGING, ECONOMICS, PROFESSIONAL SOCIETIES, INDUSTRY ORGANIZATIONS, ...

THE PROBLEMS WITH FORECASTING

-- DON'T CONCEIVE NEW FUNCTIONS/APPLICATIONS FOR EMERGING TECHNOLOGY

-- UNDERESTIMATE THE TIME TO ASSIMILATE NEW TECHNOLOGY

-- INSTITUTIONAL RESISTANCE FIGHTS NEW TECHNOLOGY

-- THE N/N/N RULE (WHERE N OFTEN EQUALS 5 OR MORE)

FUNDAMENTALS

-- WIDESPREAD APPLICATIONS OCCUR
ACROSS INDUSTRIES AND MARKETS
WHEN FUNDAMENTALS ARE MET

-- HUMAN NEEDS, INTERESTS AND CAPABILITIES PERSIST

-- VISUAL BEINGS

-- DESIRE
INFORMATION
CUSTOMIZED TO INDIVIDUAL INTEREST
DELIVERED ON-DEMAND
IMAGE RICH
INTERACTIVE
MOBILITY
COOPERATIVE WORK ENVIRONMENTS

FIG. 3

44-674 - 91 - 4

Where are those opportunities?

Takeover postulates a new service agenda for the LECs that could bring them between $66 billion and $79 billion in additional revenues over the next decade, depending on regulatory restrictions. Most of the revenue figures given are drawn from individual reports done by Probe Research on each service category. The new services list includes:

Facsimile. The LECs ignored the opportunities of the initial boom in fax, opening the door to fax service companies that now offer broadcasting, mailbox and response services. Current growth patterns nonetheless suggest revenues of $16 billion to $19 billion a year for local telcos, based on 25% to 30% market penetration for fax by the year 2000 and an average of 10 minutes of use per day. If the LECs move aggressively into broadcast and store-and-forward services, those growth projections could prove very modest.

Data Communications. The report estimates this market, already a growing portion of the LECs' traffic, to have been about $2.4 billion for private line marketing and about $7.3 billion for public network usage in 1989. By the year 2000, it will reach $24.4 billion.

Voice Messaging. Under the AT&T regime, the LECs missed an early boat by choosing not to enter voice messaging under the Computer Inquiry II guidelines, which would have required separate subsidiaries. After divestiture, the RHCs were banned from voice messaging by the Consent Decree until U.S. District Judge Harold Greene's 1988 ruling that once again allowed them into this service. *Takeover* projects LEC revenue potential of $2.75 billion by the year 2000, with 45% coming from LEC voice messaging services, 35% from increased traffic generated by voice messaging and less than 20% from call completion services.

Cable TV/Home Video. Most large LECs are pursuing the "one wire" strategy, seeking entry into all aspects of cable TV, including programming and planning to take fiber optics to the residence to accomplish this goal. This strategy faces serious legal and regulatory obstacles. *Takeover* projects less than $1.5 billion in revenue based on this strategy, assuming telcos gain entry into CATV by the mid-1990s and accumulate cable franchises thereafter. By pursuing an out-of-region acquisition strategy, which Pacific Telesis has already launched with its bid for a Chicago cable stake, telcos could acquire between 30% and 40% of the cable market by the year 2000, generating a high-side revenue estimated at $9 billion to $12 billion.

A third strategy, which emphasizes fiber optic development, could generate $5.5 billion in revenues, but faces a greater number of technological and regulatory unknowns.

Imaging. This includes electronic image processing markets such as full-motion videoconferencing, teleradiology and other medical services, electronic publishing, document image processing and computer-aided design and engineering. About $20 billion in transmission revenues will be generated in the CAD/CAE, document imaging and electronic publishing markets, but it will be focused in local area networks. Overall, image transmission represents a boom market for LECs, with revenues of $40 billion (including long-haul) by 2000.

Information Services. Including videotex, home shopping, pay-per-view TV, telemetry services and public electronic mail, this market is projected to reach $2.3 billion by the year 2000. Videotex and home shopping/pay-per-view TV lead the list with about $700 million each in market potential.

Audiotex and 700/800/900 Services. The study projects increased revenue potential for services such as audiotex and 800, of about $18.2 billion by the year 2000. If information services restrictions are liberalized, audiotex Yellow Pages and similar services could generate an additional $1.2 billion.

Custom Calling and CLASS. These services already are being delivered or will be shortly throughout the telecommunications industry. *Takeover* estimates potential revenue at $4.5 billion to $5 billion by 2000.

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ATSCALE WASHINGTON, D.C. MARCH 5, 1991

FIG. 4

"IN 2020

WHAT WILL BE THE 'AVERAGE' PERFORMANCE

FOR

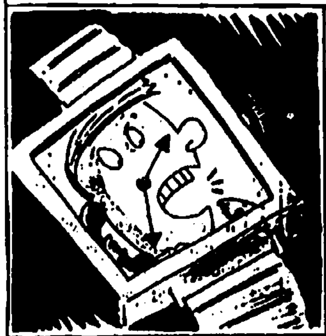
DESKTOP/HOME/VEHICLE/POCKET/WRIST"

MIPS --- PROCESSING POWER
MBYTE --- ADDRESSABLE MEMORY
MBPS --- AVAILABLE BANDWIDTH
SIZE/PIXELS --- SOFT DISPLAY
SIZE/DPI --- LOCALLY HARDCOPY PRINTING

Developments to Watch

EDITED BY OTIS PORT

COMING TO A WRIST NEAR YOU: A TWO-WAY VIDEOPHONE



Technology is finally catching up with Dick Tracy. Scientists at Scotland's University of Edinburgh have concocted a video camera-on-a-chip. Together with lenses no bigger than a match head, the 8mm-square chip lays the foundation for a wristwatch-size videophone like the one the comic-strip detective has been using for years.

That's just the most gee-whiz use for the chip. The Edinburgh team, headed by researchers Peter Denyer and David Renshaw, sees a big payoff in less dramatic products, ranging from miniature night-vision goggles to $50 video cameras for home security systems. Even "seeing" toys could show up under Christmas trees in the future.

The chip is so small and inexpensive because it sees digitally right from the start. Other imaging chips first record an analog picture, then digitize it. The university has set up a company, VLSI Vision Ltd., to license the technology. Expected revenues: some $10 million over the next five years.

ATSC/IEEE WASHINGTON, D.C. MARCH 15, 1991

FIG. 6

Displays.. flat panel, full color, very thin... about 500 dpi. and in all sizes wristwatch to wall.. in your car, on your boat for full color weather maps, documents, along with audio, etc.. etc.

Electronic pictures on your wall programmed to change by the hour, or day or whatever..

Hardcopy.. portable.. in your pocket... photo quality.
BIG VOLUME printing (100's of pages/copies) negotiated by e-mail from a local micro-print shop.

Bandwidth's aren't used as a measure.. it's response time for common things such as documents, e-mail delivered software, etc... Delivery electronically is guaranteed for 15 minutes, 1 hour, etc.. .

Cellular image transmission.. on demand.

The office travels.. Plug in networking at any hotel or airport..

Probably too conservative. Nobody cares about mips or megabytes. For the compute/science techies the measure is how many mega-processors are being used for your computation ...

Enough...fun... bob.

FIG. 7

Almost all networks will be linked by radio, not wires or fibers.

The biggest personal machines the size of a VHS cassette. Display covers one face and doubles as the input pad ... when needed it simulates a QWERTY keyboard, but it context sensitive so only displays those choices sensible at the moment.

Public-access keys useless ... any reasonable computer can able to break the code in seconds. Users security by arbitrary sequences of radio frequencies according to pre-agreed patterns.

In 2020, computers not measured in terms of Mips or Megabytes, any more than we now speak of the distance to Boston in terms of weeks.

All meaningful resources shared over networks ... your temporarily unneeded computer is quietly engaged in solving your colleague's problem without your knowledge or interest.

Everything is treated as an image. Scanning an encyclopedia for a needed reference ... the search will match an image of the phrase, not its ASCII string.

Bandwidth will be no problem ... compression far beyond our understanding today reduces large transmissions ... your computer adapts to your personal way of doing business ... sending end preparing responses based on your statistical behavior ... gathering data in a more leisurely fashion than if it waited for your actual request.

....PAUL....

AISC/IEEE WASHINGTON, D.C MARCH 15, 1991 FIG. 8

Technological Possibilities for the Year 2020

Capability	Desktop	Home	Vehicle	Pocket	Wrist
GIPs in μprocessor	10	.1-1	.01-1	.01-.1	.01-.1
MBytes (.256-1 Tbit chips available)					
--GBytes RAM in μp	>1000	1-10	1	1	1
--GBytes backup	>>1000	1-100	1-10	1	1
Soft Display					
--Size	desktop to wall size	desktop to wall size	4" x 6" to desktop	2" x 3" to 4" x 6"	2" x 3" 4" x 6"
--Pixels	extensible to 4K x 6K	extensible to 4K x 6K	extensible to HDTV	extensible to HDTV	extensible to HDTV
Network Bandwidth					
--To the site	Terrabytes/sec	Gigabytes/sec	<MByte/sec (severely limited by cellular communications)	<MByte/sec	<MByte/sec
--Within the site	Terrabytes/sec	Mega to Giga bytes/sec	Megabytes/sec	Megabytes/sec	Megabytes/sec
Hardcopy					
--Size	Wallet to 20" x 30"	Wallet to 8" x 10"	Wallet to 8" x 10"	Wallet to 4" x 6"	Wallet to 4" x 6"
--DPI	400-1200	400-800	400	400	400

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FIG. 9

DataBase Query Processing

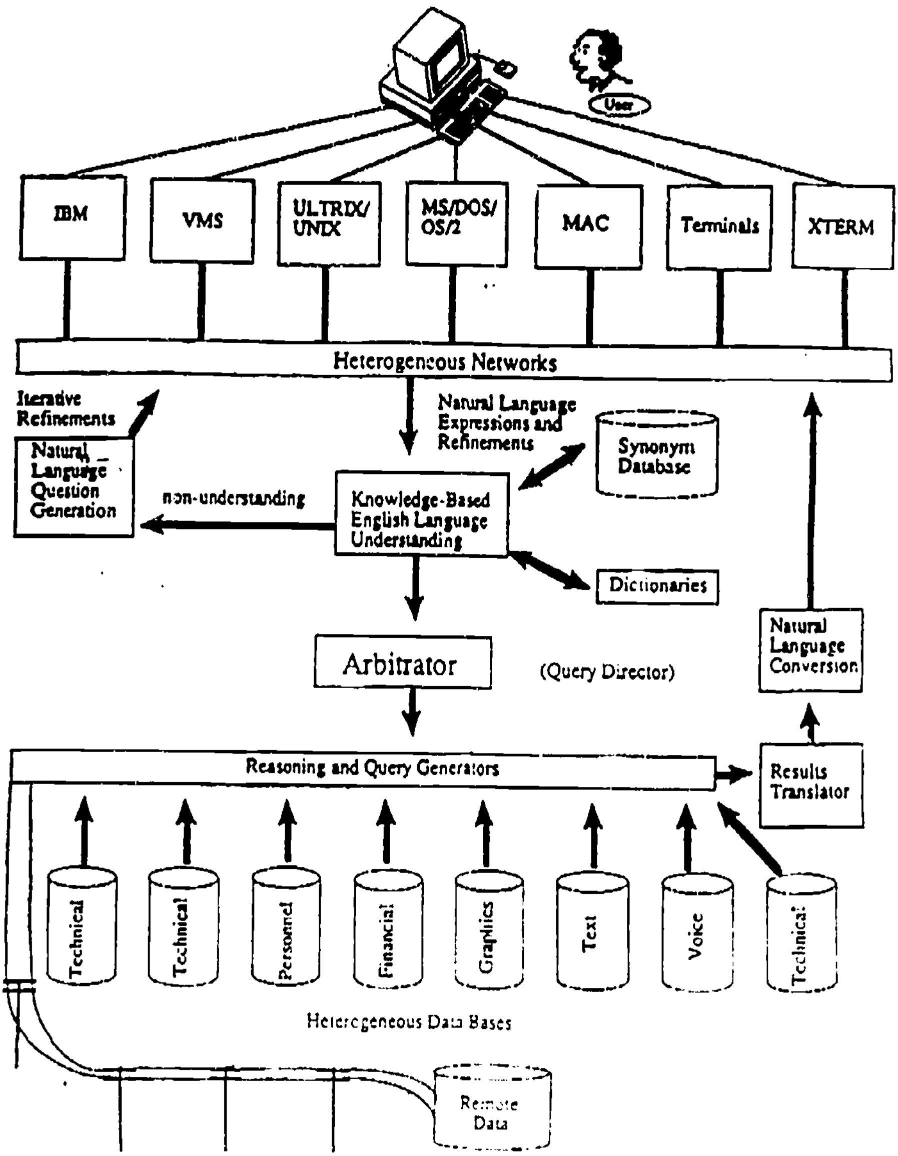

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FIG. 10

CREATIVE PRODUCTION AND AUTHORING

-- REFERENCE: JOHN V WEAVER

-- PRODUCTION CENTERS WILL DISPERSE

-- RADICALIZATION OF FINANCING TO SELF-FINANCING

-- MIGRATION FROM STUDIO TO INDIVIDUAL CREATIONS

-- "DESKTOP PUBLISHING" TO
"BACKYARD PRODUCTIONS"

-- "CAMERA ON A CHIP" ANNOUNCED

THE TELEVISION "RECEIVER"

-- REFERENCE: APAD TOTH

-- ANALOG TELEVISION ELIMINATED

-- NTSC EXTINCT

--DIGITAL VIDEO COMMUNICATION

-- DIGITAL MULTI-RESOLUTION

-- ADAPTIVE DIGITAL MULTI-RESOLUTION

--VIRTUAL VIDEO TERMINAL (STORAGE IN THE NETWORK)

-- GENERATION CHANGE REQUIRED IN DESIGN/DEVELOPMENT APPROACH

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FIG. 12

One Source Adaptive HDTV Digital Transmission Channel Could Transmit ...

- One HDTV program

  or
- Two HDTV Resolution Motion Pictures

  or
- Four NTSC Resolution Programs

  or
- High Resolution Still Photographs

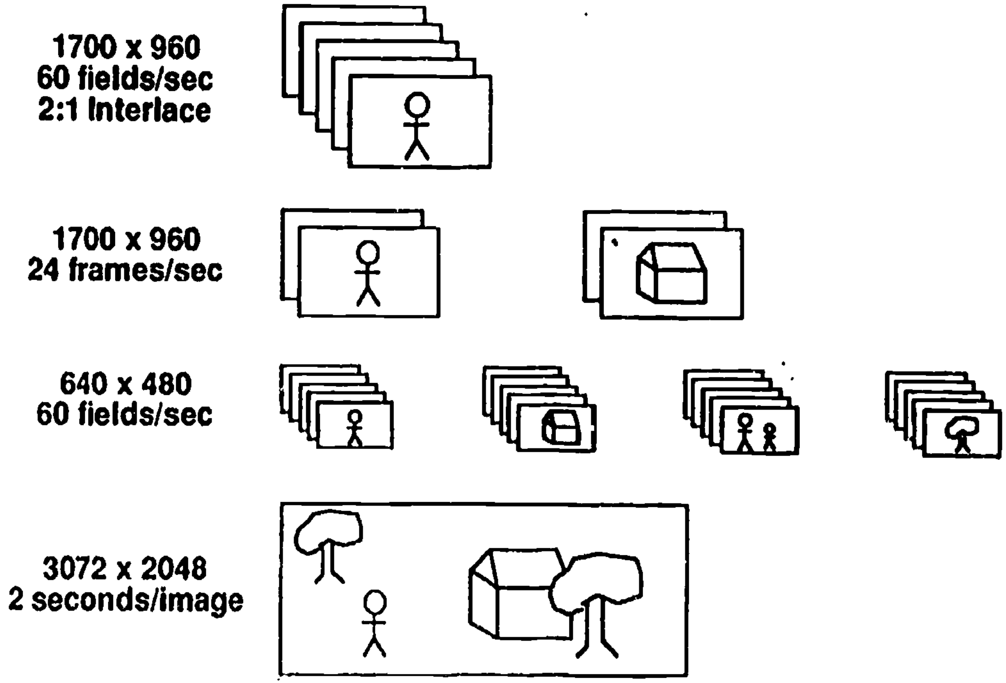

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FIG. 14

TV SET EVOLUTION (1970-1990)

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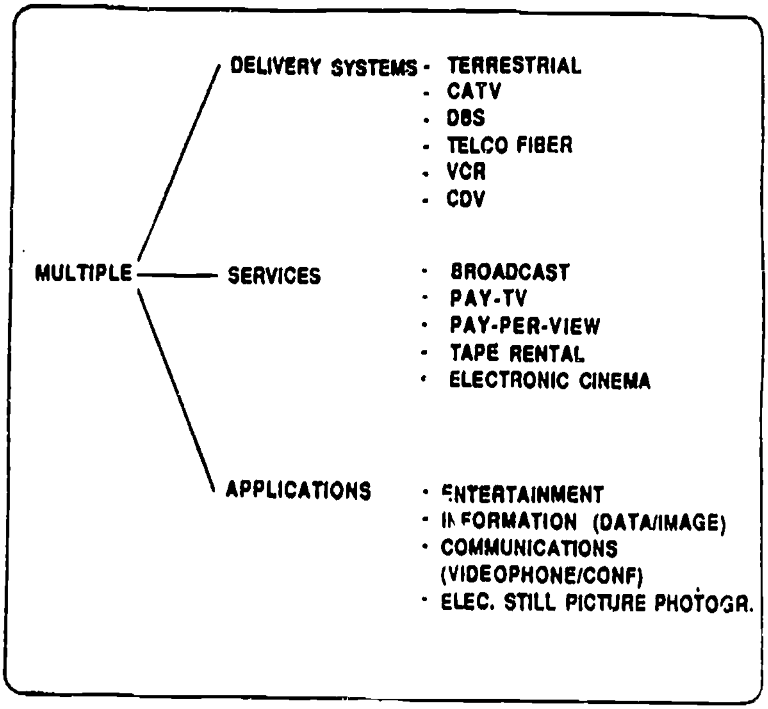

FIG. 15

DIGITAL VIDEO/MULTIMEDIA DIAL-TONE

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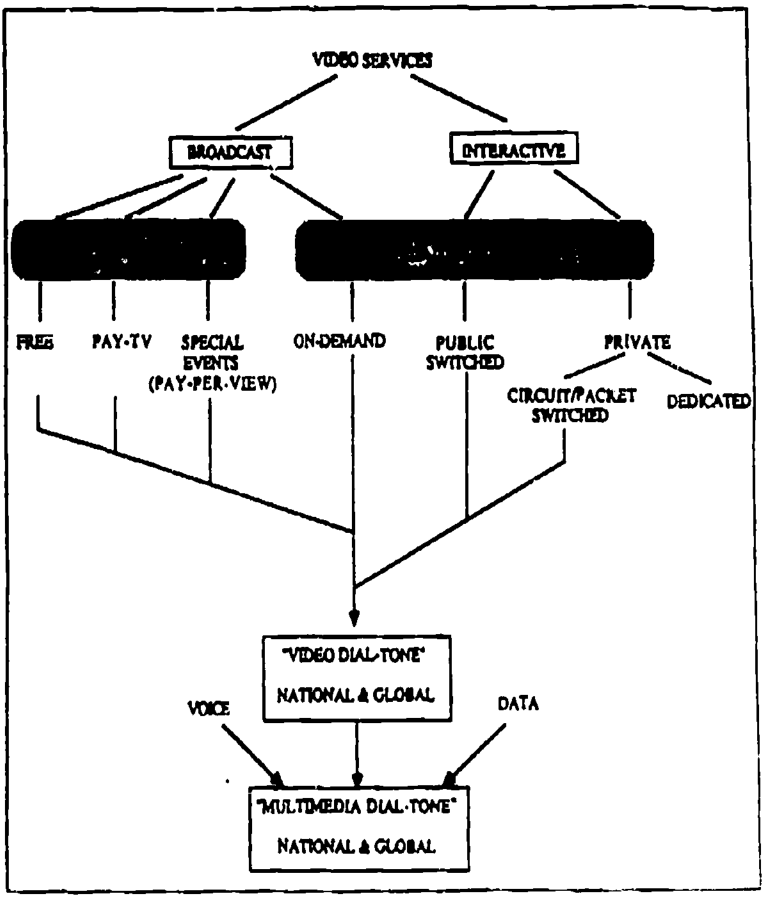


FIG. 16

IEEE/ATSC Joint Meeting on Digital Video Systems · Session 2
March 12-13, 1991, Arpad G. Toth, Philips Laboratories

BROADCASTING

-- REFERENCE: TONY UYTTENDAELE

-- BROADCAST STILL IMPORTANT INFORMATION DELIVERY METHOD (TODAY ACCESS 99% AMERICAN HOMES --- COMBINED NETWORKS 70% AVAILABLE AUDIENCE ANY EVENING)

-- BROADCAST ACROSS MULTIPLE DISTRIBUTION SYSTEMS --- SIGNALS REACHING HOMES WITHOUT TRANSMISSION IMPAIRMENTS

-- WALL SIZE DISPLAY --- MULTIPLE PICTURES VIEWED SIMULTANEOUSLY FROM DIVERSE SOURCES --- VIDEOPHONE, COMPUTER, INTERACTIVE VIDEO, OVER-THE-AIR, CASSETTE

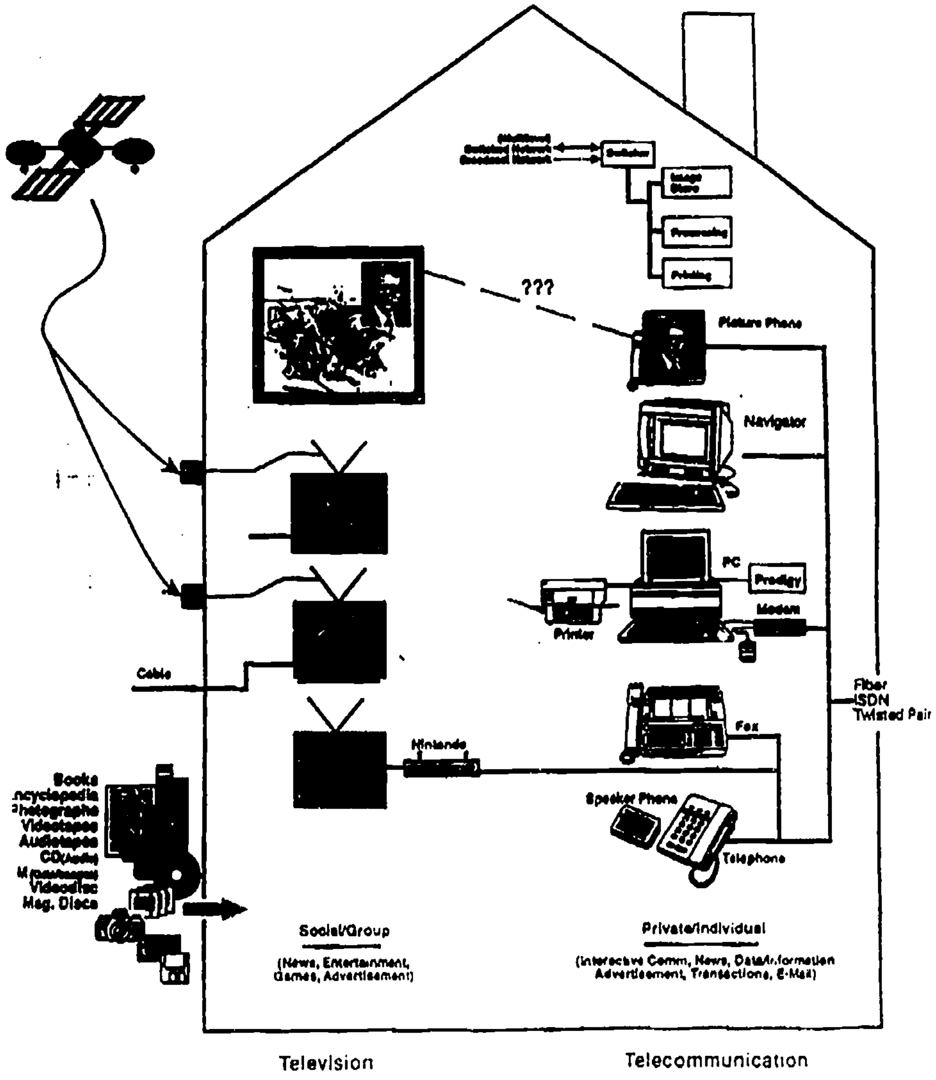
-- NTSC WILL BE RETIRED

-- EXTENSIVE USE OF FIBER IN THE TELEVISION "PLANT" LINKING FACILITIES

-- CAMERAS EXCLUSIVELY CCD --- OPERATING ON MULTIPLE RESOLUTION HIERARCHICAL STANDARDS

-- RECORDERS ALL DIGITAL --- SMALL FORMAT CASSETTE AND SOLID STATE

EXHIBIT V



MEDIA HOUSE

Mr. VALENTINE. Thank you, Dr. Sanderson.
Mr. Blatecky?

STATEMENT OF ALAN R. BLATECKY, VICE PRESIDENT, COMMUNICATIONS, MCNC

Mr. BLATECKY. Thank you, Mr. Chairman, members of the committee. I also appreciate being able to address the committee.

I do have some overheads. What I'd like to talk about is something which has been overlooked often which is the role of collaboration.

What I wanted to talk about was our experience in North Carolina with high quality video systems for collaboration, and specifically look at how high definition television can help us do a better job.

One of the factors we're very interested in is what are the factors that contribute to competitiveness. I'd like to talk about use and access of resources. The resources can be technical or human.

What we've got in North Carolina is a high performance network running across the State and it provides both video and data capabilities. I'd like to talk about how those two work for collaboration.

We've got an interactive broadcast quality video providing face-to-face communications which allows collaboration to take place in many different ways. We do it in two primary ways. We have conferences, we have collaboration activities, we have seminars and workshops and we have a great deal of work in graduate education. Our goal really is to establish face-to-face communications and not be restricted by geography or time.

To show you what's happened in the last several years, we've had a tremendous growth in conferencing and collaboration, almost 20 percent a year. We had almost 11,000 people involved last year.

The reason I point that out is because it shows how much can happen even with the limited facilities we have.

One of the problems we found though is with the video we've got in place, which is broadcast quality, it's still not adequate for the quality of research, education and things we want to do, so we've started to establish what we call a collaboratory. What we're talking about is installing high powered work stations into our video conference facility so now we can talk about exchanging high resolution images as well as the video between participants.

Step 1 is basically to have a separate system within the room to provide the high resolution, clearly Step 2 talks about combining those two, the sort of thing you addressed earlier, and Step 3 is making that available from work station to work station, requiring high definition television capabilities throughout the network.

One other thing I'll point out is an example of some of the sorts of collaboration that can take place when you have high resolution capability is a project that Bob Kahn mentioned earlier. This is one of the gigabit test beds. Basically what we're using is a high performance network to do 3D dosage radiation treatment of cancer. It takes high resolution imaging in order for a doctor to see what's going on. Clearly the only way you can do that is experimentally. What we need in the future is to find a way to make it available on a much broader range.

Let me conclude with a couple of other comments. The first is that indeed we are finding in North Carolina that we do have a lot of collaboration taking place across distance. We've got researchers now working together in ways that they never have before and we're seeing that increase virtually every year.

A primary reason for that is because of the technical infrastructure we've got in place, so we're already providing this—full motion, virtual proximity capabilities. Our experience has been that the high quality video we've got in place is barely adequate; for text and graphics it's clearly not adequate at all. We need high resolution, high definition systems.

My last point is simply to say that one of the things we found to make successful collaboration work is you've got to have, as a goal not simply the removal of travel, cost, but the goal has to be how can you leverage people, leverage resources so that they can indeed be used no matter where they are located?

The experience in North Carolina has been that we've found high quality video systems and data systems put together can indeed contribute to educational excellence and industrial competitiveness. What we really need is high definition capabilities and networks not only in the State but across the Nation so we can indeed extend the capabilities across country.

Thank you.

[The prepared statement of Mr. Blatecky follows:]

Committee on Science, Space and Technology

Subcommittee on Technology and Competitiveness

High Definition Systems Hearing

May 14, 1991

Alan R. Blatecky

Vice President, Communications, MCNC

What I would like to briefly discuss today with you is our experience in North Carolina with high quality video systems for education and collaboration, and, how the advent of high definition systems can significantly increase our ability to be more competitive.

Networking has quickly become one of the most critical resources in this electronic age. The rising costs of certain resources (human as well as facilities) coupled with the accelerating advances in science, knowledge and technology demand the existence of a networking infrastructure to ensure the continued viability and competitive success of universities, industries, education and other organizations.

In North Carolina, we have one of the most advanced communications network in the nation, providing service to education, research and industry across the state. The network utilizes state-of-the-art technologies including microwave, satellite, fiber optics and coax to provide a mix of services from many-way, interactive, broadcast quality, NTSC television for education and collaboration, to high speed gigabit data communications for supercomputing, imaging and medical research. This network is called CONCERT (COmmunications for North Carolina Education, Research and Technology) and has been built over the last 7 years with significant involvement from the state of North Carolina.

Map Overhead

The network extends across the State, from UNC-Asheville to East Carolina University in Greenville, a distance of 350 miles.

CONCERT interconnects strategic academic and research resources across the state including 5 major research universities, 2 Graduate Centers, the 4 Medical Schools in the North Carolina, the North Carolina Supercomputing Center as well as many other research and education institutions. The sites connected include private and public universities, historically black universities (NCA&T), as well as other institutions. CONCERT became operational at 5 sites in 1985 and was extended to 7 other sites by 1989. The network is funded by the State of North Carolina, and is managed and operated by the Center for Communications, MCNC. MCNC is a non-profit corporation headquartered in Research Triangle Park, North Carolina.

The primary mission of CONCERT is to provide virtual proximity capabilities to researchers and educators in North Carolina and to build collaborative university research and industry programs in communications, supercomputing, and microelectronics. Virtual proximity means that network users, regardless of where they are located, have access to strategic resources (expertise, computers, laboratories, etc).

Let me briefly describe the video component of CONCERT, its capabilities, and the impact it is having in North Carolina.

Video Overhead

The video network provides two full interactive NTSC video channels to all sites as well as a third channel for the 4 medical schools in the state. Since each site is also a switching center, the network can be configured in many ways to accommodate users. Each site has a dedicated video conference room for up to 6 users, and a video classroom which can accommodate up to 30-40 students enrolled in various graduate degree programs. Each video classroom and conference room is fully interactive; that is, all sites, including the remote locations, can see and hear every other participant.

Conference Room Overhead

Each video conference room utilizes 8 video cameras; six cameras are used to get a full head and shoulder view of each participant. Another camera provides a wide angle view of all conference participants, while the eighth is used as an overhead for graphics, handouts, and so forth. It is located over the center of the table. The video classroom has similar technical capabilities.

Usage Overhead

As you can see from this chart, we've had heavy utilization of the network which also shows steady growth since 1985. While the teleclass usage has essentially remained steady, we've seen significant growth in Seminars and Conferences. Seminars typically feature a primary speaker (guest lecture, visiting expert) who can speak and interact with all the other sites across the state. Conferences are collaborative meetings in which researchers and educators at 2 or more sites meet to discuss research projects, educational programs or inter-institutional meetings. Please note that in 1989-90, we had almost 11,000 faculty and students using the video channels and expect this to continue to increase.

Collaboratory Overhead

One of the major problems we have encountered, is an inability to transmit high resolution images. Since a high definition television system does not exist, we have designed and are implementing a program to provide this capability. The project is called a Shared Workstation Collaboratory which merges video and data capabilities to create a multi-media, high resolution, virtual proximity environment. High powered UNIX workstations are being installed in each of the 14 video conference rooms to provide a platform for sharing images, programs and information. Each workstation runs a software program called "Shared X TV", which is based on X-Windows. XTV allows researchers to manipulate the same image and program at the same time as though they were in the same facility. The program has tremendous potential for training, education, collaborative research, and remote scientific visualization.

The Impact

Let me conclude by highlighting some of the lessons we've learned and the impacts we've seen in North Carolina;

1. Successful collaboration across distances does indeed take place; researchers and educators across the entire state work with colleagues in ways they have never been able to do before. We are beginning to see new levels of cooperation and resource sharing among campuses and industries. We are also seeing that new joint programs have been established between

institutions which depend on the network for their success.

2. A primary contributing factor of success is that the technical infrastructure of CONCERT, the conference rooms and network, provides high quality video which very nearly approximates face-to-face communications. The result is that collaboration and conferencing is rapidly growing as users discover that the technology exists so that they can effectively work with other people regardless of distance.

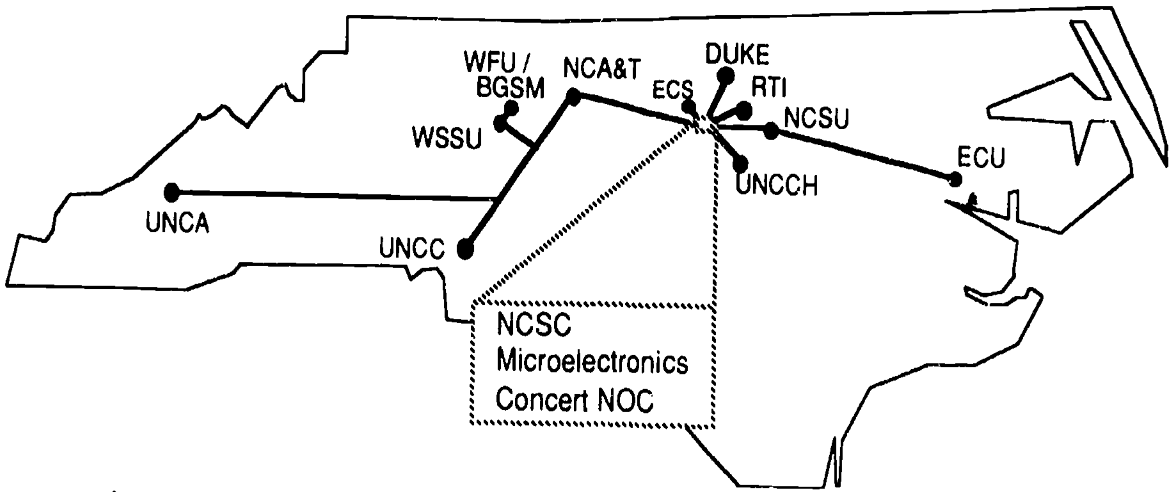
3. Our experience has shown that full motion NTSC video is minimally adequate for collaboration and teaching; what is really required to provide virtual proximity, is high definition systems. The low resolution capabilities of NTSC is inadequate for text and totally unacceptable for imaging and grapt . :. I would note that we have tried various compressed video technologies for conferencing a.d teaching, but, have found them to present almost insurmountable obstacles for regular usage. Researchers find that they really need high resolution displays and transmission in order to effectively col'aborate.

4. My last point may seem subtle, but, is at the heart of successful collaboration. If the goal of conferencing and collaboration is to save the costs of travel, then that is all it will do. It becomes a poor substitute for face-to-face communication. If, on the other hand, the goal is to leverage resources so that people can use resources in ways they have never been able to do before, then you have the possibility for success. The goal has got to be to create an environment which enables people to use the best resources to be more competitive, produce better products and generate innovation and development.

In conclusion, let me simply say that our 6 years of experience in North Carolina shows that video systems can substantially contribute to educational excellence and industrial competitiveness, but, that we desperately need high definition systems capabilities and networks in order to expand this capability throughout the nation

CONCERT

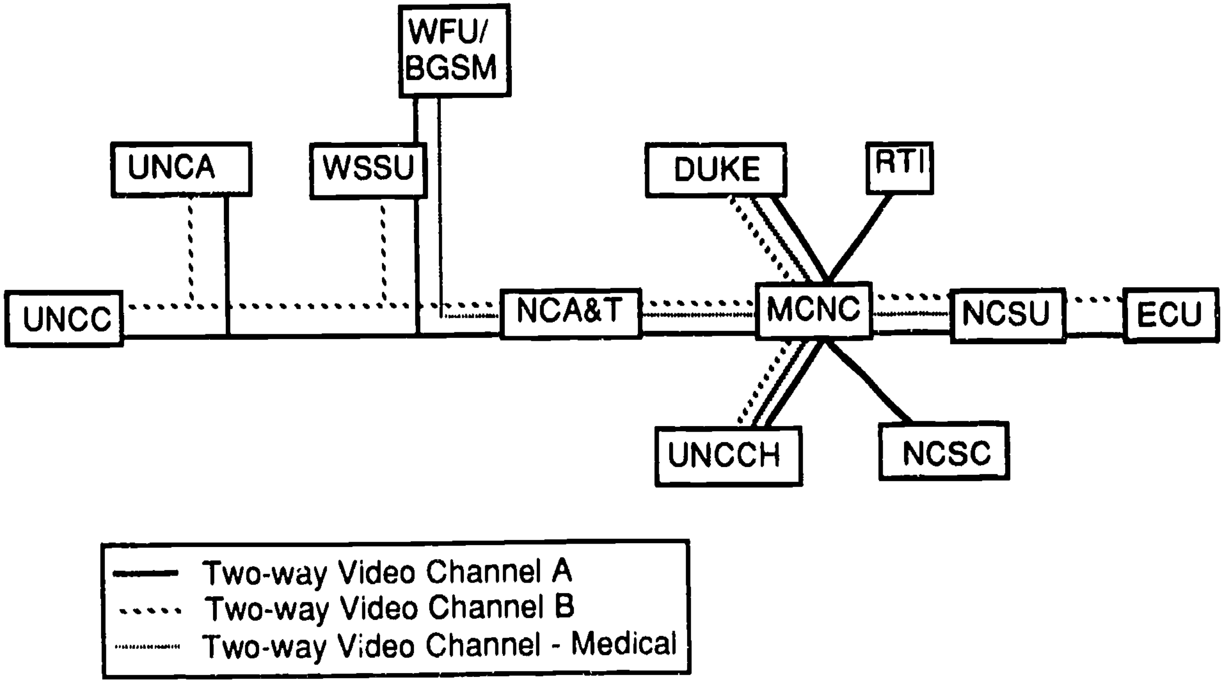
Communications for North Carolina Education, Research and Technology



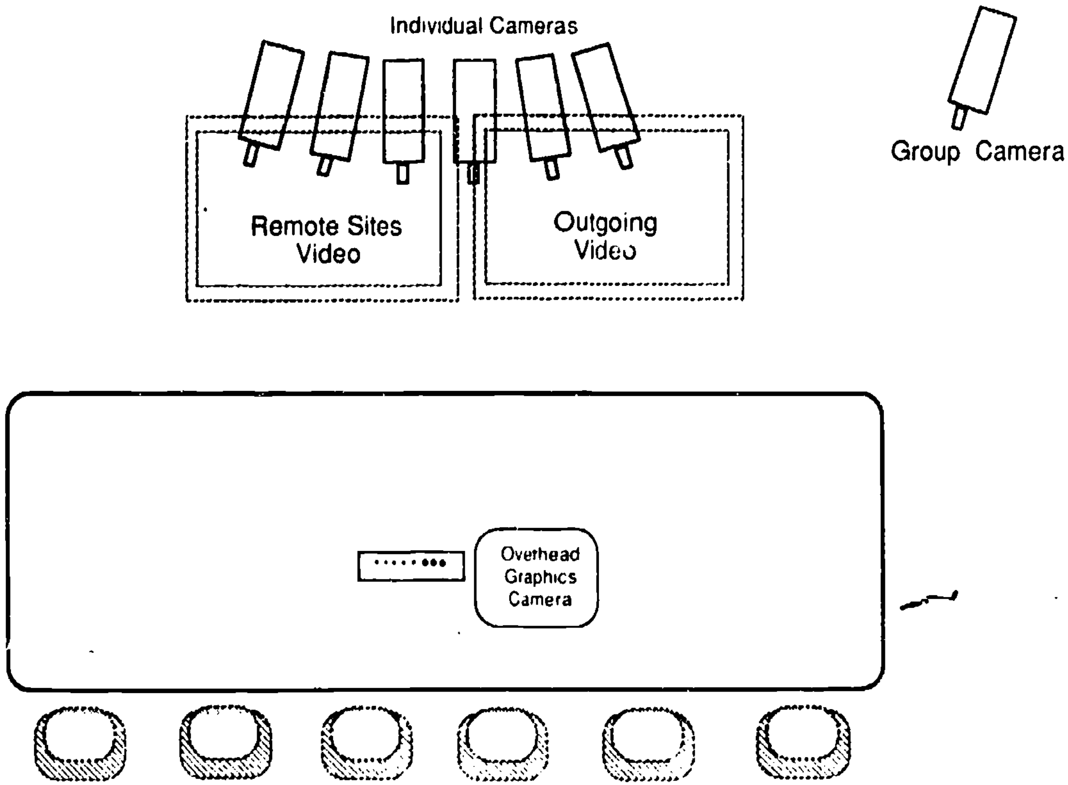
An extensive, high speed, state-wide network utilizing 25 & 45 Mbs data channels and two channels of duplex NTSC video

ARB 5/11/91

CONCERT Video Network



Video Conference Room



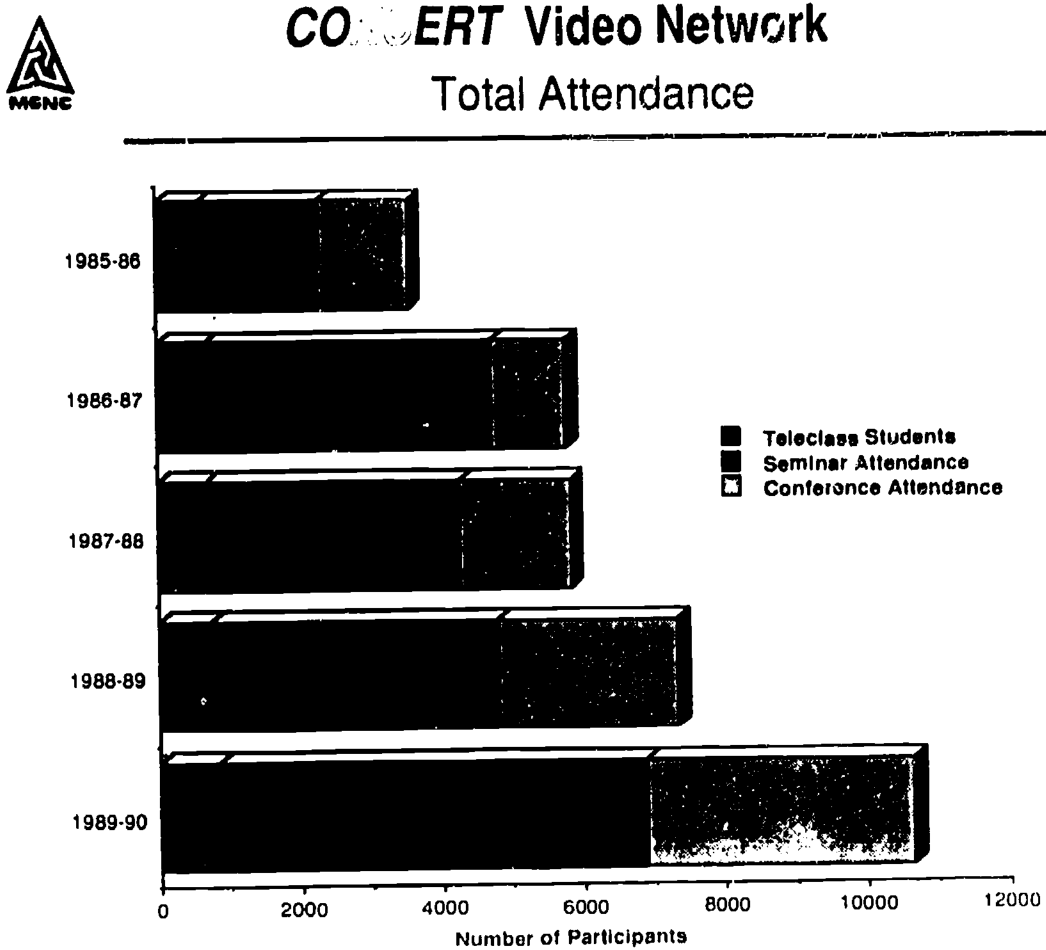
ARB 5/11/91

3

115

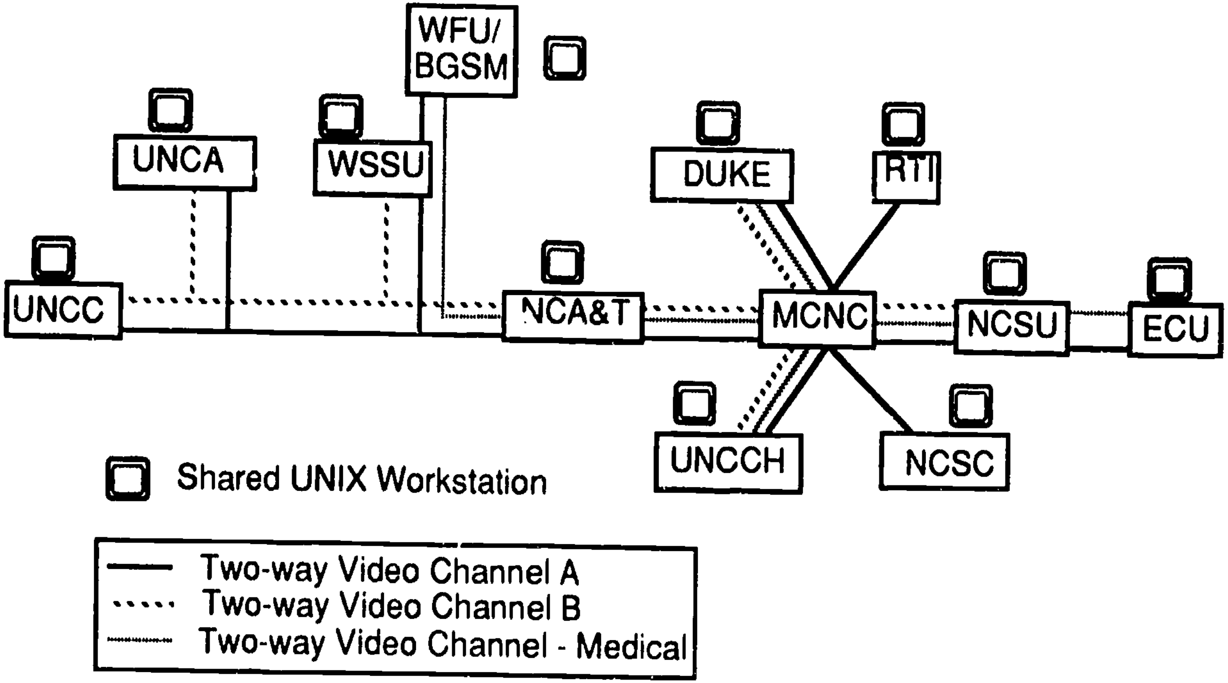
CO::ERT Video Network

Total Attendance



ARB 5/11/91

Shared Workstation Collaboratory Project



ARB 5/11/91

Mr. VALENTINE. Thank you, sir. Thank all of you.

Mr. Blatecky, is the system that you have described available to institutions, colleges and universities as well as—I know it is there but is it also available to private sectors?

Mr. BLATECKY. Yes, it's also available to the private sector. That includes both the other colleges and universities as well as industry, trying to make sure that it's an environment that's available to all those areas because as Dr. Kahn mentioned earlier, no one has resources in any one place. You need access to them no matter where they are located.

Mr. VALENTINE. Mr. Johnson, I understood you to talk briefly about video recorders and what happened to that item of manufacture. Would you describe just exactly what you mean by a video recorder?

Mr. JOHNSON. We all have them in our homes, they are basically video tape recorders that we use to record programs off the air, to play.

Mr. VALENTINE. VCR?

Mr. JOHNSON. VCR.

Mr. VALENTINE. Did I understand you to say that the VCRs were manufactured initially and developed in this country and that the judgment was made as to their marketability?

Mr. JOHNSON. All of the basic patents on VCRs are held by United States companies, that is correct. The decision was made that there was no consumer market for such devices and the Sony Company made an offer to Ampex to take a license on their patents for consumer units and that's how we lost it.

Mr. VALENTINE. Do you have any information or any opinion as to the extent of the Federal Government's participation in dollars and cents and funding in connection with the development of video recorders?

Mr. JOHNSON. As far as I know, there was no Government participation in that except I might say indirectly the Government had kind of a negative effect because the Ampex Corporation was started by people who came out of OSS during World War II and brought back to the United States some German magnetophone machines which were basically crude, early forerunners of audio tape recorders and they were used in Germany to run unmanned radio stations during World War II.

They brought them back and got funding from what then became the CIA and the National Security Agency to develop instrumentation recorders basically for espionage and snoop purposes, so unfortunately there was built into Ampex not a commercial consumer bias into the development of that and that kind of carried on to where it got to the point where it looked like this could be a fairly significant business, there was no management infrastructure that could carry that out.

Mr. VALENTINE. But the decision not to try to market video recorders was a business judgment, wasn't it?

Mr. JOHNSON. It was a business judgment.

Mr. VALENTINE. The Government didn't do that?

Mr. JOHNSON. Had nothing to do with that. I might say that there is an effort in the United States at this time to bring back some of this technology—not bring it back but rather to reestablish the so-called high density helical scan recording technology that's used in video cassette recorders. This is being done because of our strength in computers. We need to be able to do a lot of back and there has been a large import of essentially consumer video cassette recorder mechanisms into this country that has then been incorporated into very large capacity tape backups for computers. It's sort of a peculiar cycle going on here.

Mr. VALENTINE. On the question of investments and instant gratification and the expectation, reasonable and understandable, that you put your money in a company, you don't want to wait for a long time to see whether it's going to work out. Investments in companies where it's expected that you'll make a profit if the research which the company is doing pans out, if they are able to convert that research into a product, and if that product will be purchased by the general public, isn't that a picture, a diagram of a very, very high risk investment per se?

Mr. JOHNSON. Certainly the consumer electronics business has been a very high risk investment. It's been a very long payoff and uncertain. So to answer your question, yes.

Mr. VALENTINE. So you've got a real problem there that perhaps cannot be addressed by anybody except the Government and some kind of tax advantage that you can't expect that type of industrial gamble to attract a lot of money, can you?

Mr. JOHNSON. I think at this point in time, at least insofar as the video cassette recorder or the digital video cassette recorder, is concerned, that is probably accurate.

Can I make another comment? That has to do with what I think the Government's role in this whole business of HDTV has to be. I think it needs to provide a forum and a nucleus around which all of the various parties can coalesce and can act as sort of a moderator or ombudsman, if you will, so that the greatest good can be achieved for everyone.

Mr. VALENTINE. That certainly is to be desired, but that is one hell of a task.

Mr. JOHNSON. But there's no other way to do it. Certainly no company can do it, so therefore, it seems to me a natural function of Government. If our interstate highway system had been built by a bunch of independent contractors we'd not only be driving on a bunch of disconnected toll roads, but we might be driving on the left side of the road on part of them.

Mr. VALENTINE. I agree with you. I think that shows great understanding. I shudder to think what the country would look like if we didn't have the interstate system. I must point out one reason the interstate system succeeded is you could not have an interstate system unless it involved everybody. You could not get from Florida to New York unless you went through North Carolina and South Carolina so of necessity, everybody in the country had to have a piece of the action. I agree we ought to be able to emulate that example.

Mr. JOHNSON. Speaking of the interstate highway system, a number of the western railroads were built with land grants that permitted the development of the country. That sort of mechanism ought to be considered here perhaps.

Mr. VALENTINE. They did develop the country but they created one hell of a monopoly in the process.

Mr. JOHNSON. But that was only temporary.

Mr. VALENTINE. I'm asking this question for the benefit of everybody else here. I know the answer, mostly staff. What's so special about digital transmission of a television signal?

Dr. GLENN. With digital transmission, the transmission system can be completely transparent so that what comes out is what went in. You don't have any degradation of any sort. It can withstand noise and it can tolerate a lot of problems that we normally have in transmission systems.

I think now that we have digital compression techniques, it turns out that there is no longer a serious penalty to using digital transmission. At one time, it took several channels just to transmit what could normally be transmitted in analog form, but now with visual compression techniques, which is a very new development, we are able to do that without paying such a large penalty.

Mr. VALENTINE. Mr. Johnson?

Mr. JOHNSON. There is also the whole matter if you send a bunch of digital signals down the wire, which is a whole series of zeros and ones, it is totally transparent to whatever you want to send. It could be images, it could be television, it could be data, it can be high resolution television, it can be ordinary NTSC television, it can be virtually anything at all. What is sent is independent of the transmission channel and that's very critical.

Mr. Glenn mentioned compression technologies. They are really not applicable in analog signals and only are applicable in digital systems.

Dr. SANDERSON. In terms of digital transmission, you also have the opportunity of doing error correction coding. That is, if you have a noisy channel, you can actually encode the information so that at the other end, even if you lost some of the bits, you can really reconstruct the signal, so that possibility is there also in terms of channel degradation, corrections.

You asked about transmission. There is a broader issue in terms of the reusability of the information when it gets to the other end if it's in a digital form. That's not just the transmission issue, but it deals with the ability to manipulate the images to be able to use images from one application in another, and the reusability, the migratability, the manipulability of those images is far enhanced by the digital encoding.

Also in some applications you have to do a lot of processing on the image, for example, in the creative arts where the images are originally captured but then they are changed, go through a number of processes if the information is encoded digitally early on. Those subsequent processes, which in an analog world, would degrade the image every time it was processed, the digital image will be maintained basically in its integrity.

Mr. VALENTINE. When we talk about the use of fiber optic transmission, we're talking about transmission over a cable made out of a substance called fiber optics and we have a national network now, don't we, along the highway right of ways throughout the whole country. So when we talk about problems there, are you talking about transmission through fiber optic networks within the towns, cities, and communities to deliver this source to individual homes and offices?

Dr. SANDERSON. Well, I think personally that the issue is having a communication infrastructure that can provide a variety of cost performance options to the consumer, whether a business or a home environment consumer or whatever. The facsimile machine is an image transmission receiver, reconstructor or an image communication system and it works over normal telephone lines and provides low but acceptable quality for a lot of applications.

Wide band clearly will provide us significant advances in video, motion image, more complex images, more detailed images, but it isn't necessary for all applications. What is important is the ability for the person who uses these services to be able to deliver information across different kinds of networks in a somewhat transparent way, that is not having to change your applications software or your product attachments for every different channel. That does require some uniformity of standards, protocols and things of that sort.

The fiber optic cabling and cable to the house that would be important in the long term but we really need to have a variety of services and a variety of cost performance tradeoffs available.

Mr. VALENTINE. Does the usefulness of the fiber optic cable have anything to do with the size of it?

Dr. SANDERSON. Physical size?

Mr. VALENTINE. Yes.

Dr. SANDERSON. There are probably people here better able to answer that than I.

Dr. GLENN. No, it doesn't have to do with the size particularly. The limit on the fiber optic cable is actually the input and output terminal. If you look at the channel capacity of the single mode fiber that's being laid all over the country, the fiber itself could handle about 140,000 digital HDTV channels without any compression, but the terminals on the two ends are the limit.

I think when these terminals have higher capacity, we will have a network that has very broad band width as long as we are able to interconnect these in ways that can talk to each other.

Mr. BLATECKY. Let me just add that to one of the other issues is not so much the individual fiber but when you start looking at the terminal equipment and then the switching, how do you manage that? That's just a whole new world also.

Mr. VALENTINE. Thank you very much, gentlemen. We've got a quorum call and I would not suggest that you wait here until I go over there and get a few more members and we come in here and think up some more questions. You have heard enough from laymen perhaps for one day.

Thank you all very much for being here and for sharing these thoughts with us.

The subcommittee will stand adjourned.

[Whereupon, at 4:09 p.m., the subcommittee adjourned, to reconvene at the call of the Chair.]

HIGH DEFINITION INFORMATION SYSTEMS

TUESDAY, MAY 21, 1991

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:35 a.m., in Room 2318, Rayburn House Office Building, Hon. Tim Valentine [chairman of the subcommittee] presiding.

Mr. VALENTINE. I understand that Mr. Lewis will be here momentarily, so if you'll find a place to perch, we'll get started.

Good morning, ladies and gentlemen, and welcome to the Subcommittee on Technology and Competitiveness.

In last week's hearing on high definition systems, we heard testimony about the future vision for these systems. This morning we want to explore the Government's role in the implementation and standardization of these systems.

Last week's witnesses testified about the importance of the advancement of high definition systems to enhancing our everyday lives. These advancements would enhance our medical care, education, entertainment, and business environments. However, these technologies will require greater interoperability between image, information and communication. An example shared by one of the witnesses is the use of the large screen television display to view the videophone image of relatives in a distant city or a foreign country.

Equally important, if not more important, the witnesses testified about losing the manufacturing or production capabilities of many of the technological ideas and advances to offshore industries. This is a concern that we want to explore in more depth today.

The Federal Communications Commission will be setting a national terrestrial broadcasting standard for high definition television in early 1993. The standard selected will deliver the images of our next generation television sets. If the standard is digital, the upcoming decision will facilitate the integration of the various components of high definition systems. Also, these decisions will influence the delivery medium, whether it is cable, over the air, fiber optic, or a combination. One of our witnesses today is from the FCC, and I, with other members of the committee, look forward to hearing how the FCC actions will fit into the implementation strategy of high definition systems.

Also this morning we want to hear testimony on the impact of this standard on the other components of high definition systems. Additionally, we want to discuss other implementation efforts needed in making the high definition systems a reality. These implementation efforts, among other things, include standards identification and development. We want to ensure that industries are developing components that will be interoperable with other components such that conversion equipment will be kept to a minimum.

Again I say, on behalf of myself and all members of the committee, welcome here. We look forward to hearing the testimony of all of the witnesses. We will recognize Mr. Lewis when he comes in.

The Chair recognizes Mr. Swett. Do you have an opening statement at this time?

Mr. SWETT. Thank you, Mr. Chair. Good morning. It's a pleasure to be here this morning. I appreciate your coming to discuss yet another very important topic on the slate of the Technology and Competitiveness Subcommittee.

I would like to commend the Chair for his series of hearings on intertechnological cooperation, and I think that we have had a great deal of very formative and informative discussions regarding the requirements that our industry needs to meet in order to bring forth a more unified and cooperative effort in the technological front.

So far we have had a great deal of discussion about the identification of the problem, and I'm excited about today's hearing because we are beginning to look at not only discussing the problem but searching for solutions. These are some solutions that I have seen through the remarks on testimony that we'll be hearing today, are exciting and necessary, and I am very interested in hearing in greater detail the solutions that you have proposed and are here to testify about.

I look forward to your testimony, I appreciate your coming this morning, and I yield back the balance of my time, Mr. Chairman, with great anticipation.

Mr. VALENTINE. Thank you, sir.

Before I recognize the distinguished member from Maryland, Mr. Wayne Gilchrest, let me say that I'm going to have to leave here for a few minutes to attend another subcommittee meeting. I will be back, I hope, by 15 minutes after 10:00 or something of that kind.

Mr. Gilchrest, we are happy to hear from you at this time for an opening statement.

Mr. GILCHREST. Thank you, Mr. Chairman. I, too, will have to leave shortly for another committee hearing. Maybe we should use some of this technology to coordinate our activities a little bit better up here on the Hill.

Thank you, Mr. Chairman, for bringing this topic to our attention. I look forward to the testimony as far as the advances of high definition television are concerned, the advantages that it will provide for us as a Nation, how possibly these things can integrate with other technologies and how we can begin to improve our competitiveness with, I guess—Is it the Japanese? I think it's the Japanese who are advancing in this particular field.

Mr. VALENTINE. Among others.

Mr. GILCHREST. Among others, yes.

I look forward to the testimony and I thank you all for coming and sharing this information with us. Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, sir.

The Chair recognizes at this time the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman. And I hate to say what my schedule looks like this morning. It might get depressing for everybody out there. Hopefully there'll be somebody to hold our fort.

But, Mr. Chairman, as co-Chairman, along with Congressman Levine, of the House HDTV Caucus, someone who has served for a decade on the Telecommunications and Finance Subcommittee of Energy and Commerce, someone who has pushed for Federal R&D investments and advocated private sector investment incentives and Government policies to stimulate HDS in America, made in America, I want to thank you for holding this hearing. I think it's a very important subject.

In the information age, a nation's ability to compete is going to be directly related to its ability to move information, and right now we are on the verge of radically changing the way we transmit and receive visual information. When digitally combined with computer technology, and eventually a national fiber network, high definition television and other high definition systems will form the highways of tomorrow's information society, much in the same way that the interstate highway system served as the location of movement for the automobiles in the automotive age.

HDS represents another benchmark in the evolution of electronic goods in the direction of computer-like digital technologies. It is driving the state-of-the-art for a number of technologies and will be integrally, strategically linked to a number of high value-added manufacturing industries and jobs in fields such as semiconductors, consumer electronics, computers and telecommunications, among so many others.

In the not too distant future, the television computer and broadcast industries will need a new common standard, or common standards, acceptable to the needs of each of these industries. Such a standard, or such standards, should also be compatible with current television, permit two-way communication, and be flexible enough to accommodate unforeseen needs created as technology further evolves in the future.

The existing TV broadcast standard was established in 1953 and is becoming obsolete as technology is evolving. The Federal Communications Commission is beginning to test a variety of HDS broadcast systems and is scheduled to announce the new standard in about 18 months.

Our witnesses today represent the interests of the computer, communications, and cable television industries. Their expert testimony should help to assure that the standard or the standards ultimately selected by the FCC do not unreasonably restrict the development of high definition systems and, indeed, promote the creative American evolution of high definition as a major player in the information age.

So once again, Mr. Chairman, thank you for holding this hearing. I look forward to the testimony of our distinguished witnesses.

[The prepared statement of Hon. Don Ritter follows:]

OPENING STATEMENT
HEARING ON HDS IMPLEMENTATION
HON. DON RITTER (R-PA)
MAY 21, 1991

Thank you, Mr. Chairman.

As Co-chairman of the HDTV Caucus and one who has long served on the Telecommunications and Finance Subcommittee; also, as someone who has pushed for Federal R&D investments and advocated private sector investment incentives for HDS, I want to thank you for holding this important hearing on high definition systems, standards and implementation.

In the information age, a nation's ability to compete will be directly related to its ability to move information. Right now, we are on the verge of radically changing the way we transmit and receive visual information. When digitally combined with computer technology, and eventually, a national fiber network, High Definition TVs and other High Definition Systems will form the highways of tomorrow's Information Society.

HDS represents another benchmark in the evolution of electronic goods in the direction of computer-like digital technologies. It is driving the state-of-the-art for a number of technologies, and will be integrally, strategically linked to a number of high value-added manufacturing industries such as semiconductors, consumer electronics, computers, and telecommunications, among others.

In the not-too-distant future, the television, computer and broadcast industries will need a new, common standard--one acceptable to the needs of each of these industries. Such a standard should also be compatible with current televisions, permit if and when possible two-way communication, and be flexible enough to accommodate unforeseen needs created as technology further evolves in the future.

The existing TV broadcast standard was established in 1953 and is becoming obsolete as technology is evolving. The Federal Communications Commission is beginning to test a variety of HDS broadcast systems, and is scheduled to announce the new standard in about 18 months. Our witnesses today represent the interests of the computer, communications and cable television industries. Their expert testimony should help to assure that the standard ultimately selected by the FCC does not unreasonably restrict the development of high definition systems. Thank you.

Mr. VALENTINE. Thank you, sir.

Our first panel consists of Dr. John W. Lyons, who, of course, is Director of the National Institute of Standards and Technology, and Dr. Tom Stanley, Federal Communication Commission, Chief Engineer.

Without objection, the opening statement of our colleague, Representative Joan Kelly Horn from Missouri, will be inserted into the record. If other members would like to be accommodated in that fashion, just let us know.

[The prepared statement of Hon. Joan Kelly Horn follows:]

Opening Statement of Joan Kelly Horn
Before the Technology and Competitiveness Subcommittee
May 21, 1991

Mr. Chairman, colleagues, and distinguished witnesses, the focus of today's hearing, the implementation of high definition systems, is timely because the decisions we make in the next few years will determine the cost and level of services available in the home and businesses for a decade or more. It is imperative that we allow maximum flexibility and compatibility to guide us in setting standards and determining the communications infrastructure we install. It is equally imperative that we realize that high definition technology is not limited to use in the entertainment industry, but has broad applications in communications activities in research, medicine and education.

I look forward to hearing suggestions from witnesses on both panels on how to insure flexibility for multiuse purposes of lines into and out of homes and businesses. It seems to me that lines which can carry various kinds of data, including voice and video into and out of buildings are the best investment for future installation. This may mean optic fiber installations should be encouraged, as they can accommodate two way communications of all kinds to and from homes, businesses, and institutions of all kinds. If there are other transmission materials that can accomplish the same goals, I hope our witnesses will tell us.

We also want to be sure in setting standards for broadcast television that we encourage the telecommunications market to expand. In any case we must be sure that such standards we do impede expansion of computer based technologies into the home and offices. This likely means that the standard set for broadcast television will be digital. However, it is important to insure that any standards set keep in mind both broadcast and non-broadcast functions.

I await the comments of our distinguished witnesses on how we can insure to the maximum extent possible that our telecommunications infrastructure can best serve to increase options for our homes, businesses, and educational, medical and governmental institutions. Specifically, I want to know if one line into and out of a building (for example, a telephone line) could accommodate all data transmissions from many sources, including educational video, data from computers, television transmission, and audio and video communication If this is possible, how can we encourage the use of multipurpose lines while insuring access to these lines for all communication services? What problems would arise from this?

I look forward to hearing from the witnesses.

Mr. VALENTINE. I would ask you gentlemen to please summarize. Your statements will appear in the record as presented to us.

Dr. Lyons.

STATEMENT OF JOHN W. LYONS, DIRECTOR, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY; ACCOMPANIED BY ROBERT E. HEBNER, DEPUTY DIRECTOR, ELECTRONICS AND ELECTRICAL ENGINEERING LABORATORY, NIST; AND THOMAS P. STANLEY, CHIEF ENGINEER, FEDERAL COMMUNICATIONS COMMISSION

Dr. LYONS. Thank you, Mr. Chairman, and good morning. It's a pleasure to be here once again to testify before the subcommittee, talking today about high definition systems. This field shows promise of being one of the most important areas of technology as we enter the next century. The combination of increased speed and data capacity in computers, networks, and telecommunications systems, and improvements in data compression technology, offers American business and the public an unprecedented amount of information in their homes, offices, or at remote locations.

These advances in information technology result from advances in physical sciences, mathematics, and computer science. Today, the technology exists to deliver large amounts of information, rapidly and with high quality. Yet, it is reasonable to expect that in the future both the quantity and quality of information available will continue to increase dramatically as the cost decreases.

High definition systems are those in which much improved resolution and depiction of detail are presented because of very great increases in the rate at which information can be moved about and manipulated. These increases in data rates are enabled in turn through advances in a series of related technologies that I consider fall under the general label of advanced telecommunications. In addition to higher speeds, the new technology is rapidly converting to digital signal processing and relies increasingly on optical and optoelectronic techniques. The new digital technologies are considerably less vulnerable to various sources of interference.

This advancing technology is also attracting significant attention in the courts, regulatory agencies, and in Congress. One of the reasons for this attention is that the U.S. has, as do other industrialized nations, a regulatory structure that was established at a time when telephones, radio and television, libraries, newspapers, movies, and computers were treated as separate entities and technologies.

It is increasingly clear that advancing technology is bringing a major reshuffling of these activities. Factors which influence such changes include market forces, regulatory actions, and availability of technology. Other Federal agencies and organizations are concerned with and positioned to discuss the regulatory and market issues.

Since NIST is a technical organization, I will focus here on our technical activities which convince me that the necessary technology will be available when America moves to exploit these advances.

NIST supports the high priority technical aspects of high definition systems in two ways. First, through its laboratory programs, we are developing standards, measurements, and test technology that industry needs to design, develop, test, sell, and service products based on the new technology, and second, through the Advanced Technology Program, we are contributing to the support of industry's advances in precompetitive, generic technologies such as in storage and display technology.

NIST does not focus on which products should be developed; rather, it provides the measurement capability all firms need to make the products that the private sector determines to be necessary.

Our view of the component technologies of high definition systems matches the description in the Report of the National Critical Technologies Panel released just last month. The Panel divided the category of "high definition imaging and displays" into five components: high definition vision, real time signal processing, high rate data transmission, high density data storage, and high definition displays. I will summarize NIST's activities within these categories.

First, high definition vision. This includes video cameras, document scanners, and computers that synthesize images. We have two programs that are particularly related to industrial needs in this area. First, we are establishing a visualization laboratory to develop and evaluate techniques to present computer-generated simulations of physical and chemical processes. Second, we are developing techniques to test solid-state photodetectors. Arrays of these detectors are used in cameras to convert light to an electrical signal. We do not have a program focused on cameras but have a strong program in the supporting electronic and optical technology.

Real time signal processing, which includes analog-to-digital data converters, digital processors, data compression techniques, and semiconductor memories. NIST maintains programs which provide needed measurement technology. The newest facility at NIST in the signal processing field is the Princeton engine, an image processing supercomputer developed by the David Sarnoff Research Lab at Princeton, NJ. This video supercomputer has just been installed at NIST as the cornerstone of a joint DARPA-NIST program on signal processing. This massively parallel computer provides real time simulation permitting the efficient evaluation of processing hardware.

High data rate transmission. NIST has programs which are critical to both hardware and software aspects of such transmission. Advanced microwave technology is needed, for example, for cellular telephones, satellite communications, wireless computer systems, and other remote or mobile applications. NIST is working with the Department of Defense and the private sector to develop and distribute some of the most critically needed new standards and measurement techniques.

Another critical factor in high data rate transmission is industry's use of fiber optic technology. NIST measurement techniques have influenced this industry primarily through voluntary standards, 28 of which are based on NIST work.

High data rate communication cannot exist without both hardware and control software. NIST is instrumental in the operation of the North American Integrated Services Distributor Network User's Forum, the ISDN users' forum, which was established as a partnership among industry, user organizations, and the Government, with over 300 participating members.

High density data storage. In this area we're working with industry to improve storage technology in three different areas: one, to improve the speed at which data can be stored and retrieved; two, to improve the performance of nonvolatile memories—that is, storage elements which do not forget when they lose power—and three, to develop laser sources for optical memory devices.

We also provide measurement support for the magnetic recording industry. As part of this program, NIST has developed a scanning electron microscope with polarization analysis to provide images of the magnetic microstructure of materials.

High definition displays. NIST is addressing the generic technology which underlines development of such displays.

In conclusion, there is a significant domestic and industrial activity in the general area of high definition systems and, spurred by foreign advances, it is growing rapidly. In this area of technology, there is an ever-widening base of technical commonality among computers, telecommunications, and some types of business and consumer electronics. In the future, I expect that distinctions among these areas will be increasingly the result of market forces or regulations and, to a much lesser extent, resulting from differences in technology. High definition systems technologies are emerging, and both defense and commercial will require a healthy technology base. NIST's mission of supporting U.S. industry in its drive to be competitive requires the Institute to work with American companies and agencies as the private sector ushers these technologies into the global marketplace.

Mr. Chairman, I have with me Dr. Robert Hebner, who has specialized in these matters for some time, and he, too, is available to answer your questions if you wish.

Thank you.

[The prepared statement of Dr. John W. Lyons follows:]

UNITED STATES
DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS
AND TECHNOLOGY

U.S. DEPARTMENT OF COMMERCE
STATEMENT OF JOHN W. LYONS, DIRECTOR
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
BEFORE THE SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

May 21, 1991

Mr. Chairman and members of the Subcommittee, I am pleased to appear before you today to discuss NIST's role in helping the private sector and other agencies to implement high definition systems. This field shows promise of being one of the most important areas of technology as we enter the twenty-first century. The combination of increased speed and data capacity in computers, networks, and telecommunications systems, and improvements in data compression technology offers American business and the public an unprecedented amount of information in their homes, offices, or at remote locations. These advances in information technology result from advances in physical sciences, mathematics, and computer science. The potential benefits of this widespread access to information are stimulating the imagination of technologists and non-technologists alike. Today, the technology exists to deliver large amounts of information, rapidly and with high quality. Yet, it is reasonable to expect that in the future both the quantity and quality of information available will continue to increase dramatically as the cost decreases.

High definition systems are those in which much improved resolution and depiction of detail are presented because of very great increases in the rate at which information can be moved about and manipulated. These increases in data rates are enabled in turn through advances in a series of related technologies that I consider fall under the general label of "advanced telecommunications." In addition to higher speeds, the new technology is rapidly converting to digital signal processing and relies increasingly on optical and optoelectronic techniques. The new digital technologies are considerably less vulnerable to various sources of interference.

In the U.S., industry is pursuing this technology vigorously. The American Electronics Association, for example, has scheduled special meetings with me and other NIST staff to assure that we are aware of the range of private activities under way. The Institute of Electrical and Electronics Engineers is convening groups to establish voluntary standards in this area and is formally considering some reorganization and the establishment of a new technical journal in response to the growth in related technical activities. Hardly a month passes by without a significant announcement by one company or another of plans to improve their competitive position in the area of information technology with implications for high definition systems.

This advancing technology is also attracting significant attention in the courts, regulatory agencies, and in Congress. One of the reasons for this attention is that the U.S. has, as do other industrialized nations, a regulatory structure that was established at a time when telephones, radio and television, libraries, newspapers, movies, and computers were treated as separate entities and technologies. It is increasingly clear that advancing technology is bringing a major reshuffling of these activities. Factors which influence such changes include market forces, regulatory actions, and availability of technology. Other federal agencies and organizations are concerned with and positioned to discuss the regulatory and market issues. Since NIST is a technical organization, I will focus here on our technical activities which convince me that the necessary technology will be available when America moves to exploit these advances.

NIST Role

NIST supports the high priority technical aspects of high definition systems in two ways:

1. Through its laboratory programs, NIST is developing standards, measurements, and test technology industry needs to design, develop, test, sell, and service products based on the new technology.

2. Through its Advanced Technology F ogram, NIST is contributing to the support of industry's advances precompetitive, generic technologies such as in storage and display technology.

NIST generic measurement technology is needed to help industry develop and improve the quality and timeliness of their products over the range of product life from research and development, to manufacturing, to sales, and to service. NIST does not focus on which products should be developed; rather, it provides the measurement capability all firms need to make the products that the private sector determines to be necessary. Such measurement-related research and services is NIST's traditional role in support of U.S. industry. As the area of advanced information technologies has become more important to industry's products and services, it is only natural that they have turned to NIST for the generic support which is our mission.

In the same vein, the Advanced Technology Program provides grants to individual companies and consortia for research and development on generic, pre-competitive technologies. The program emphasizes technologies that underlie a wide range of potential applications. The first eleven projects have been selected on the basis of technical merit in this new program, with four being directly relevant to high definition systems.

Summary of NIST Activities

Our view of the component technologies of high definition systems matches the description in the Report of the National Critical Technologies Panel released last month. The Panel divided the category of "high-definition imaging and displays" into five components:

- High-Definition Vision
- Real-Time Signal Processing
- High-Rate Data Transmission
- High-Density Data Storage
- High-Definition Displays

I will summarize NIST's activities within these categories.

High-Definition Vision. High-definition vision includes video cameras, document scanners, and computers that synthesize images. NIST has two programs that are particularly related to industrial needs in this area. First, NIST is establishing a visualization laboratory to develop and evaluate techniques to present computer-generated simulations of physical and chemical processes. Sophisticated computer models of complex phenomena generate reams of numbers which by themselves are difficult or impossible to interpret. Appropriate visualization is an effective means to interpret and evaluate the results of the computation.

Second, NIST is developing techniques to test solid state photodetectors. Arrays of these detectors are used in video cameras to convert light to an electrical signal. NIST does not now have a program focused on cameras, but we have a strong program in the supporting electronic and optical technology.

Real-Time Signal Processing. Real-time signal processing includes analog-to-digital data converters, digital processors, data compression techniques, and semiconductor memories. NIST maintains programs which provide needed measurement technology for all of these categories. The newest facility at NIST in the signal processing field is the Princeton Engine, an image-processing supercomputer developed by the David Sarnoff Research Laboratory at Princeton, NJ. This "video supercomputer" has just been installed at NIST as the cornerstone of a joint DARPA-NIST program on signal processing. This massively parallel computer provides real time simulation permitting the efficient evaluation of processing hardware. The computer is an extremely useful adjunct to the NIST program which already addresses the mathematics of signal processing and the testing and evaluation of electronic circuitry. This facility will be used both for defense-related research and to support NIST's program. It should save researchers both time and money and help move products to the defense and commercial markets more quickly.

High Data-Rate Transmission. NIST has programs which are critical to both the hardware and software aspects of high data rate transmission. Advanced microwave technology is needed, for example, for cellular telephones, satellite communications, wireless computer systems, and other remote or mobile applications. The major technology trend in advanced microwaves is the miniaturization of systems and their integration in semiconductor circuits, just as lower frequency electronics have progressed in the past. These integrated circuits are incompatible with the microwave standards which have heretofore permitted the advances of the microwave industry. To address this problem, NIST is working with the Department of Defense and the private sector to develop and distribute some of the most critically needed new standards and measurement techniques.

Another critical factor in high data-rate transmission is industry's use of fiber optic technology. NIST measurement techniques have influenced this industry primarily through voluntary standards, 28 of which are based on NIST work. For example, NIST provided the technical basis for the international standard for numerical aperture, which limits the amount of light that can be put into or taken out of a fiber. Prior to the adoption of this standard, NIST developments helped resolve a discrepancy between test methods for numerical aperture used by the two major domestic suppliers of optical fibers. In cooperation with industry, NIST also developed the technical basis for a new voluntary standard to measure the core of an optical fiber, which influences light losses during transmission as well as at connections. NIST conducted comparative measurements of various techniques used by industry to perform this measurement and identified limitations of the various approaches.

Currently, NIST is investigating the performance of diode lasers for high data rate systems. One of the laser types being studied is the surface emitting laser, which is expected to permit electronic devices such as computers, to operate using pulses of light rather than electrical signals. This type of optical data transfer appears to be an important part of Japan's new sixth generation computer system, as well as an important development activity by U.S. industry.

High-data rate communication cannot exist without both the hardware and the control software. NIST is working closely with the telecommunications industry to assure that the software structure needed for a versatile, open telecommunication system is available in a timely manner. This work complements that being performed by our sister agency, the National Telecommunications and Information Administration. In particular, NIST is instrumental in the operation of the North American ISDN Users' Forum which was established as a partnership among industry, user organizations and the government, with over 300 participating members. The initials "ISDN" stand for Integrated Services Digital Network, an approach for handling voice, data, and images on the same telecommunications system.

High-Density Data Storage. NIST is working with industry to improve data storage technology in three different areas as a result of first-year awards under the Advanced Technology Program. To improve the speed at which data can be stored and retrieved, NIST provided funding to the Microelectronics & Computer Technology Corporation in the development of a holographic mass storage system. To improve the performance of nonvolatile memories -- that is, storage elements which do not "forget" when they loose power -- NIST provided funding Nonvolatile Electronics, Inc., to improve device speeds, density, and production yields. Finally, NIST is funding the National Storage Industry Consortium to develop laser sources for optical memory devices. These projects were selected after both technical and business reviews of 247 competing proposals.

NIST also provides measurement support for the magnetic recording industry. As part of this research-based program, NIST has developed a scanning electron microscope with polarization analysis to provide images of the magnetic microstructure of materials. More than 100 companies have inquired about this magnetic imaging technique, and NIST has worked cooperatively with several firms interested in adopting this method. Other activities have included the development of techniques to characterize recording heads, the development of a unique magnetic force microscope, the evaluation of techniques to determine magnetic properties of magnetic tape, and standard reference magnetic tapes.

High-Definition Displays. The Advanced Technology Program also is providing funding for the generic technology which underlies development of high definition displays. Through a first-year project, support is being provided to the Advanced Display Manufacturers of America Research Consortium to develop automatic inspection and repair technology for displays. The results are expected to be applicable to the design, production, testing, and manufacturing of the several different types of flat panel displays.

Conclusion

There is a significant domestic industrial activity in the general area of high definition systems-- and, spurred on by foreign advances, it is growing rapidly. This industrial activity is augmented by a number of Federally funded programs; for example, the President's fiscal year 1990 budget identified more than $100 million devoted to help develop advanced imaging technologies. In this area of technology, there is an ever widening base of technical commonality among computers, telecommunications, and some types of business and consumer electronics. In the future, I expect that distinctions among these areas will be increasingly the result of market forces or regulations -- and only to a much lesser extent resulting from differences in technology. High definition systems technologies are merging and both defense and commercial success will require a healthy technology base. NIST's mission of supporting U.S. industry in its drive to be competitive requires the Institute to work with American companies and agencies as the private sector ushers these technologies into the global marketplace.

Mr. SWETT. [Presiding.] Thank you very much, Dr. Lyons, and thank you for attending this hearing also as a support backup.

At this point in time we would like to hear the testimony of Dr. Tom Stanley.

Dr. STANLEY. Thank you, Mr. Chairman.

Good morning, members of the subcommittee. Thank you for giving me the opportunity to speak with you this morning.

Pursuant to the Commission's responsibilities under the Communications Act, the FCC is charged with not only making available to the American public an efficient, nationwide communications system, but also with encouraging the introduction of new technology. Thus, since 1987, we have been engaged in the process of selecting a national standard for the next generation of broadcast television, a high definition system with video quality approaching that of 35 millimeter film. I thought it might be helpful if I give you an idea of the scope of this activity and the Commission's progress to date.

Let me say from the outset that the Federal Communications Commission and the involved industries have invested a great deal of time and resources into pursuing the goal of selecting an HDTV standard early in the 1990s. Our work appears to be progressing towards a successful conclusion.

We began four years ago in response to a request from 57 broadcast entities. Even though work on various HDTV concepts was underway in several countries, we determined early on that we would choose a standard uniquely suited to the interests of the United States. One of our first steps was to create the FCC Advisory Committee on High Definition Television Service, to advise the FCC on standards and policies in connection with the introduction of advanced television in the U.S. This committee is composed of TV broadcasters, cable TV interests, TV producers, and receiver manufacturers.

Millions of dollars have been spent in developing systems and prototype hardware. Industry has established a number of laboratories to test and evaluate the various proponent systems in cooperation with the FCC's Advisory Committee. These laboratories are the Advanced Television Test Center and Cable Labs, both with facilities in Alexandria, VA, and Canada's Advanced Television Evaluation Laboratory. This summer, these facilities will begin testing proposed HDTV systems as part of the Advisory Committee's process of evaluating the systems and making a recommendation to the Commission.

One of the earliest policies announced by Chairman Sikes was to set a goal of June, 1993, for making a final selection on an HDTV standard. At the same time, it was made clear that the Commission would leave a door open to permit new technological developments—for instance, the development of a fully digital HDTV system. As a result of this policy, four of the six proponent systems to be tested are now fully digital. In fact, many today consider the U.S. a leader in the development of digital technology for high definition television.

It should be noted that the Commission has been working under certain principles and constraints. First, it was understood several years ago that the interest of the United States would best be served by the implementation of an HDTV service without delay. And, as I have noted, we have expended significant resources and effort towards this end.

Second, HDTV service will be available to all the people of the United States. It will have to be provided on a wide area basis, not, for example, only to urban or city-grade coverage.

The bandwith of the transmission channel is also relatively limited—six megahertz. The transmission environment is characterized by significant variations in signal strength, noise, interference from reflected signals, and signals on adjacent channels. An HDTV standard will have to support a mass marketed receiver which would be affordable to the American public. These are some of the constraints and challenges we have to deal with in the development of a TV broadcast service.

I think there is great similarity in high definition video technologies that inevitably will result in various levels of compatible applications. The current momentum in design of broadcast TV systems is to employ digital technology, and I believe that a digital standard may well be selected as the broadcast HDTV standard. This would be a significant step towards compatibility between broadcast television technology and other digitally based video applications, including computer video technology.

As Professor Marc Krivocheev, Chairman of the Broadcasting Service Group of the CCIR Committee, has stated, "Certainly the current move in the United States and elsewhere towards digital HDTV and away from analog TV provides the greatest opportunity for harmony among all the users of high definition TV or high resolution imaging."

I believe that with digital technology one can predict a common broadcast/computer interface will be developed in something like five to ten years, regardless of the action that we take on an HDTV standard now. To the extent that discussions between computer and broadcast industries begin early, the process will be facilitated and the ultimate costs will be minimized.

I do think it would be desirable for those developing high definition video systems for computers to join the other participants of the FCC Advisory Committee to explore areas of compatibility that can be determined now. I'm sure their contribution would be valuable and, in the long run, hasten the development of a common high definition interface. I believe that significant progress may well be possible to harmonize broadcast and nonbroadcast HDTV applications.

Mr. Chairman, this concludes my remarks. I would be happy to answer any questions.

[The prepared statement of Dr. Thomas P. Stanley follows:]

Statement of

Thomas P. Stanley
Chief Engineer
Federal Communications Commission

Before the

Subcommittee on Technology and Competitiveness
Comm..tee on Science, Space, and Technology
U.S. House of Representatives

on

High Definition Systems Implementation

Tuesday, May 21, 1991

Mr. Chairman and Members of the Subcommittee:

Good Morning. Thank you for giving me the opportunity to speak to you this morning. Pursuant to our responsibilities under the Communications Act, the Commission is charged not only with making available to the American public an efficient, nationwide communications system, but also with encouraging the introduction of new technology. Thus, since 1987, we have been engaged in the process of selecting a national standard for the next generation of broadcast television, a high definition system with video quality approaching that of 35 mm film. I thought it might be helpful if I give you an idea of the scope of this activity and the Commission's progress to date; and then, of course, I'll be happy to answer any questions you may have.

Let me say at the outset that the Federal Communications Commission and involved industries have invested a great deal of time and resources in pursuing the goal of selecting an HDTV standard early in the '90s. Our work appears to be progressing towards a successful conclusion.

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FCC on standards and policies in connection with the introduction of advanced television in the United States. This Committee is composed of television broadcasters, cable television interests, television producers, and equipment manufacturers. Millions of dollars has been spent in developing systems and prototype hardware. Industry has established a number of laboratories to test and evaluate the various proponent systems in cooperation with the Advisory Committee. These laboratories are the Advanced Television Test Center and Cable Labs, both in Alexandria, and Canada's ATEL (Advanced Television Evaluation Laboratory). This summer, these facilities will begin testing proponent HDTV systems as part of the Advisory Committee's process of evaluating the systems and making a recommendation.

One of the first policies announced by Chairman Sikes was to set a goal June 1993 for making a final decision on an HDTV standard. At the same time it was made clear that the Commission would leave a door open to permit new technological developments, for instance, the development of a fully digital HDTV system. As a result of this policy, four of the six proponent systems to be tested, are now digital. In fact, many today consider the United States the leader in the development of digital technology for HDTV.

It should be noted that the Commission has been working under certain principles and constraints. First, it was understood several years ago that the interests of the United States would best be served by the implementation of HDTV service without delay; and, as I have noted, we have expended significant resources and effort toward this end. Second, HDTV service will be available to all people of the United States. Thus, it will have to be provided to a wide area. The bandwidth of the transmission channel is relatively limited - 6 MHz. The transmission environment is characterized by significant variations in signal strength and the presence of interference from reflected signals, noise and signals on adjacent channels. An HDTV standard will have to support mass marketed, affordable receivers. These are some of the constraints - and challenges - we have to deal with in the development of a television broadcast service.

I think there is a great similarity in high definition video technologies that, inevitably, will result in various levels of compatible applications. The current momentum in design of broadcast HDTV systems is to employ digital technology, and I believe a digital system may well be selected as the broadcast HDTV standard. This would be a significant step toward compatibility between broadcast television technology and other digitally based video applications, including computer video technology. As stated by Professor Marc Krivocheev, the Chairman of Broadcasting Service Study Group of the International Radio Consultative Committee, "Certainly, the current move in the

United States and elsewhere toward digital HDTV and away from analog HDTV provides the greatest opportunity for harmony among all the users of HDTV or High Resolution Imaging." I believe that with digital technology, one can predict that a common broadcast/computer interface will be developed in five to ten years, regardless of the action that we take on an HDTV standard now. To the extent that discussions between the computer and broadcast industries begin early, the process will be facilitated and the ultimate costs will be minimized.

I do think it would be desirable for those developing high definition video systems for computers to join the other participants of the FCC Advisory Committee to explore areas of compatibility that can be determined now. I'm sure their contribution would be valuable, and, in the long run, hasten the development of a common high definition interface. I believe that significant progress may well be possible to harmonize broadcast and non-broadcast high definition applications.

Mr. Chairman, that concludes my remarks. I would be happy to answer any questions.

Mr. SWETT. Thank you, Dr. Stanley.

At this time I would like to acknowledge the presence of two of my colleagues. Welcome, Mr. Rohrabacher from California, and welcome Miss Kelly Horn from Missouri.

I would like to take this opportunity, rather than my focusing on questions that I have, to allow the senior members whose schedules are equally busy and have voiced their desire to move on with their schedule, the opportunity to ask the first questions.

I turn the microphone over to my good colleague from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thanks, Mr. Chairman.

Let me ask a question here. Is NIST working closely with the FCC and the Advanced Television Test Center in analyzing or at least giving input to the analysis of the different competing systems for an HDTV standard?

Dr. LYONS. Mr. Ritter, we work closely with the FCC, and always have. We've discussed this area and I think we've made a suitable division of responsibilities and duties. FCC, as Dr. Stanley has testified, has a certain scope of activity which covers the broadcast standards area, and we feel that our responsibility is to work in a somewhat more supportive role on component standards and more general kinds of communications standards.

I think we have a working agreement. We've gotten together and talked about this and visited the Center and so on.

Mr. RITTER. Okay. So the FCC then, and the Advisory Committee on HDTV and the Test Center, is taking full advantage of the in-depth scientific and technical understandings of NIST staff?

Dr. STANLEY. That's right, Congressman. In particular, let me mention the Princeton engine that Dr. Lyons had mentioned. That, as a resource, has been made available to the Commission and to the Test Center and to the proponents to develop any aspect of their systems or for the analysis that appears needed.

Mr. RITTER. You mentioned—you discussed digital and the eventual merger between broadcast and digital in five to ten years. People are now proposing as part of the different standards, broadcast transmission standards being tested, digital compression technology that would make substantially more use of the existing 6 megahertz bandwidth.

Do you want to comment on the progress to date, today, that you see having been made here? There are claims, there are dates proposed for demonstrating this technology, and Dr. Lyons, you might want to also chime in on this. But why don't we start with you, Dr. Stanley.

Dr. STANLEY. Thank you.

Actually, the progress in this area is nothing short of astonishing. Less than a year ago, none of the proponent systems to be tested was a fully digital scheme. Within the course of the last 12 months, just in June of 1990 specifically, the first all-digital proponent popped into our field of view, and within the next six to eight months three additional ones followed. So the actual progress of the state-of-the-art, people feeling the capabilities to compress the digital bit stream and squeeze it into a 6 megahertz channel, had reached such a level as to be put together and actually tested in the FCC's processes. So again, within the course of the last year, it looks as though technology has kind of changed our—

Mr. RITTER. Now you, and the FCC, really hasn't tested any one of these digital compression schemes to date, but the first one is projected for when, September, the General Instruments Scientific Atlanta—

Dr. STANLEY. That's right. The actual—

Mr. RITTER. —Cable Television, Cable Labs proposal.

Dr. STANLEY. I don't remember the specific time slots. The full testing program of the six proponents starts in early July. As I recall, the first one is not specifically a digital proponent, but the next one I believe is, which would make it about September, correct.

Mr. RITTER. Who is now in the digital compression game, in addition to the one that I mentioned?

Dr. STANLEY. Let's see. There's MIT, ATA—

Mr. RITTER. Zenith, AT&T—

Dr. STANLEY. Zenith and AT&T. Let's see, there's one more. I guess there's a North American TV research consortium.

Mr. RITTER. Is the United States—You know, we've always heard that if things go digital, we end up doing better because we have some technology leads over our prime competitor, the Japanese.

Where do you see that?

Dr. STANLEY. I think that's exactly so. I think the digital state-of-the-art has been very well developed in the U.S. For example, these compression techniques have been U.S. developed. I think that's one of the benefits of living in a tight environment with regard to spectrum. You have to develop techniques like compression, squeezing out extra capacity in systems given the limitations. This has been a unique situation in the U.S.

Mr. RITTER. Dr. Lyons, you might want to comment on this. You might want to just think of the production side of it. I mean, a lot of times we do develop—We innovate, we invent, we innovate, we engineer, we develop, and brand "x" produces. Where does the U.S. manufacturing capability stand in regard to this potential?

Dr. LYONS. Well, if I may, Mr. Ritter, let me go back a little and then try to come forward and cover that.

Mr. RITTER. Sure, please.

Dr. LYONS. What we're talking about here is really chip technology and how fast you can manipulate the signals. It's true, the progress is astonishing, and I have every confidence it will continue to astonish for the rest of my career, so that any prediction you make will probably fall short of what they'll be able to do over the next decade.

My sense in watching—

Mr. RITTER. People did not predict 16 megabit chips this quickly, did they?

Dr. LYONS. Of course not.

My sense in watching technology in all of our programs is that the chip technology has never been the limiting problem. We've seen that in factory automation, where you can do things horribly inefficiently because the chips are so powerful and so inexpensive. So we do things we never would have dreamed of a few years ago.

I believe the case here is that the technology is going to be available almost without limit, and as we said in our testimony, the issues will be institutional in the grandest sense. How do we make the tricky decisions that are in the regulatory side, fortunately Dr. Stanley's side and not mine, make all these tradeoffs and come out with something. The technology will be there, no matter which route we pick. I'm sure the compression will come along very nicely, no matter how you do it.

In the assessment of where we stand in this country, logic chips, as you know, we do very well at. That's our strong suit in semiconductors, is manipulating information. Where we're not doing so well, of course, is in memory chips. I'm confident we can handle the logic part of it without any trouble.

Now, we're pushing now against rate limits. This is really going to get us into the integrated services digital network technology, where we're talking about tens of gigabits per second data rates, and the limit is not, as you know, in the fibers but it's in the modulation rates and the multiplex/de-multiplex rates and so on. But all those technologies I'm sure are going to move faster than we, as political animals, are going to move.

Mr. RITTER. Are we going to produce them? Do we have a good shot at manufacturing them here with some lead, with some comparative advantage?

Dr. LYONS. I think so. I think if this goes all digital, and I believe—You know, every month goes by and you become more certain. Dr. Stanley just said he had, what, four systems, and now they're all digital. That's where our strength is. We still have—

Mr. RITTER. They're not all American. They're all digital but—

Dr. LYONS. That's another subject, I guess.

I think the chances are very good. But as you know, we don't commercialize as well as we develop new ideas. That's certainly still true in many areas.

Mr. RITTER. Thank you very much, and thank you, Mr. Chairman.

Mr. SWETT. Thank you, Mr. Ritter.

Mr. Gilchrest, would you like to take the mike and ask your questions at this time?

Mr. GILCHREST. Thank you, Mr. Chairman.

I'm not quite as sophisticated as Mr. Ritter. When I first heard gigawatts, I was watching "Back to the Future". I thought it was a term they pulled out of Hollywood. I guess, looking at more of a philosophical perspective, you are in the business, I suppose I could say, of developing generic technologies, and then the manufacturers our there in the hinterlands can absorb this and process it and then commercialize it to wherever this leads them, or wherever they think the consumer will go.

Is there any way that the two can get together, the private sector with your group, and kind of predict what the future will hold, what the consumers will want, how to enhance our competitiveness with the rest of the world, so the technologies perhaps don't need to be so generic but they can be orientated toward what the people will need or want in the future?

Dr. Lyons?

Dr. LYONS. We attempt to define and plan our research program in concert with industry, so that, although we clearly separate what we should do and what industry should do, we talk together all the time. So before we start an area, we have informal meetings, we have workshops, we have lots of mechanisms to involve industry in the goal-setting of these individual programs.

We have official committees that come and visit with us and talk with us and make reports, and many, many individual interactions. So even though the role of the private sector and NIST is clearly demarked, I don't think there's any separation when it comes to talking and thinking and acting together about the R&D plans.

Mr. GILCHREST. So that means that also this technology, because of these communications with various groups, is integrated between medicine, between the average viewer of home videos, to the whole range of possibilities for this type of technology?

Dr. LYONS. Well, we would count on our industrial colleagues to have the market sense. The reason that we stay out of finished products and final process detail is that we don't believe we, because of the breadth of the market opportunity—and you just mentioned medicine and some other things—that we can understand and make intelligent choices about the final products. So we stay back and look for the commonalities where we can get high leverage by our programs.

Our industrial friends in the electronics industry are the ones who specialize in understanding the details of the market, so we count on them to tell us what the implications are.

Mr. GILCHREST. Thank you.

This is kind of a simplified question, I guess, for me, or for you but not for me. Could you explain—and you both, I think, mentioned it—wireless computer systems and broadcasting and computer integration, exactly what that is?

Dr. STANLEY. Sure. Wireless computer systems—Currently, the components of a computer are interconnected in most cases with copper, sometimes even fiber optics, that go a very short distance. It's not out of the question in the future radio technology to take these cords away, very much like your cordless phone at home. You really don't have to have a cord as long as you're within proximity to your base station. Well, you can do the same thing with computers, so wireless computers are very much along those lines.

The other term you had mentioned is sort of the marrying of broadcast and nonbroadcast technologies. Currently, much of the entertainment medium, if you want to think of television as only entertainment, involves developing the next generation of high definition television standards.

Nonbroadcast technology involves similarly very high resolution displays but not necessarily oriented towards television—things like for education, for training, for gathering and displaying large amounts of information.

Mr. GILCHREST. Thank you, gentlemen.

Thank you, Mr. Chairman.

Mr. VALENTINE. [Presiding.] Thank you.

The Chair recognizes the lady from Missouri, Miss Horn.

Ms. HORN. Thank you, Mr. Chairman.

I would like to follow up on an earlier line of questioning about the commercialization. I find this very disturbing that we have such a division between the research and development and the commercial—I find the results of that disturbing on the commercialization. As Mr. Ritter's line of questioning was going, someone else takes it and makes the money and sells it to the world, including us.

What is the basic problem as you see it? I see what NIST and FCC obviously are not going to commercialize products, but where do you see the problem? Where do you see we have a hole there that perhaps we might attend to?

Dr. LYONS. Well, there have been many studies made of this competitiveness issue, if you will. There are many factors that go into explaining why our companies are having difficulty competing with our international trading partners. One of those is cost of capital, another relates to intellectual property policies, another to antitrust and so on. There's a list, I suppose, of eight or ten factors.

The one that I know something about is how we deal with technology itself. There the consensus seems to be that we still generate technology better than anyone else in the world; that is, our laboratories are still very productive, and the same is true for American science. But the other factors get in the way of commercializing it. The financial environment is not what it might be and it is not conducive, compared to the environment in other countries, to going to market. So it makes our business leaders much more hesitant to invest in commercializing technology.

Ms. HORN. You seem to have the ability—companies seem to have the ability to put together these consortiums and these working arrangements at the research end of it and the development end. What would be an answer to getting them to work together on the commercialization? We can't do much, I suppose, in the Congress at this time about the cost of capital in the short term. Property rights we're trying to deal with, intellectual property rights.

In terms of antitrust, are the prohibitions there that perhaps could be dealt with?

Dr. LYONS. Yes. Back in the 1980s, we relaxed the antitrust rules to permit joint R&D ventures between and among firms. It now seems a good idea to continue that move and permit joint manufacturing. I think there is legislation now before the Congress to do that, and there was also the last Congress. That would be helpful, to allow, under some conditions, companies to manufacture together.

Ms. HORN. That, of course, would not really change the cost of capital or the other prohibitions but perhaps would spread, as they perceive it, the risk over more companies.

Dr. LYONS. Yes.

Ms. HORN. I'm not familiar with those people—

Dr. LYONS. It probably changes the apparent cost of capital to an individual player. I think that's also true in the joint R&D ventures where the apparent cost of research is reduced because you're sharing across many companies.

The President, of course, has made proposals in the cost of capital area in terms of capital gains tax, and that's before you as well.

Ms. HORN. I see. Thank you, sir.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you.

The Chair recognizes the gentleman from California, Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman.

Just a note on financial environment, as you said, Dr. Lyons. A lot of times people up here don't understand that perhaps one of the reasons that our high technology companies and other companies are not competitive doesn't have to do with our brains but has a lot to do with Government policies that get in the way. When you have a government that's sucking so much money, investment money in particular, out of the system, and taxing our major corporations and basically treating our corporations as a "milk cow" rather than an engine for human progress, of course you're not going to be able to compete when you have other nations that are treating their companies as "sacred cows" in order to be nurtured, realizing that they are vehicles for their own national progress.

We've had a lot of discussions on the Hill about the capital gains tax. I don't believe they have a capital gains tax in Japan; I'm not sure about that, but I believe there is no capital gains tax in Japan for industry. I would have to check on that. But, whatever it is, the Japanese do not call up their companies and tell their companies "you better not cooperate because you may be in violation of an antitrust law." Instead, they get them in a room and say "You will cooperate. We're going to outdo the Americans."

Perhaps you have a comment on that. Would you like to comment on that? Okay, fine.

[Laughter.]

One thing that I would like a comment from both of you on, however, is I remember when I first came here there was this—basically from the same people who are telling us how noncompetitive we are but ignoring the fact that we're taxing our companies out of the competitive world—we're trying to—and to make up for that, we have Government programs; you know, we cause a problem and then we come up with some solution, or at least something that looks like a solution.

The solution that was looked at when I first got here was we are going to subsidize HDTV so that we can catch up with the Japanese who are ahead of us, and all we need are hundreds of millions of dollars, and that was the proposal, and they're telling us unless we give these hundreds of millions of dollars, that America is going to continue to fall behind and what a drastic thing this is going to be.

Now, in retrospect—you guys know the technical end of this—I seem to remember that what we were being asked to subsidize at that time was what is today a totally outdated approach, meaning analog HDTV rather than digital HDTV, and what you're telling us today is it's digital that's actually going to control the future; that is the future.

With that in mind, had we come forward with all of these hundreds of millions of dollars worth of subsidy for analog HDTV, would that have been a waste of money?

Dr. STANLEY. Let me comment. You're certainly correct about the assessment of what I'll call digital high definition television in the world today.

It's interesting. People have come to the U.S. and tried to pump us as to what was the secret of our springing ahead to this world leadership position. The proof of the pudding, I might add, is still in the testing. We have proponents to be tested, and they're really facing a fairly rigorous gauntlet of tests to show that they can, indeed, stand up to commercial structures. But the impetus has largely come from industry itself.

The Commission has never been lacking for proponents. I believe we started with something like nearly two dozen several years ago. These have been winnowed down to now just barely—just a half a dozen proponent systems.

Mr. ROHRABACHER. So in terms of the money that would have been channeled into HDTV two years ago, which we were being requested, would that have been a bad investment?

Dr. STANLEY. I guess I'd have to compare that with whatever these companies have invested, and I have no way of knowing how much they have invested to bring up the digital state-of-the-art. But an independent investment, it's not clear it would have shown up among the Commission's proponents.

Mr. ROHRABACHER. Dr. Lyons, would you like to comment on that?

Dr. LYONS. Well, assuming that the money was invested in intelligent investigators, I would assume that, as the technology moved forward, they would move with it.

In the electronics business, you have to run very fast, of course, to keep up with what they're doing. So I may request a budget from the Congress for a certain area in electronics. By the time the money comes back, say, 18 months later, we've actually had to ratchet up to maybe two generations beyond where we were when we asked for the money. But the rationale usually holds. It's just that the chip people have moved so fast that we have to keep chasing them.

Mr. ROHRABACHER. In this particular case, even a—well, someone who is not an expert, and I'm certainly not an expert as you are—was able to see that we were basically talking about a different type of technology that right now you're suggesting is outdated. I'm not sure sure we can have a Government program, especially a Government program that subsidizes a private interest, whether or not it gives that private interest the leeway it needs in using those particular funds in order to spend them on a different approach than what was allocated. I don't know if you're following me or not. But if we allocated $200 million for analog HDTV and then can we, indeed, give that same company that type of latitude in order to use it on digitial TV? That is the complication when you're dealing with Government contracts.

Dr. LYONS. Well, I think, sir, that you raised a question that's broader than just the one you mentioned. We have the same problem with standards. We've always had this problem with all kinds of standards, not just in this field.

If you set a standard, say, prematurely, and it's too prescriptive, you essentially freeze the technology; that is, people can't go beyond what the standard permits. We have all kinds of examples of that, ranging from building codes to, I'm sure, in Dr. Stanley's area as well. So the question is how do you do a procurement or set a standard that allows the technology to come to fruition. I know the FCC is worrying about that, we're worrying about it in related areas. So it goes beyond just writing a bad R&D contract, but it also runs to the rest of the activity as well.

Mr. ROHRABACHER. I understand that and I thank you very much for your comments today.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, sir.

The Chair recognizes the distinguished lady from Maryland, Miss Morella.

Mrs. MORELLA. Thank you very much, Mr. Chairman. I again want to welcome our visitors here who are testifying. Dr. Lyons, of the National Institute of Standards and Technology, I'm very proud of you, Dr. Stanley.

I wanted to pick up on that very point because, in looking at the testimony and listen to what you have said, it seems to me that you've got to look ahead if we are going to be competitive. You've got to look at standards that are going to serve us ten, fifteen years down the road that are going to allow you the flexibility where you're not going to feel that you are strangled in that bind. So, recognizing that this is a problem, if you see it as such—and I think from what you said you do—what are we doing about it and what can we do about it?

That would be my question to both of you.

Dr. STANLEY. I think it's a very perspective view of the standard-setting process. It is a nightmare having to make a set of decisions. The Commission does this in a variety of ways when it determines virtually any aspect of a communications system. As Dr. Lyons had said, to a degree you do freeze some aspect of the system.

I guess we trot out the word "flexibility". I think we are very conscious of this chilling effect we have. Even on something that might make a lot of sense now, two years later, that which made sense is an albatross to be shed at the next opportunity. So in the regulatory arena we simply try to do as little, say as little as possible when it comes to setting up and defining services, defining interference situations. So one key to that is what I call minimalism and flexibility, trying to do just what's needed to keep the services on the correct track or path, but giving them flexibility to change features that are not necessary to the regulatory matters.

Dr. LYONS. Well, we're trying to take the broadest possible view, that one way to look at this is to think about the communication networks and, in the future, we believe at least over the guided networks, such as fiber optics or copper cable, that we will very quickly be into the business of passing video, voice, and data over the same lines. That has already led to the first narrow band ISDN, Integrated Services Digital Network, the first standard and the first implementations by the common carriers primarily, and that should grow into a much broader band communications, much higher data rates.

What we would like to see happen—and we're working toward this end in our small way—is to see the high performance computing initiative, for example, which is a special kind of digital network, and to see these television standards as they relate to passing them over fibers or copper be done in such a way that they will be compatible with the next generation, or the third one or the fourth one or the ISDN standard. I regard that as kind of a common characteristic they should all have.

I am concerned that, for example, the National Research and Education Network be compatible, because it's not true that our computer networks in the past have had that characteristic. Now we're getting ready to build another one and I keep reminding people they want to make sure it's convenient to hook these things into the public-switched network.

Mrs. MORELLA. Is saying it enough, unless—

Dr. LYONS. Well, probably not enough, but we're trying.

Mrs. MORELLA. Let us know what we can do.

Dr. LYONS. We are pretty much involved ourselves in the development of the ISDN standards, so we do have a platform from which we can speak. We're helping industry write the next generation broadband ISDN standard, and as we do that, we try to remind our colleagues in this business that they ought to pay attention to what's being developed and join with us, sit on the committees and be active.

Mrs. MORELLA. Don't hesitate to let this subcommittee know, with the leadership of the Chairman, what we can do to also bring this along.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, Miss Morella.

Dr. Lyons, if NIST becomes involved in assisting the private sector in establishing standards, would this require additional funding or can that be placed at some suitable place within your framework of what you have to spend?

Dr. LYONS. First we have, I think, a very good budget in this area. It's one of our strong points, the general electronics and telecommunications areas. Secondly, we are as involved as I think we need to be in the standards for characterizing, measuring, and assessing the component pieces of these systems. I expect not to be involved in the system standards business, apart from the ISDN aspect, certainly not to be directly involved in the broadcast standards. That's Dr. Stanley's area. I think we've got a pretty good division of duties there. So I'm confident that we have a strong program and that we can move forward whatever way the technology demands.

Mr. VALENTINE. Perhaps more by way of emphasis or summary, Dr. Lyons, what should we be doing now to ensure compatibility between computer standards and the coming HDTV standards?

Dr. LYONS. Well, I think the best way is for the players involved to participate fully in the current activities. I mentioned the North American ISDN users forum, I believe, in my testimony. All interested parties are welcome to join in that. That is exactly what it says it is. It's a forum, it's place to discuss and thrash out these issues.

I know that Dr. Stanley and his colleagues are very receptive to inputs from everybody. In fact, they're probably deluged with them. I think mostly it's just making sure that no one of the players goes off on a tangent without telling the rest of us, so that we can accommodate whatever necessary changes are required.

Mr. VALENTINE. Do you think a central authority is needed?

Dr. LYONS. Well, of course, in the Federal Government we have one. The OMB is the central authority that worries about some of these things. But we have—I think mostly it's just a matter of information exchange. This issue is so prominent and so important that I believe we're all talking. No, I don't think we need a new czar in this field.

Mr. VALENTINE. Dr. Stanley, why should it take from five to ten years to develop a common broadcast computer interface?

Dr. STANLEY. It's really a comment on the various cultures involved. The broadcast community and the computer community each have developed over the years with separate physical environments, separate economic factors, that affect their decisions. I think this is very much reflected in any standard setting.

Also, factors such as penetration—again, it's very much related to the penetration for consumer devices. It takes a while for there to be sufficient capacities built up in the marketplace to begin to make these kinds of changes.

Mr. VALENTINE. What you were saying then is it's not mainly a technical problem?

Dr. STANLEY. Exactly so. I think most standards problems are more economic than technical. Although the words seem to be technical, when pursued to the end, many, many of the matters seem to be, at heart, economic ones.

Mr. VALENTINE. I'm trying to find a way to say this in the best possible way. It came to my attention yesterday that there is today, in the Capitol, a display of HDTV by the Sony Corporation. It's in the foyer of the Capitol, I believe. It's somewhere over there. I was invited—as I said, it was mentioned to me by a colleague. I was invited to advise the members and staff of this committee that it was there and they could go by and view this.

What is the significance of that? That's what I was really trying to say. Here we go attempting to find ways to enhance the competitiveness of this great union, and here is a display in the Capitol of that kind of product. What do you say about that, Dr. Stanley?

Dr. STANLEY. Well, actually, you're right. It actually is an example with many lessons behind it, some good, some bad. What you see there really is the culmination of over a decade, probably thousand and thousands of manhours and probably millions of dollars—at least a billion dollars—of development on the part of the Japanese to develop the next generation of television standards. They did it, they did a good job. As I mentioned, it took the great resources put in.

But it's an analog system. That set, I don't remember the exact cost, but it probably costs something anywhere from $20,000 to $30,000, hardly a consumer electronics device. In a way, that kind of technology may be viewed as outdated, as Congressman Ritter had said, that somehow getting in and getting the jump on the community may have been a great idea had it been brought to some market early. It looks like much of the smart money has moved on into digital now, and there's a variety of opinion on different people's parts.

The United States process is actually beginning somewhat later than that, but it's interesting that, not having had that lead, we already are said by some to be in a world leadership position because of the possible entrance of digital into it.

So your example really has some lessons about the realities of the marketplace and the realities of a Government role in standard setting.

Mr. VALENTINE. Dr. Lyons, would you favor us with a comment? I wouldn't ask you if you wanted to comment.

Dr. LYONS. Well, I was just thinking of this new supercomputer that we had installed a couple of weeks ago, the Princeton engine, so-called. The display tubes on that machine are Japanese built, I think, from two sources. Very impressive. They, of course, get their signals in analog fashion. The rest of that system is digital.

I do think it's an interesting question, the time of entry, and whether or not our competitors are bogged down in their past investment in whatever—really, I guess, hybrid technologies. It may rebound to our advantage to come in late. That remains to be seen, of course, and it depends a lot on how we comport ourselves from now on.

Mr. VALENTINE. Well, I don't know why that episode reminds me of these "Roadrunner" cartoons that you see on television, used to on Saturday morning. The Japanese would just jump up and say "Beep Beep" and off they go down the other direction and still come back with the digital. Maybe they will be here within two years with a display of the digital, with the lumbering way that we have seemed to approach innovation in this country. But I'm sure that is not a prophecy.

Thank you all very much.

The next panel consists of Mr. Michael Liebhold, who is Manager, Media Architecture Research, Advanced Technology Group, Apple Computer, Inc.; Mr. Kenneth L. Phillips, Chairman, Committee of Corporate Telecommunication Users; Mr. Gary Demos, President and Chief Executive Officer, DemoGraFX; and Mr. David Deas, Director, Technology Planning, HDTV and Fiber Optics, Southwestern Bell Corporation.

We are advised by Mr. Liebhold that he has a video which he would like to show before his testimony, which we will be happy to receive.

At this time the Chair recognizes the distinguished lady from Maryland, Mrs. Morella, who has a statement for the record at this point.

Mrs. MORELLA. Mr. Chairman, I simply want to ask unanimous consent to include an opening statement about this hearing in the record, if I may, sir.

Mr. VALENTINE. I didn't read the rest of your note. Without exception—I mean, without objection. Also without exception.

Mrs. MORELLA. Thank you. Thank you, Mr. Chairman.

[The prepared statement of Hon. Constance Morella follows:]

Constance Morella

CONSTANCE A. MORELLA

SST/T&C SUBCOMMITTEE

HEARING ON HIGH DEFINITION SYSTEMS IMPLEMENTATION

MAY 21, 1991

MR. CHAIRMAN, I AM PLEASED WE ARE CONDUCTING A SECOND DAY OF HEARINGS FOCUSING ON THE STATUS OF HIGH DEFINITION SYSTEMS IN THE UNITED STATES.

AS WE BEGIN TO COMPETE IN THE INTERNATIONAL MARKETPLACE FOR HIGH DEFINITION TELEVISION SYSTEMS, WE MUST PURSUE THE BEST STANDARDS FOR PRODUCTION AND TRANSMISSION. INDEED, THESE STANDARDS, SUCH AS THE AMOUNT OF LIGHT CYCLES PER SECOND, WILL GREATLY INFLUENCE THE FUTURE OF UNITED STATES COMPETITIVENESS IN THIS CRUCIAL, AND POTENTIALLY VERY PROFITABLE, INDUSTRY.

IT IS IMPERATIVE THAT WE DETERMINE, NOW, AS WE BEGIN TO ADVANCE IN THIS FLEDGLING TECHNOLOGY WHETHER TO ADOPT STANDARDS SIMILAR TO JAPAN AND EUROPE. IF WE WERE TO ADOPT DIFFERING STANDARDS, FOREIGN MANUFACTURERS WOULD HAVE TO PRODUCE SEPARATE TELEVISIONS FOR THEIR OWN DOMESTIC USE AND FOR EXPORT TO THE UNITED STATES.

I LOOK FORWARD TO HEARING FROM TODAY'S WITNESSES FROM GOVERNMENT AND PRIVATE INDUSTRY. THROUGH THE INSIGHTS OF OUR ASSEMBLED WITNESSES, WE CAN WORK TOGETHER TO FORMULATE A COURSE FOR OUR NATION'S COMPETITIVENESS IN THIS IMPORTANT FIELD.

Mr. VALENTINE. We ask the witnesses—your testimony will appear in the record as presented to us. We would appreciate it very much if you would summarize and, if possible, limit your summaries to five minutes.

Mr. Liebhold, would you like to proceed with your presentation, as stated to us? Do you need the screen?

STATEMENTS OF MICHAEL L. LIEBHOLD, MANAGER, MEDIA ARCHITECTURE RESEARCH, ADVANCED TECHNOLOGY GROUP, APPLE COMPUTER, INC.; KENNETH L. PHILLIPS, SCIENCE ADVISOR AND CHAIRMAN FOR LEGISLATIVE AFFAIRS, COMMITTEE OF CORPORATE TELECOMMUNICATIONS USERS; GARY DEMOS, PRESIDENT AND CEO, DEMOGRAFX; AND DAVID A. DEAS, DIRECTOR, TECHNOLOGY PLANNING, SOUTHWESTERN BELL TECHNOLOGY RESOURCES

Mr. LIEBHOLD. Thank you, Mr. Chairman.

Yes, I have a video here, if I could have someone just press "start" here. This, I think, exemplifies the context for my testimony.

Mr. Chairman, we build systems that are currently in use now for entertainment, education, information and transactions. It's a unified environment that includes many data types. Here we go.

[Video Presentation.]

Mr. LIEBHOLD. Thank you, Mr. Chairman.

The video you have just seen is not a future projection. It is, in fact, currently available for computers made by Apple Computer. Similar systems are either available or in development by other American computer companies. So this is an application that exists today.

So as we look at the future, we can anticipate an environment where communications of this type integrate broadcast television, images from compact discs, or images from a variety of network resources, from copper wire, cable television, or fiber optics.

It's a unified environment that really is not dependent on any one particular data type, any one video type. There are many, many video types. The video you saw here was a software decompression technique. There are at least half-a-dozen of these software techniques that I know about that can be incorporated equally well in a document like this. In the future, we'll be able to incorporate NTSC television, PAL television, high definition television, as well as a range of computer graphics, medical images, maps. This is the business environment we live in today for education, information transaction, and entertainment.

In order for us to proceed in our business, we need to see that the standards environment that determines the standards for these media types is as carefully coordinated and integrated as possible to minimize the cost of the playback devices and media creation devices that create these kinds of compound documents. So there are really four criteria that we think should be given more weight in the process.

One is the notion of interoperability, so that an image that is created for television should not be constructed in such a way that it would be prohibitively expensive to integrate it into a fully digital document environment that you've seen here. There are, in fact, scanning parameters and frame rates that could be optimized in the selection of a broadcast process to minimize the cost for such communication systems.

The notion of extensibility becomes very important to us because, as was pointed out previously, we see a rapid development of new digital video technologies. In just one year we've seen the emergence of four proposals for digital high definition television. We can anticipate many more significant breakthroughs in digital imaging techniques in the coming years, so we need to ensure that a high definition television standard is, in fact, extensible and anticipates continued improvement in American and, in fact, international imaging processing techniques. So we would like to suggest the notion of a self-identifying video stream, so that a receiver, whether it's a computer or television set, can read an identification from the video stream and then display it properly within the context of the document.

The notion of scalability becomes increasingly important, since we have a variety of playback devices, from hand-held LCD displays to CRT television sets, to projection displays. So we need an image coding scheme that is going to work well at varying display resolutions as well as a facility to be communicated over a variety of communications channels, whether it's a copper wire, a fiber optic, or over the air. So there is, in fact, some notion of scalability that could be incorporated into the television standards that will allow us to move freely between hardware environments.

Finally, the notion of harmonization is something that really seems to be highly recommended at this point. From our point of view, as a group that has to integrate many data types into the computing environment you saw, we are faced with almost an insurmountable number of standards committees to participate in. In the area of high resolution systems alone, there must be at least 20 committees worldwide that are taking very important deliberations on various components of the process. Somewhere there has to be some explicit mechanisms. I'm not suggesting a czar, but I am suggesting that some mechanisms have to be incorporated to harmonize these processes.

Thank you, Mr. Chairman. That's a summary of the written testimony that I've submitted.

[The prepared statement of Michael Liebhold follows:]

Statement of

Michael Liebhold
Manager, Media Architecture Research
Advanced Technology Group
Apple Computer, Inc.

Representing
The Committee for Open High Resolution Systems

Hearing Before the
Committee on Science, Space, and Technology
Subcommittee on Technology and Competiveness
United States House of Representatives

Washington, D.C. 20515
May 21, 1991

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Introduction

Mr. Chairman, thank you for giving me the opportunity to make a this presentation today. on behalf of COHRS, The Committee for Open High Resolution Systems. COHRS is a group composed of professional experts affiliated with for-profit and not-for-profit organizations. I hope my written testimony and the enclosed information help further understanding of some of the significant issues posed by the inevitable convergence of telecommunications, television, and computing. I would like to summarize my comments and submit a written document for the record.

It is good to hear the Congressional interests in these important technical issues which have significant impact on the future competitiveness of American industry . I have enclosed with my written statement, a summary of information on some emerging issues regarding the relationship of HDTV to image based computing and telecommunications. Several issues are briefly defined and discussed: HDTV *interoperability, extensibility, scalability, and harmonization* . Growing interest in these issues is driving research which could lead to technology enabling an intelligent, digitally-based high-resolution video system to be useful for a variety of both broadcast and non-broadcast applications across a wide range of communications media.

An American HDTV standard for terrestrial broadcast created in such a wider context would require thorough consideration of related imaging standards being developed concurrently by various computing and telecommunications bodies. Carefully crafted, this digital HDTV standard would enhance the development of a powerful, flexible new communications infrastructure, and thereby provide both significant new business opportunities for a wide range of American enterprises and improved facilities for public activities such as scientific research, education and health care systems. Given the position of the United States as a leader in communications, such a standard might also have an excellent chance of achieving worldwide acceptance. Subsequent economies of scale could stimulate high quality, low cost communications services to growing segments of the population.

Selected Issues: Interoperability, Extensibility, Scalability, and Harmonization of HDTV and Related Standards

Prepared by
The Committee for Open High Resolution Systems
Michael N. Liebhold, Editor

May 21, 1991

The following points are generally understood by many of the proponents competing for an American HDTV terrestrial broadcast standard. It is possible that, given a sufficient extension to the current FCC ATV test process most, if not all, of the digital systems proposals could be modified to satisfy the following issues:

Interoperability - *The capability of operation between different video and image formats.*

Context: An intelligent HDTV system will be useful for a variety of non-broadcast high definition applications which might include: teleconferencing, educational video from compact discs and other mass storage, corporate training, medical diagnosis and collaboration, scientific research collaboration, and on-line commercial services like multiple-listing housing pictures, car-sales classified ads with pictures, etc.

• The specifications for any American HDTV standard should be selected to optimize, wherever possible, interoperability between broadcast television, multi-media computers, graphics workstations, color hardcopiers, video recorders, cd-rom and future mass storage devices, film recorders, film and still image color scanners, world-wide video formats, narrow and broadband computer network and interconnection protocols, satellite spectrum width, cable channel modulation schemes.

• To simplify code and hardware, and minimize costs, it is feasible to select scanning standards for HDTV as a super format which have natural relationships among: 24 frame-per-second film source material; 59.94 Hz NTSC TV; 50 Hz Pal and SECAM TV; and typical computer workstation displays operating at >70 Hz flicker rate. It is possible that a master HDTV scanning parameter could be selected (i.e. 2048x1152x72fps) which would not only minimize the costs of interoperability, but would also be attractive as a possible international standard. With proper design, this can be done without increasing costs for the typical HDTV consumer. It should be possible with scalable designs to ensure that both low-price, low feature sets and high-end sets will be practical for HDTV. *It is not clear that the FCC ATV has given serious considerations to format compatibilities with non-broadcast systems in the evaluation procedures for proposed HDTV standards.*

• International distribution: From the viewpoint of the health of U.S. exports, it would be extremely valuable if HDTV system parameters made it easier to sell video and films internationally. The current HDTV proposals before the FCC are designed with a relationship to NTSC, but do not have an easy conversion relationship to PAL and SECAM, nor the systems already decided upon in Europe, a market which is growing even faster than the domestic market. The European and other foreign proposals have been rejected by U.S. television and film interests for good technical reasons, and in addition, being analog systems, do not have built-in extensibility for the future nor compatibility with computer systems. However, the U.S. has an opportunity to adopt all-digital systems which would be both efficient for terrestrial spectrum and easily convertible to overseas HDTV.

Extensibility - *Ability of a video standard to incorporate extended functions over time.*

Context: We are witnessing an explosion of developments of new digital processes for video compression and communications across increasingly diverse media. How can we ensure that any HDTV standard established in the 1990s will adequately anticipate future improvements and consequent radical cost reductions for image processing? Solutions, not now part of the FCC ATV process, would include:

• Video streams which are self-identifying, so that receiving systems may intelligently decide which decoding process to apply. The use of a 'header' descriptor or 'side channel' has been proposed. This idea has received widespread enthusiastic response internationally, has been adopted by the CCIR harmonization working party, and is inherent in CCITT imaging standards for B-ISDN. It should be introduced into the ATV process in the U.S.

• Establishment of a header descriptor format for HDTV requires explicit coordination with other international bodies defining related communications, video, and multi-media document protocols especially the ISO, IEEE, and others.

Scalability - *The degree video and image formats can be combined in systematic proportions for distribution over communications channels of varying capacities.*

Context: In order for a future intelligent HDTV system to successfully decode a variety of formats from different sources, flexible 'family' relationships between image standards could significantly reduce costs. Lower resolution pictures may be nested, or embedded within high definition pictures. These schemes would define variable (but related) rather than fixed parameters for resolution, image size, and frame rate. The parameters would depend on processor power, memory availability, and cómmunication channel limitations permitting absolute minimum cost (and capability) consumer devices as well as well as extensibility for capabilities using technology not yet possible.

• It possible that such hierarchical coding schemes will enable several types of flexibility:

1. Different "terminal devices" capable of displaying differing numbers of pixels accessing the same data stream. The quality of the picture would depend on the hardware investment chosen by the consumer, and the capabilities of the software transmitted.

2. Reasonable picture quality maintained despite variations or interruptions in data supplied to the receiver by transmission channel. This is a critical design element for variable bit-rate networks such as B-ISDN using ATM. *(Asynchronous Transfer Mode)*

3. Multiple video 'windows' of different quality source formats could be more easily displayed simultaneously on one monitor. This would permit reception on the same American HDTV set of European 50 Hz HDTV and 24 fps film (upgraded to a non-flicker rate) *without* expensive conversion.

• Variable bandwidths: It would be useful for a given HDTV signal to be able to interact with varying channel loads while sharing a channel with other HDTV signals. This is called "graceful degradation" and goes very far towards maximizing the efficiency of spectrum use, a goal which is mandated in the FCC act. Digital HDTV designs are naturally somewhat "elastic" in respect of graceful degradation and maximizing spectrum utility. However most of the current HDTV proposals do not exploit this extremely valuable elasticity with one exception (a proposal developed to be compatible with asynchronous broadband ISDN). When a channel is heavily loaded with many simultaneous picture streams, it would be useful if each picture stream were still the best that it could be within its reduced allocation of data bandwidth. When the channel is lightly loaded, it would further be useful if the high definition images using the channel could expand to provide maximum quality during the light load conditions. Research has shown that such applications are quite feasible with current technology -- analog and digital.

Such a 'family' relationship already exists among international video telephony standards (CCITT & ISO H.261), JPEG still image standards and, to a somewhat lesser degree, MPEG moving picture standards for compact disc. All four of the current FCC digital HDTV proposals are based on related coding architectures similar to these standards, but have stopped short of fully scalable implementations. Given sufficient additional time by the FCC, these proposals may be modified to incorporate much greater scalable functionality.

Harmonization: *The organization of different standards efforts into an orderly process.*

Context: At some point in the future, it is inevitable that an intelligent HDTV device will be required to process video formats from a variety of different sources including videotape, mass storage (optical & magnetic), telephone wire pairs, cable TV, direct broadcast satellites, fiber-based broadband ISDN and perhaps standards from overseas HDTV systems.

Coincident with the development of an American HDTV standard, a number of other international bodies are evaluating related imaging standards. The most important international fora are the International Telecommunication Union (ITU) and the International Organization for Standards (ISO). In the United States, ISO work on video communications is occurring in the Joint Picture Experts Group (JPEG) for compressed still images and Moving Picture Expert Group (MPEG) for compressed moving images on compact discs. For ITU issues, the US National Committee for the CCIR works on broadcast technologies, while the parallel CCITT committee works on wireline network standards such as video telephony and variable bit-rate encoded video for Broadband ISDN.

• In order to minimize costs to the consumer imaging devices, it is desirable for these emerging standards to be created in a coordinated fashion. It may not necessarily be a requirement that a future HDTV be fully backward compatible with all lower resolution formats, but at the minimum it would be in the public interest if the terrestrial HDTV standard did not *preclude* a low cost, multi-standard set. *Other than discussing other television modes (cable, DBS, etc.) the FCC ATV process, so far, has not included consideration of imaging harmonization issues in the proposed evaluation of U.S. terrestrial systems.*

The preceding information was prepared as a result of efforts by a group of individuals (known informally as COHRS - the Committee for Open High Resolution Systems) who have met and corresponded over the last two years. Much of the material here has been released previously at conferences sponsored by the National Academy of Sciences, IEEE/USA and in response to various U.S. CCIR working parties. Many of these individuals and their organizations would be willing to provide additional information to the Commission.

Key contributions by the following people are gratefully acknowledged:

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Ken Phillips, CitiCorp and Corporate Committee of Telecom users
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David Staelin, Massachusetts Institute of Technology
Greg Thagard, Consultant
David Trzcinski, Hewlett Packard, Inc.
Mark Urdahl, International Business Machines Corporation
John Weaver, Liberty Television

Although the following researchers did not necessarily contribute directly to this process, their work, nonetheless, is the source of some important technical insights: Special thanks to Professors Michael Bove, Andy Lippman, William F. Schreiber, (retired), and David Tennenhouse, from the Massachusetts Institute of Technology, and Glenn Reitmeier, from the David Sarnoff Laboratories.

Attachments:

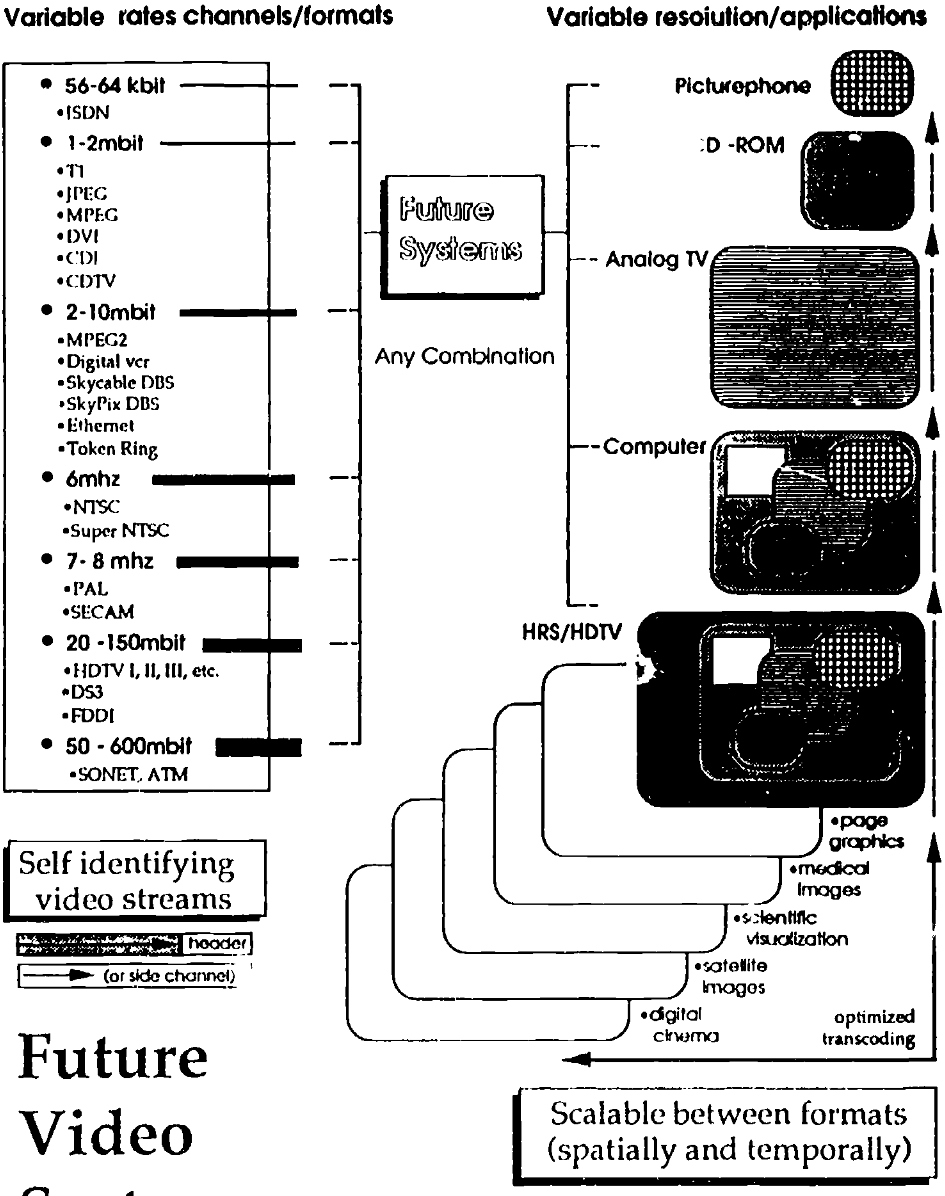
Diagram
Future Video Systems - M.Liebhold, Apple Computer, Inc. 11/25/90

IWP Doc. 11/9-66 -
Considerations for the Cross industry Harmonization of HDTV and other High Resolution Systems 9/5/90

Doc. USTG 11/1-1,2
Open Systems for HRI/HDTV Applications
System and Signal parameters for HRI/HDTV Applications 1/17/91

IEE/USA
Report of the workshop on an Architecture of Standards for Interoperation of High Resolution Systems Across Industries 6/26/90

Memorandum
To: The US National Committee for CCIR Study Group 11
From: The Ad-Hoc High Definition display and Television Working group 2/22/90



Future Video Systems

Mike Liebhold Apple Computer, Inc. 11/25/90

Documents
CCIR Study Groups
Period 1990-1994

Doc. IWP 11/9-66
USA 11/9-1
5 September 1990
Original: English

Received:
Subject: Decision 91
Report BK/11

United States of America

Considerations for the Cross Industry Harmonization of HDTV and Other High Resolution Systems

1.0 Introduction

There are many specific issues that IWP 11/9 could address in future studies. The work of IWP 11/9 would be facilitated if it develops a list of specific areas for investigation. Report BK/11 indicates numerous areas for investigation and harmonization. The following areas of investigation could form the basis of such a list. An information document has been prepared by one group of high resolution video experts that elaborates on the nature of these areas.

2.0 Areas of Investigation

2.1 Compatibility and Exchangability Between and Among High Resolution Systems (HRS)

Different industries have different resolution and frame rate requirements, and it is desirable to exchange data and programs material among them. In this regard, it may be worthwhile to investigate whether a scalable architecture offers benefit.

2.2 Signal, Compression, and Transcoding

The potential impact of signal, compression, and transcoding questions should be considered in HDTV and HRS. Because no one encoding mechanism will suffice across industries and applications over time, considerations of coding mechanisms which account for cross industry/application uses and which permit compatible extension over time are warranted.

2.3 Descriptor Conventions

Cross industry harmonization may be served by searching for a universal descriptor convention that accommodates current and future uses.

2.4 Communications

Benefits may result from coordinated studies of communications practices across industries (terrestrial broadcast, satellite, cable, telecommunications, computer networks, etc.).

2.5 Ergonomics

The psychophysical criteria across industry/application uses of HDTV/HRS systems merits consideration.

3.0 <u>Work of IWP 11/9</u>

The work of IWP 11/9 in addressing these areas should carry out the following:

- Identify those standards bodies which are working in these areas;
- Identify fields of study that overlap among bodies;
- Identify fields of study that are not undertaken in the work of these bodies; and
- Develop a glossary of terms as studies are conducted.

REFERENCE:

"Questions and Information for Harmonization of HDTV/HRS Across Industries," Architecture Working Group, Committee on Open High Resolution Systems (COHRS). *COHRS Technical Nomograph 90/10.* (Copies of this document may be obtained from DemoGraFX, 10720 Hepburn Circle, Culver City, CA 90232, USA.)

Documents
CCIR Study Groups
Period 1990-1994

Document USTG-11/1-1
Document 11/1-
17 January 1991
Original: English

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Subject: Question 27-1/11
Question 69/11 (SP 27A-1/11)
Report 1223 (BH/11)

United States of America

OPEN SYSTEMS FOR HRI/HDTV APPLICATIONS

This document discusses the concept of Open Systems as applied to high-resolution imagery (HRI)[1] and HDTV. The bases for this consideration are emerging contribution and distribution channels, and a broader range of applications.

The terms "open systems" and "open architecture" are widely used but imprecisely defined. The imprecision arises because different groups mean different things by the terms. From the perspective of the computer industry, open architecture is simply the public specification of an interface. Other industries have long employed similar principles. For example, the broadcast industry has traditionally specified interfaces and made them public (NTSC, PAL, SECAM). It is important to recognize the new significance of open architecture in the context of recent rapid changes in underlying electronics and imaging technologies, whereby programmes can be distributed to a variety of users via multiple distribution media.

The term open architecture, as used in discussions of the harmonization of HDTV production and programme exchange standards with HRI systems, in general, implies more than just the public specification of interfaces. Parameters that may be acceptable today may be inadequate in the future. Therefore, open architecture further implies an organization of system parameters that are scalable and extensible, e.g., resolution, aspect ratio, frame rate, and colorimetry, for digital imaging and communication.[2,3] A scalable system permits the adjustment of parameters over time and over varying levels of cost and technical sophistication. An extensible system

[1] CCIR IWP 11/9 draft new report, "The Harmonization of HDTV Standards between Broadcast and Non-Broadcast Applications," Tokyo, October 1990.

[2] William F. Schreiber, "A Friendly Family of Standards for all Media and All Frame Rates," Proceedings of the 43rd Annual Broadcast Engineering Conference, pp. 417-426, NAB, 1989.

[3] William F. Schreiber, et.al., "Open Architecture Television Receivers and Extensible/Intercompatible Digital Video Representations," IEEE ISCAS '90, New Orleans, 1-3 May, 1990.

permits future augmentation of system features and functions to embrace unforeseen applications and opportunities. Thereby, an open, scalable, and extensible high resolution systems architecture could provide benefits across industries and applications.

Primary examples of these scalable/extensible principles can be found in computer operating systems, page description languages, and communication networks.

Open architecture approaches have found widespread use over the past ten years. The seminal example is the Open Systems Interconnection (OSI) model, adopted by the International Organization for Standardization (ISO), the CCITT, and referenced in a number of CCIR documents.[4] The OSI model specifies an environment where information is exchanged using protocols following a particular layered pattern. More recently, open standards approaches have very successfully been applied to messaging, electronic data interchange, and document architectures. Far-reaching Managed Information Object (MIO) models are now nearing completion by the ISO and CCITT for sharing information among open networks and applications, and have relevance to indexed high-resolution video file structures, compression and coding algorithms, and other header data. Recently, open architecture approaches have also become popular among telecommunication regulatory communities worldwide.[5,6,7,8]

Report 1223 (1986-1990) offers a tentative solution based a direct mapping of the HDTV chain to the OSI model. A more robust solution would be to develop a digital HRI architecture.

An open systems approach could lead to the development of a wide variety of HRI devices and displays that might also be suitable for HDTV applications.

Future HRI applications will use switched broadband communications, digital compression technologies, and a large variety of mass storage systems. The video index (header/descriptor) concept will permit video extensibility so that, for example, multiple shots (tight and wide) of events could be delivered simultaneously over a single channel with sufficient header data. An image appropriate to a given display may be selected and presented (e.g.,

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[4] ISO 7498 (CCITT Rec. X.200).

[5] United States Federal Communications Commission, Report and Order, 104 FCC2d 958 (1986).

[6] 33 CEC Journal L 192 (24 July 1990).

[7] "Measures to be taken in accordance with Article 2 of Supplementary Provisions of the Nippon Telegraph and Telephone Corporation Law," Ministry of Posts and Telecommunications (30 March 1990).

[8] Report of the Chairman, GATT-GNS Working Group on Telecommunication Services (20 Oct 1990).

wide shots on large, wide displays, and tight shots on small, narrower aspect displays). Future display systems may serve multiple purposes; a videophone call may be displayed in a window on a wall-size screen.

The IWP 11/9 draft new report concluded:

"- Widely diverse applications are embraced by high-resolution systems;

"- this diversity results in numerous different requirements with respect to resolution, sampling distribution, dynamic range, colorimetry, image format, temporal rate and aspect ratio, among other attributes;

"- harmonization across this diverse range would be beneficial, and technically feasible, in principle;

"- harmonization requirements should take account of the consumer-cost implication of proposed solutions."

To achieve HRI open systems, it is necessary to define the enabling technologies, characteristics, and parameters, including:

(1) system and signal parameters;

(2) compression and coding mechanisms;

(3) a video index (universal descriptor/header); and

(4) broadband or highspeed telecommunications protocols

This will require harmonization with related activities underway in other organizations such as CCITT, CMTT, and ISO/IEC.

Documents
CCIR Study Groups
Period 1990-1994

Document USTG-11/1-2
Document 11/1-
17 January 1991
Original: English

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Subject: Question 27-1/11
Question 47/11 (BC/11)
Question 69/11 (SP 27A-1/11)
Report 1217 (XE/11)
Report 1223 (BH/11)

United States of America

SYSTEM AND SIGNAL PARAMETER CONSIDERATIONS FOR HRI/HDTV APPLICATIONS

Recent technology advances could alter the foundations of image generation for high-resolution imagery (HRI) systems, and have broadened the applicability and implications of such applications. Previously, the standards process would have concentrated on specifying numerical system and signal parameters. Now, it is conceivable to consider the system organization and content in a context that recognizes the full importance of the synergies obtained from cross-industry applications. As a starting point, this document sets out to look at system and signal parameters.

Scalable Image Formats and Scalable Frame Rates

The HRI source definition should acknowledge a family of compatible resolutions and temporal rates, as opposed to a single resolution and rate.

Two recent approaches to this issue, Common Image Format (CIF) and Common Data Rate (CDR), are partial answers. CIF is conducive to fixed format devices such as CCD sensors and flat panel displays. On the other hand, CDR is conducive to fixed bandwidth media such as magnetic tape and fixed rate channels. The CIF and CDR approaches interact when frame rates and resolutions are selected.

Progressive Scan and Isotropic Image Sampling (Square Pixels)

Progressive scan and square pixels are desirable for digital signal processing and HRI applications, and remain a target for HDTV as well.

Other Criteria

The nature of the 16:9 aspect ratio suggests that the vertical resolution be divisible by 9 and that the horizontal resolution be divisible by 16.

The likely use of block transform coding, such as HDTV-extended JPEG or MPEG types of DCT compression, suggests that there may be efficiencies in considering standard block sizes of 8x8, 16x16, and 32x32 as well.

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June 26, 1990

REPORT OF THE WORKSHOP ON AN ARCHITECTURE OF STANDARDS
FOR THE
INTEROPERATION OF HIGH RESOLUTION SYSTEMS ACROSS INDUSTRIES

This workshop composed of professionals affiliated with for-profit and not-for profit organizations whose annual world-wide revenues exceed $175 billion has concluded that:

Whereas,

- The U.S. is in the process of establishing standards for HDTV, the entertainment uses of high resolution systems;
- The standards and technologies related to these high resolution systems will have a significant impact on multiple industries in addition to television for many decades;
- An open-architecture, modular approach to standards for high resolution systems can provide maximum opportunities for industry to create new markets and to expand current markets;
- Digital technology permits an open, modular, scalable, extensible, architecture. Such an architecture would provide the basis for standards for implementing interoperability of multimedia systems (i.e., data, image, video and voice) across traditionally distinct industries. These industries include consumer electronics, defense, education, medicine and health, personal computers and workstations, telecommunications, television (terrestrial broadcast, cable, fiber, and satellite), and others;
- Implementation of multimedia capability is important to all of the above industries, their suppliers, and users and consumers. The critical technologies common across these industries include: image and video capture and generation, distribution, processing, display and storage;
- Synergies and scale economies from implementations of technologies across industries are essential for success in a globally competitive environment;
- Fully digital implementations offer: cross-industry benefits of products and applications, ongoing performance and quality improvements, reduced transmission artifacts, no loss through multiple generations of recording and storage, better encryption mechanisms, better compression techniques, flexible digital processing, and future system flexibility;

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The Institute of Electrical and Electronics Engineers, Inc.

- Technologies requisite for practical implementation of fully digital multi-media systems are rapidly emerging;

- In turn, the above conclusions imply that early consideration of the benefits of a fully digital system within the open, modular architecture is essential to establish a credible basis for competitive selection of standards in all the relevant industries.

Therefore,

This workshop resolves to work with experts from and enlist the support of interested industries:

1. To demonstrate the mutual benefits of an open, modular <u>architecture</u> and its related standards.

2. To define and establish characteristics of a fully digital <u>implementation</u> within this architecture.

Memorandum to: U. S. National Committee for CCIR Study Group 11

From: The Ad Hoc High-definition Display and Television Working Group

Subject: U.S. position at the March IWP 11/6 in Atlanta on the "single worldwide standard for HDTV programme production and international programme exchange"

Date: 22 February 1990

We would like to thank this study group and other associated organizations for their energy and efforts to orchestrate the adoption of an HDTV standard for international production and program exchange which would allow the United States to move forward into the next generation of technology and communications. Your collective efforts have captured our attention.

Equally important, the recent rapid pace of technological change has convinced us that the destinies of the television and broadcast industry, the cable industry, the motion picture industry, information services industries, local telephone and interexchange carriers, the computer and related high-technology industries, and the national scientific and research community are inextricably intertwined in the convergence of computers, consumer and professional electronics, and transmission media.

These industries are going through vast changes: Within the past few years, image, digital signal, and information processing have improved by several orders of magnitude. Further, one can now buy the equivalent of half a Cray 1S in a desktop workstation at last years' workstation prices. The world telecom carriers are rapidly digitizing, with consequent influence on software and hardware. Such advances in overall technology, fueled by America's seemingly insatiable demand for all new forms of information technology, were simply not known or accepted by many in the imaging field with any degree of confidence even two years ago.

The combination of these two factors -- the perceived urgency for an HDTV production and exchange standard, and the recognition that this standard must be much more than a new generation of consumer television -- has led to our collective desire to contribute to the important discussions of what this new high-definition media standard must be if we are to accommodate all competing and complementary interests in the U.S. fairly, and to maximum competitive advantage.

Indeed, the adoption of this standard represents a tremendous new opportunity for America to regain lost ground in the technology race by taking advantage of our traditional strengths: technological innovation and entrepreneurial creativity. (Importantly, there are several companies represented in our ad hoc body which employ fewer than 100 people, but which are nonetheless respected in their industry for innovative and leading-edge products. Academic and scientific institutions are represented as well.)

Therefore,

We conclude that a productive, extensible, and globally useful definition of advanced television and other high resolution imaging systems will require the full efforts of competent engineering and manufacturing expertise if it is to be accomplished in the time frame of the next CCIR study cycle.

It is our unanimous consensus that we must cooperate on the creation of a standard that:

1) provides advantages to all the industries involved, and

2) lowers artificial barriers to entry in the competition for future technology, software, and transmission markets, particularly in light of the expected advances in media, distribution, and computation technology.

In short, we feel that it is in the best interests of the United States to continue to work on standards characteristics to achieve a family that will benefit all American industries and institutions. This path is particularly important as we await the outcome of the FCC's Advanced TV Inquiry. NO PRODUCTION STANDARD SHOULD BE ADOPTED UNTIL THAT OUTCOME IS KNOWN.

Therefore, we recommend to the U. S. Department of State, that the US delegation to the March CCIR IWP 11/6 meeting endorse a continuation of the work on an HDTV standard for international production and program exchange during the next 4-year study cycle, in the context of the broader interests of all U.S. industries.

Alan McAdams, IEEE, The Economic Strategy Institute, and Professor, Cornell Graduate School of Business

Ed Bleier, President, Warner Pay Television, Animation, & Network Features

V. Michael Bove, Jr., Associate Professor, MIT Media Lab

Dr. James E. Carnes, Vp, Consumer Electronics & Information Services, David Sarnoff Research Center

Linda Carpenter, Manager, Business Development, Paramount Pictures

Birney Dayton, President, Nvision

Gary Demos, President, DemoGraFX

Claude Feistel, IBM Corp., Advanced Workstation Div

Branko Gerovac, Digital Equipment Corp., Corporate Research.

Alan Cole-Ford, Sr. Vp., Business Development, Paramount Communications Inc.

Virgil Conanan, Sr. Assistant Engineer, Home Box Office

Robert Hansen, President, Zenith Consumer Products

Edward Horowitz, Sr. Vp., Viacom

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Bruce Sidran, Bellcore

John Sie, Vp. TCI Inc.

Richard Solomon, Research Laboratory of Electronics, Massachusetts Institute of Technology

David Tennenhouse, Assistant Professor, Laboratory for Computer Science, Massachusetts Institute of Technology

Greg Thagard, Director of Special Projects, Showscan

David Trzcinski, Hewlett-Packard Co., Graphics Technology Div.

Mark Urdahl, IBM Corp., Advanced Workstation Div.

John Weaver, Producer, Liberty Television

Mr. VALENTINE. Thank you, Mr. Liebhold.

Mr. Phillips.

Mr. PHILLIPS. Thank you. My name is Kenneth L. Phillips. I'm Science Advisor and Chairman of Legislative Affairs for the Committee of Corporate Telecommunications Users, as well as professor of telecommunications in New York University's graduate program in interactive telecommunications. I have also been Vice President for Telecommunications at Citicorp for some 15 years.

In listening and occasionally participating in the meetings and proceedings surrounding high definition television systems over the past few years, I am reminded perhaps of the crowning literary achievement of the great mathematician, Lewis Carroll, also known as C.L. Dodgson, who, in recounting some of "Alice's Adventures in Wonderland," tells of Alice's astonishment over observing the Mad Hatter consult his watch in order to discover the day of the month, and the March Hare who, in attempting to fix things, dips his watch in a cup of tea. The to-date exclusive focus on commercial television when speaking of high definition systems is, in my opinion, much like the March Hare dipping his watch in his tea in an attempt to get things working again.

Now, this is not to say that television is not important. Indeed, in the overall scheme of things, especially future information services, it may be of critical economic importance. But the debate thus far has been between warring entertainment factions, each of which fears the loss of its already declining preeminence, rather than planning effectively for what we have already heard is undoubtedly a digital future. Technological progress is inevitable, if not always desirable.

The effective implementation of high definition digital systems could drastically cut the cost of providing access to inter-LATA basic telecommunications services for all Americans and, in the process, add new meaning to the term "universal service". For in the digital world there is no difference, technologically speaking, between a packet containing information bound for a high definition display device depicting the latest feature movie and a packet carrying the instantaneous quote of the spot price of a rare metal between traders thousands of miles apart and in different countries.

Indeed, the point is that the incremental marginal cost of adding a 64 kilobit bit stream, such as a basic telephone conversation, to a fiber already carrying a television signal, is minimal. But these economies of scale will only be obtainable if the architecture and format of the high definition broadband signal are thought through thoroughly and implemented smoothly. In addition, a fundamental question yet to be addressed is whether, given the fact that the digital world is transparent to content—that is, a packet comprising a TV image is, from an engineering viewpoint, no different from a packet representing the telephone call—indeed, whether there is any future justification for separate regulatory treatment of these two media.

The question, therefore, is not whether video dial tone is going to be part of the future but, rather, whether it shall be accessible over the airwaves, over the coaxial cable, or through strands of glass fiber. Yet, the existence of consumer demand is hardly an issue, as last Saturday's New York Times reported the issuance of a U.S. patent to Robert R. Harmon for a machine essentially identical to a bank ATM machine, except in one respect: instead of vending money from a bank branch, it is placed on the wall of a video rental store and dispenses tapes after accessing the store's computer and reading the customer's credit card. Not surprisingly, the name of Mr. Harmon's company is "Thru the Wall."

Now, having a proper set of standards for high definition systems will play a greater role in determining the economics of delivery and terminal devices than it will in choosing the medium of delivery, which is more tied to regulatory issues at present. Clearly, the most impressive benefits in terms of marginal costing apply when the broadband signal is delivered by fiber.

A further barrier to entry for the local exchange companies, who have a remarkable stake in this, is the table of depreciation policies they are held to for such advanced technologies as high density compression equipment, multiplexors operating at rates of several hundred million bits per second, and a host of other microprocessor-based switching and transmission services. The depreciation adjustment process is perhaps the least understood and most ill-informed of the three arenas required to make high definition systems a reality—standards setting, regulation, and depreciation.

Congress needs to know that the effective implementation of high definition systems will involve a great deal more than the technical agreement on a standard, or improving matters at the FCC, which is far ahead of most other agencies actually in dealing with issues of this degree of technological complexity.

In the few minutes remaining, I would like simply to highlight some specific dynamics and recommendations to be followed in moving closer to developing a standard for the panoply of applications which are subsumed under the general term "high definition system".

Firstly, high definition applications are neither exclusively things of the future, nor space age technologies likely to be retarded by slowing general economic trends. For example, the trend in personal computing operating systems is clearly towards software environments which will make possible multiple teams of workers focusing on the same problem simultaneously at remote locations, essentially anywhere in the world. My colleague from Apple represents the company at the forefront of that effort. Apple has also filed with the FCC a generic Petition for Rulemaking on spectrum reallocation of 40 megahertz in the 1850 to 1990 megahertz band in support of something called "DATA PCS". We heard this referred to in the last panel as wireless computers.

This is basically a personal communications system for portable computers functioning essentially as a radio frequency-based LAN, Local Area Network. However, the interconnection of multiple DATA PCS's with both the public switched network, value-added packet networks, and broadband corporate networks supporting the type of high definition applications discussed in these hearings is, in fact, inevitable. Apple's petition seeks an open standard, not a proprietary technology, and deserves your study and support. It has already won the support of both large telecommunications users and its much larger competitor, IBM.

I would further mention only in passing today that the legislative effort to fund the NREN, the National Research Educational Network, which would most certainly be supported by wideband backbone facilities, will result in even more immediate and robust demand for a cost-efficient and unified approach to high definition standards and architecture.

Trends, briefly, in the financial services industries, one of the three largest sectors of the telecommunications and processing markets, all have implications for the high definition environments, though most are yet to define their architectural needs cogently. Widespread availability of broadband infrastructure, be it on public or privately operated networks, will open new realms of opportunity for product differentiation and for financial service providers if a set of model high definition imaging standards is developed making image-based processing of financial instruments possible.

New levels of authentication, encryption and processing of everything from negotiable documents to live image/full motion credit cards will render today's "smart cards," point of sale terminals, and cash machines obsolete, while saving institutions and ultimately the public hundreds of millions of dollars stemming from reduced fraud.

The most recent major entrant into consumer financial services, AT&T, is already looking into the feasibility of communicating cards and other related technologies. American Express is on a similar track. These devices will have much greater utility over the span of the next five years or so, when the North American dialing plan shall run out of numbers and require telephone numbers possibly as long as 15 digits.

There are many other exciting applications to speak of. However, time does not permit us to go through all of those at the moment. You'll find them in the prepared text which I have submitted.

Finally, we must answer the question, what about the process, the process of developing a set of standards for high definition systems?

Digital telecommunications standards do exist today, though when the FCC process was established, nobody could have anticipated the velocity of progress in digital signal processing as the tables appended to the end of today's comments demonstrate.

The standards set ultimately adopted must be an open standard, both extensible and scalable. The absence of an open standard would set the stage for information monopolies, not unlike the telecommunications monopolies of the past. Scalability is particularly important during the early phases of deployment, since television or movies will most likely be the economic engine driving this overall change, with the less bandwidth-demanding applications piggybacking on the entertainment applications.

Since on a frame-to-frame basis the amount of digital information required to convey a moving picture is relatively low on a raster addressing basis, bandwidth needs to be dynamically allocated between the packet stream supporting the imaging, and those supporting other applications where the base bandwidth may be lower but where the frame-to-frame ratio of change is far higher.

Of the four digital systems thus far proposed, only Sarnoff Lab's Advanced Television System proposes a fully packetized data transport layer.

I would like to conclude with five one-sentence recommendations.

Since high definition systems have vast implications for future telecommunications infrastructure, and the potential for reducing costs to all Americans of basic telephone services, the standards and evaluation process must include parameters far wider than those connected simply with television. To achieve this, Congress needs to empanel a committee or some other body, focusing specifically on the harmonization of standards in the various groups that we've heard from, possibly under the Government advisory process.

The FCC may be the appropriate venture for the consideration of broadcast aspects of the high definition television issue. However, technology has now advanced to a level where other, nonbroadcast issues are centrally involved. Standards adoption should not be based solely upon broadcast-based advanced telecommunications activities at the FCC.

Either additional initiatives should be initiated at the Commission or at another agency, such as NIST or the National Academy of Engineering, for study and recommendations relating to telecommunications, data handling, technology and privacy aspects of high definition systems design.

A coordinating committee, as I mentioned before, should be established with congressional support to assure involvement of the private sector, including the entertainment, information services, electronics, broadcast, and telecommunications components.

Recognizing the multisectoral applications and implications of high resolution systems, this committee should endorse a process leading to a set of standards guidelines which, de minimis, should embrace the open standard based upon the precepts of scalability and extensibility and nonchannelized digital formats, fully compatible with both advanced display devices and the CCITT standards in the telecommunications arena, especially those connected with broadband ISDN's, Signaling System VII, and the SONET class of transmission protocols.

Well, unlike the March Hare that I spoke of before, I haven't placed my watch in the tea as a last ditch effort to set the high definition cluster of issues back on track. Nonetheless, by participating in the process, I have gained a healthy dose of empathy for Alice's predicament and do appreciate having had the opportunity to speak with you here today and to share thoughts on issues on high definition systems.

Thank you very much.

[The prepared statement of Kenneth Phillips follows:]

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY

"High Definition Systems Implementation: Implications for Telecommunications"

Oral Testimony of

Kenneth L. Phillips

Prof., Graduate Interactive Telecomm. Pgm., N.Y. Univ.

Science Advisor &

Chairman, Committee of Corporate Telecommunications Users

MAY 21, 1991

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My name is Kenneth L. Phillips. I am Science Advisor and Chairman for Legislative Affairs of the Committee of Corporate Telecommunications Users, as well as Professor of Telecommunications at New York University's Graduate Program in Interactive Telecommunications. I have also been Vice President for Telecommunications Policy at Citicorp in New York. The CCTU is not a trade association, but rather, a group of very large telecommunications users who are critically dependent upon all forms of telecommunications and who participate in the regulatory process focusing on advanced technology policy issues and supporting Common Carrier initiatives beneficial to large users. I would like to thank Congressmen George Brown and Tim Valentine and especially Jim Turner of the Committee Staff for providing the opportunity to share a few thoughts surrounding an area which all three branches of the Government now have recognized as critical: High Definition Systems.

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In listening and occasionally participating in the meetings and proceedings surrounding High Definition Systems over the past few years, I am reminded of perhaps the crowning literary achievement of the great mathematician Lewis Carroll, (C.L. Dodgson) who, in recounting some of "Alice's Adventures In Wonderland," tells of Alice's astonishment over observing the Mad Hatter consult his watch, in order to discover the day of the month, and the March Hare who in attempting to fix things, dips the watch in a cup of tea. The to date exclusive focus on commercial television when speaking of High Definition Systems is in my opinion, much like the March Hare dipping his watch in his tea in an attempt to get things working again.

This is not to say that television is not important. Indeed, in the overall scheme of future information services, it may be of critical economic importance, but the debate thus far has been between warring entertainment factions each of which fears for the loss of its already declining preeminence rather than planning effectively for a digital future. Technological progress is inevitable, if not always desirable.

The effective implementation of high definition digital systems could drastically cut the cost of providing access to inter-LATA basic telecommunications services for all Americans and, in the process, add new meaning to the term "universal service," for in the digital world there is no difference, technologically, between a packet containing information bound for a high definition display device depicting the latest feature movie, and a packet carrying an instantaneous quote of the spot price of a rare metal between traders thousands of miles apart. **The incremental marginal cost of adding a 64kb/sec. bit stream (such as a telephone call or link to a personal computer) to a SONET rate backbone already carrying a 125 mb/sec. is minimal.** But these economics of scale will only be obtainable if the architecture and format of the High Definition broadband signal are thought through thoroughly, and implemented smoothly. In addition, a fundamental question yet to be addressed is whether, given the fact that the digital world is transparent to content, (that is, a packet comprising a t.v. image is from an engineering viewpoint no different from a packet representing a voice telephone call,) **there is any justification for separate regulatory treatment of the two media.** Several cogent arguments exist for the separate regulation of television, most notably its use of the rf spectrum, clearly a public resource, but as entertainment increasingly becomes delivered by terrestrial means, i.e, cable and eventually fiber, the nature of broadcast television will begin to shift, and increasingly, I would suggest, look more and more like an information business, which by then, will be an activity very much at the heart of the inter-LATA telecommunications markets, and one not at all foreign to the Local Exchange telephone companies.

The question therefore is not whether video dial tone is going to be part of the future, but rather whether it shall be accessible over the airwaves, over the coaxial cable, or through strands of glass fiber. This is an issue discussed in greater detail in my written testimony submitted to the Committee. Yet the existence of consumer demand is not an issue, as last Saturday's *New York Times* reported the issuance of U.S. Patent #5,013,897 to Robert R. Harmon for a machine essentially identical to a bank ATM machine except in one respect: instead of vending money from a bank branch, it is placed in the wall of video rental stores and dispenses tapes after accessing the store's computer and reading the customer's credit card. Not surprisingly, the name of Mr. Harman's company is Thru-the-Wall!

The importance of having a proper set of standards for Hi Definition systems will play a greater role in determining the economics of delivery and terminal devices than it will in choosing the medium of delivery, which is more tied to regulatory issues at present. Clearly the most impressive benefits in terms of marginal costing apply when the broadband signal is delivered by fiber. Ironically, while the inter-LATA carriers and their customers have enjoyed the benefits of deregulation, divestiture (stemming from the settlement of the Justice Department's antitrust case against AT&T,) has not resulted in deregulation of the all important "last mile," which remains under the purview of 50 different state regulatory commissions, which are also regulating water companies, gas lines, and other comparatively ancient technology bases. In addition, of course, the Cable Act continues to exclude the Local Exchange Companies from providing entertainment as part of the content flowing over their local loops, even though technologically they are probably the most efficient bearer of those goods.

One must remember that the architecture of most cable systems will not permit two-way interactive services running over the coaxial loop, because of the "tree architecture" used for signal distribution under the streets of the larger metropolitan areas. A further barrier to entry for the Local Exchange Companies is the table of depreciation policies they are held to for such advanced technologies as high density compression equipment, multiplexors operating at rates of several hundred million bits per second, and a host of other microprocessor-based switching and transmission devices. The depreciation adjustment process is perhaps least understood and most ill-informed of the three arenas required to make Hi Definition Systems a reality: standards setting, regulation, and depreciation.

Largely at our behest, the Treasury Department undertook a preliminary hearing on this subject last year. A clear and cogent explanation by an AT&T representative of the fact that telephone switches and computers are no longer basically different technologies was met with both vehement disbelief by officials of the Treasury, and tacit accusations that the company was trying to pull the wool over the officials' eyes. Congress needs to know that the effective implementation of High Definition systems will involve a great deal more than technical agreement on a standard, or improving matters at the FCC, which is far ahead of most other agencies dealing with issues of this degree of technological complexity. Indeed, Commissioner Sikes and Mr. Pepper who heads the Commission's Office of Planning and Policy are to be thoroughly commended for having just initiated an outstanding series of hearings on the Network of the Future, highlighting just these issues.

In the few minutes remaining, I would like to highlight some specific dynamics and recommendations to be followed in moving closer to developing a standard for the panoply of applications which are subsumed under the general term, "High Definition System."

Firstly, High Definition applications are neither exclusively things of the future, nor space age technologies likely to be retarded by slowing general economic trends. For example, the trend in personal computer operating systems is clearly towards software environments which will make possible multiple teams of workers focusing on the same problem simultaneously at remote locations, essentially anywhere in the world. My colleague from Apple represents the company at the forefront of that effort. Apple has also filed with the FCC, a generic Petition for Rulemaking on spectrum reallocation of 40 MHz in the 1850-1990 MHz band in support of "DATA PCS ." This is a personal communications system for portable computers functioning essentially as an rf LAN, however the interconnection of multiple DATA PCSs with both the Public Switched Network, value added packet data networks, and broadband corporate networks supporting the type of High Definition applications discussed in these hearings is inevitable. Apple's Petition seeks an open standard, not a proprietary technology, and deserves your study and support. It has already won the support of both large telecommunications users, and its much larger competitor, IBM.

I would further mention only in passing today that the legislative effort to fund the NREN, which would most certainly be supported by wideband backbone facilities, will result in even more immediate and robust demand for a cost efficient and unified approach to High Definition standards and architecture. The NREN which essentially replaces the TCP/IP-based Internet and original ARPA Nets, by definition links major research and developments centers throughout the world. These scientific centers surely constitute the most critical uses of high definition imaging, along with the medical community. As an advisor to the Office of Technology Assessment, I have already testified as to how the NREN, a major broadband network capable of supporting high definition imaging, could also play a central role in increasing the reliability and survivability of the United States' three major carrier operated inter-LATA communications systems, which become somewhat more vulnerable as increased traffic is placed on dense fiber routes.

Trends in the financial services industries, one the the three largest sectors of the telecommunications and processing markets, all have implications for the High Definition environment, though most are yet to define their architectural needs cogently. Widespread availability of broadband infrastructure, be it on public or privately operated networks will open new realms of opportunity for product differentiation for financial service providers if a set or model of High Definition Imaging standards is developed making image-based processing of financial instruments possible. New levels of authentication, encryption and processing of everything from negotiable documents to "live image/full motion" credit cards will render today's "smart cards," point of-sale terminals, and Cash Machines obsolete, while saving institutions and ultimately, the public, hundreds of millions of dollars stemming from reduced fraud. The most recent major entrant into consumer financial services, AT&T, is already looking into the feasibility of communicating cards and other related technologies. American Express is on a similar track. These devices will have much greater utility over the span of the next five years or so when the North American Dialing Plan shall run out of numbers and require telephone numbers possibly fifteen digits long.

Medical records based around full motion imaging gained from non-invasive Magnetic Resonance Imaging and similar less costly systems should be available digitally, and on demand, as eventually should be digital libraries. Digital libraries possessed of the resources of the Library of Congress, New York Public Library, or major university libraries would eliminate millions of dollars of redundant costs buried within today's library systems. But simply digitizing books isn't the answer; high definition imaging systems coupled with Asynchronous Transfer Mode-based communications protocols could embed indexing pointers in message inquiry packets and lead to vastly increased "intelligent networks" capable of locating information sources rich in particular topic-based files. Museums, the performing arts, and personal expression could, given a world telecommunications infrastructure adhering to a scalable and extensible set of standards for high definition image processing, be the base for virtual realities within electronic letters, memos and digital books. Thus far, all of the discussion surrounding High Definition Systems has been within the video sector. Often overlooked are the even closer event horizons associated with high definition audio. As a musician, I am perhaps particularly aware not only of the potential for virtual realities surrounding high definition sound but of the remarkable extent to which sensory information processing crosses over sensory lines.

It is noteworthy I feel, that in experiments with all of the various High Definition Television standards, when presented on today's screen sizes such as 17 and 21 inches, less than 20% of the viewers felt that the HDTV's were vastly improved over standard NTSC, yet when viewers of todays television hear the audio played through a high quality stereophonic speaker system, if uninformed of the experiment,a large percentage indicate that the *video* has improved by as much as 40%. It seems to me that this phenomenon, coupled with the fact that the networks do not receive any large number of complaints regarding the quality of the visual image, the entire notion of a business opportunity of multi-billion dollar proportions will surely involve a lot of hype.

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Finally, we must answer the question of **What about the Process** of setting a set of standards for High Definition Systems?

Digital telecommunications standards do exist today, though when the FCC process was established,nobody could have anticipated the velocity of progress in digital signal processing, as the Tables appended to the end of today's Comments demonstrate,

The standards set ultimately adopted must be an **open standard, both extensible and scalable.** The absence of an open standard sets the stage for information monopolies, not unlike the telecommunications monopolies of the past. Scalability is particularly important during the early phase of deployment since television or movies will most likely be the economic engine driving this overall change, with the less bandwidth-demanding applications piggy-backing on the entertainment applications.

Since on a frame-to-frame basis the amount of digital information required to convey a "moving" picture is relatively low on a raster addressing basis, bandwidth needs to be **dynamically allocated** between the packet stream supporting the imaging, and those supporting other applications where the base bandwidth may be lower, but where the frame to frame ratio of change is far higher. Fixed, channellized structures within the transport layer architectures will prove wasteful and inefficient if a television standard is adopted making the Adaptive Transfer Mode difficult. Incidentally, this fact has not escaped the strategic planners of offshore manufacturers of fiber optics.

Of the four digital systems thus far proposed, only Sarnoff Labs' "Advanced Television System" proposes a fully Packetized Data Transport Layer. It is also very important to realize that by adhering to Adaptive Transfer Mode (ATM) formats under the CCITT H^4 proposed formats, interconnection with basic rate broadband ISDNs operating under Signaling System Seven generics should be vastly more transparent and therefore less costly in all regards. Cell relaybased data transport layers adhering to these and yet to be approved protocols may add to the complexity of equipment manufacturers' effort to obtain patents, however in the long run, these difficulties will be vastly outweighed by the benefits of far greater market penetration.

I would like to conclude with a few recommendations:

- Since High Definition Systems have vast implications for future telecommunications infrastructure and the potential for reducing costs to all Americans of basic telephone services, the standards and evaluation process must include parameters far wider than those connected simply with television.

- The FCC may be the appropriate venue for the consideration of broadcast aspects of the high definition television, however technology has now advanced to a level where other, non-broadcast issues are centrally involved. Standards adoption should not be based solely upon broadcast based Advanced Television Committee at the FCC.

- Either additional initiatives should be initiated at the Commission or at another agency, i.e., NIST or the National Academy of Engineering, for study and recommendations relating to the telecommunications, data handling, technology, and privacy aspects of High Definition Systems design.

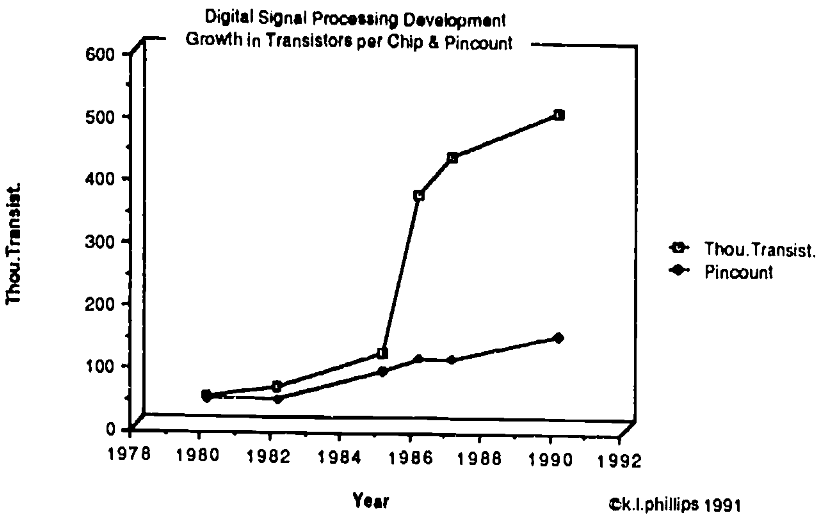
- A coordinating Committee be established with Congressional support to assure involvement of the private sector, including the entertainment, information services, electronics and broadcast interests, Department of State, the FCC, Congressional Science, Technology, and Telecommunications Committees and Subcommittees, as well as the NTIA and Defense Sectors. Such groups such as COHRS, CCTU, and other already representing a broad base of sectors should sit on the Coordinating Committee.

- Recognizing the multi-sectoral implications of High Resolution Systems, this Committee should endorse a process leading to a set of standards guidelines which *de minmis* should embrace an open standard based upon the precepts of scalability, extensibility, nonchannellized digital formats fully compatible with both advanced display devices *and* CCITT standards in the telecommunications arena, especially those connected with Broadband ISDNs, Signaling System VII, and the SONET class of transmission protocols. It is key that bandwidth for a programming or imaging source in which there is a great deal of motion be able to dynamically "borrow" bandwidth not used by other sources where the motion factor, and therefore demand is lower. The likelihood of a large percentage of sources requiring full screen updates within the same frame time is slim, even in todays world of 40 or 50 simultaneous program sources.

Well, unlike the March Hare, I have not placed my watch in the tea as a last ditch effort to set the High Definition cluster of issues back on track, nonetheless, I have gained a healthy dose of empathy for Alice's predicament, and do appreciate having had the opportunity to speak to the non-television aspects of High Definition Systems, and would ask for a motion that the record be kept open a week or longer so that more extensive written comments may be submitted as part of the record. I would be pleased to respond to any questions you may have.

TABLES & SUPPORTING DATA[1]

[1] Data from *Recent Advances in DSP Systems*, H.M. Ahmed, R.B. Kline; IEEE Communications, May 1991, Vol.29., No.5., p 33.


Digital Signal Processing Development
Growth in Transistors per Chip & Pincount
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600
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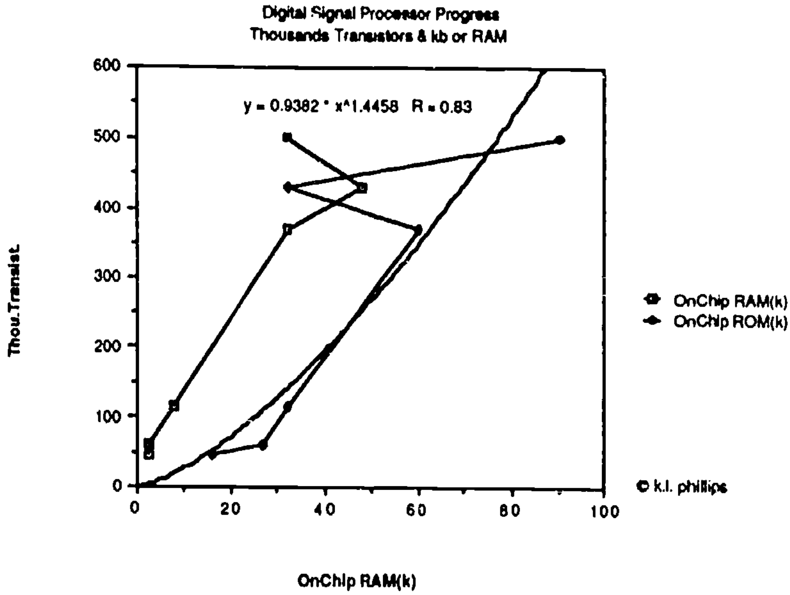
©k.l.phillips 1991



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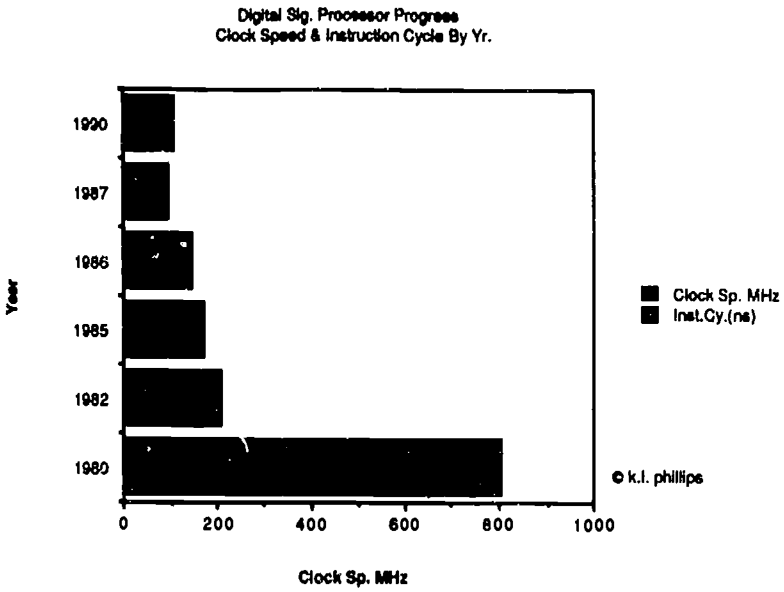
Testimony of K.L. Phillips, ©1991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Biographical Sketch

Ken Phillips

Ken is Chairman for Legislative Affairs and Science Advisor to the Committe of Corporate Telecommunications Users. He has been Citicorp's Vice President for Telecommunications Policy. In addition, he is a Professor at New York University's Graduate Program in Interactive Telecommunications. He has also taught at MIT, Carnegie Mellon, Columbia, and Minnesota Universities and is the author of over sixty articles and contributions to text books on a wide variety of topics ranging from Information Theory and human information processing to telecommunications regulation, policy, and the latest wave of "privatizations" He is on the Editorial Board of both Network World and Communications Week.

He holds graduate degrees in Psychology and Physics. He lives in New York City where he also has a private consulting practice in international and domestic technology/telecommunications planning, economics, and regulatory issues. He is also a classical pianist.

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Mr. VALENTINE. Thank you, sir.
Mr. Demos.
Mr. DEMOS. Thank you, Mr. Chairman.
I have brought with me several additional documents for the record, one from Mr. Staelin, who came before this committee a week ago, who had some further thoughts on unbundling the FCC standards selection process; a memo to the CCIR on harmonization. I will proceed here. Thank you, Mr. Chairman.

Recent HDTV developments have created new potential uses. In the past year, four of the five proposals for high definition television being considered by the FCC have switched from being analog type to being all digital systems. The change to all digital is a major improvement in quality. Digital HDTV systems allow many uses beyond the current uses of television.

The innovations inherent in the digital proposals in the United States have temporarily given us the lead internationally. However, even though we can be proud that four excellent technical proposals for digital HDTV have been developed, these proposals fall far short of what is possible because of the original perception that HDTV was only an entertainment medium. We must adjust our view of HDTV away from being only an entertainment and broadcast medium in order to understand the full potential that high resolution images can play in everyday life.

Before we examine the broader potential for HDTV, I would like to comment on desirable capabilities of HDTV which are not contained in the current proposals.

Scalability. One valuable and feasible attribute of HDTV systems would be an ability to extract lower quality images off of the main high-quality HDTV signal. This is possible with a small adjustment to the current digital HDTV systems. A lower quality picture could be received on a much lower cost receiver. This would allow a picture of higher quality than our current NTSC television but without paying for the highest quality HDTV system. The high definition image can carry both the highest quality as well as reduced but improved quality at the same time. This idea is called scalability.

None of the current proposals before the FCC has this property of scalability. The HDTV proposals for terrestrial broadcast have been optimized solely for a single standard without any ability to scale resolution or frame rate. Frame rate is the speed at which images are updated on the screen. The HDTV proposals for terrestrial broadcast which are before the FCC all operate at 60 images per second, like current NTSC television, which optimizes primarily for sports coverage. The major broadcasters in the United States are most concerned with covering sports and special events with their broadcast, where fast motion is a crucial aspect of the image. However, motion picture film operates at 24 frames a second and also makes up a substantial portion of the images presented on current television.

Motion picture film inherently has the higher resolution that high definition television will be able to reproduce. Any television system which operates only at 60 images per second wastes two-and-a-half times the quality available for motion pictures. It would be desirable if HDTV systems could offer high resolution for the best quality signal when showing 24 frame per second motion picture film.

Those systems which propose interlaced HDTV are even more difficult to apply to film production. Interlacing is the technique of showing alternate scan lines during each 60th of a second field. This technique is in use in the current television format which was conceived around 1940, and is being proposed by some for HDTV. However, the technique of interlace is incompatible with both film production as well as computer displays.

The new multimedia computers, which are being introduced by major U.S. computer manufacturers, can display video on the screen. None of these computers can make use of displays which use interlace.

Another issue involved in computer display compatibility is the need for computer screens to refresh at rates higher than 60 images per second. There is a general trend to refresh rates above 70 images per second. This higher refresh is needed when the HDTV images are viewed in a bright lighting environment where the eye is more sensitive to flicker. A typical office, factory, or library environment, where there are bright fluorescent lights, will need these higher rates.

Another valuable potential attribute of HDTV system parameters would be an ability to easily exchange images internationally. The current proposals before the FCC are designed with relationship to NTSC, the current television standard, but do not have an easy conversion relationship to PAL and SECAM, the standards of Europe and Asia.

The FCC HDTV examination process is focusing exclusively on a 6 megahertz terrestrial channel. Alternate channel sizes, both larger and smaller, might also be useful for one or more HDTV formats. Satellite and cable systems can potentially use wider channels. The ability to provide the best quality of picture signal for a variety of digital channel bandwidths is a desirable feature of an HDTV architecture.

Interactive two-way video communications are not yet widely available. In the next ten years, the home portion of such communication will be within the financial reach of most citizens, just as the VCR has become widely available. However, the communications infrastructure which would support such interactive citizen-to-citizen communication is neither present nor planned. Our current regulations deny the proper framework for building interactive visual communications. The development of HDTV affords us an opportunity to design the entire architecture for national interactive visual communications. Interactive visual communications require an infrastructure similar to the current telephone network.

Although there are several methods of providing interactive visual communications, fiber optics is certainly the leading technology. An HDTV architecture which is conceived in this broader context would have substantially more social benefit than the system optimized for a single type of broadcast distribution. It would benefit the United States in global competitiveness if the HDTV system architecture also provided a framework for a national communications infrastructure. Improved information access is a very valuable piece of infrastructure to benefit the United States. Educational access to study aids, encyclopedias, news archives and technical journals from a home or office can be very beneficial.

In ten or twenty years, when the HDTV system is fully deployed and is part of everyone's everyday life, it is likely that fiber optics will be the primary way in which HDTV signals are sent and received. Cable, satellite and video tape may be used more to exchange HDTV pictures than terrestrial broadcast reception from an antenna.

If terrestrial broadcast has the substantial possibility to become the least favored mode of reception, why should it be the focus of our technical evaluations? It is possible that the majority of use of high resolution displays would involve education, work, interaction with colleagues and friends, and exploring new issues and ideas. If such becomes the case, then the exclusive focus of the HDTV system testing on terrestrial broadcast usage for news and entertainment would also be quite inappropriate.

The FCC testing process has no provision for measuring whether the HDTV systems are scalable, extensible, or compatible with the broader range of uses being discussed.

The ability of the HDTV signal to operate with medical imagery, educational material, pages of text from a library, legal documents, computer images, fax pages, color photographs, scientific and engineering drawings, et cetera, would clearly be beneficial to the United States economy. Current HDTV proposals before the FCC do not provide for these capabilities and even prevent them to varying degrees. However, these proposals could be modified somewhat in order to allow these capabilities.

The ability to work collaboratively with colleagues at meetings via teleconferencing would also be beneficial. The current HDTV proposals before the FCC have been optimized for the needs of the broadcasters. Although the broadcasters are a very important group, their needs should be met in addition to serving the broadest possible public interest, rather than to the exclusion. It would benefit us all if the broadest spectrum of citizens were to be served with benefit to their education, health and workplace.

HDTV must not be viewed as only an entertainment and broadcast news medium. It is a potential vehicle by which the United States can greatly improve the quality of life and our economic stature.

Thank you, Mr. Chairman.

[The prepared statement of Gary Demos, with attachments, follows:]

Testimony of DemoGraFX

before the

House Subcommittee

on

Technology and Competitiveness

High Definition Systems

May 21, 1991

Gary Demos
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Testimony
Committee on Science, Space, and Technology
Subcommittee on Technology and Competitiveness
U.S. House of Representatives
May 21, 1991
Gary Demos
DemoGraFX

Recent HDTV Developments

In the past year, four of the five proposals for High Definition Television being considered by the Federal Communications Commission (FCC) have switched from being traditional analog-type systems to being all-digital systems. The only system not to switch is the system being proposed to the United States by the Japanese National Broadcasting Corporation (NHK).

The change to all-digital is a major improvement in quality. Digital HDTV systems also allow many uses for high definition television beyond the current uses of television. These new potential uses have come to light recently through technical studies taking place within the United States, through taking advantage of new possibilities enabled by digital technology.

At the heart of digital high resolution television proposals is a technique known as "compression". Digital compression allows a high resolution moving image to be stored or sent to viewers using a small fraction of the channel width which has previously been required (prior to one year ago, when the digital systems began to be introduced). This digital compression technology, although it has been developed internationally, was first embraced for high definition television in the United States. Both Europe and Japan had developed their HDTV systems through a political process which prematurely adopted a more traditional television technology. The innovations inherent in the digital proposals in the United States have temporarily given us the lead internationally. We have the lead despite many billions of dollars which have been invested in Japan, as well as substantial investments in Europe.

However, even though we can be proud that four excellent technical proposals for digital HDTV have been developed, these proposals fall far short of what is possible. They do not fall short because the technology is not capable of being extended to take advantage of new possibilities, because it quite definitely can be extended. They fall short primarily because of the original perception that HDTV was only an entertainment medium, and that the only concerned parties were the broadcasters.

We must be cautious that we do not let our steps forward to digital HDTV technology fall short of their potential. Both the Europeans and the Japanese have both a stronger national will to dominate HDTV and a stronger inclination for substantial investment with respect to HDTV, especially in Japan. It can be expected that they will both upgrade to digital technology in the next year or two. In order for our present technical lead to mean anything, we have to do our best to propel the new technology toward enhancing our traditional national strengths of entrepreneurship, technical innovation, individual creativity, and empowering and educating the individual citizen. We must adjust our view of HDTV as an entertainment and broadcast medium, to understand the full potential that high resolution images can play in everyday life. Such a change of focus with respect to high resolution images as a national resource could give us an international technical and implementation lead which could last for possibly decades.

Worthwhile Objectives of HDTV System Architectures

The current primary methods of video distribution are terrestrial broadcast, cable, and videotape rental distribution. Also in more limited use is direct broadcast satellite reception, the rental of video laser disks, and the purchase of video tapes and laser disks. It should be anticipated that work on a new standard (MPEG) will also result in a possible distribution of video imagery using audio digital disks.

There is a potential for other future ways to distribute moving imagery. These methods will most likely be digital. The FCC examinations of candidate HDTV systems have resulted in all of the U.S.-based proponents for systems recommending digital systems for terrestrial broadcast. However, the digital picture processing (encoding) techniques which they have developed are useful for other digital distribution channels as well.

The "broadcast" method of distributing video is presently in use with terrestrial television, cable television, and direct broadcast satellite. Funding for these broadcast services comes from direct advertising or from "premium movie channel" fees. Video tape or disk rental is a more selective process, where thousands of shows are available for selection. Once selected, the show may be viewed at the renter's convenience. "On demand" on-line viewing is not available except in limited locations with a limited choices of shows.

Broadcast advertising has a problem with effectiveness, since the audience for a given commercial may be mostly inappropriate. For example, I am not in the market for a car, and I don't drink beer. Therefore, all car and beer advertisements which are shown to me are wasted. However, newspaper classified advertisements allow a broader and more detailed selection of used items for sale. A new item equivalent could be quite valuable to a shopper looking for a particular product. Current "shopping networks" suffer from the same broadcast problem, where the item being offered is not one which is currently of interest to the majority of viewers. It would be desirable to improve advertising effectiveness through matching the viewer's needs with the product offerings.

Interactive two-way video communications are not widely available, but rather require expensive dedicated hookups and equipment. However, technology to support such communications is rapidly becoming economically viable. Certainly in the next ten years, the home portion of such communication will be within the financial reach of most citizens, just as the VCR has become widely available. However, the communications infrastructure which would support such interactive citizen-to-citizen communication is neither present nor planned. It is not planned because the current regulatory environment in the United States precludes the potential providers from offering enough of the appropriate services to make the investment in this infrastructure attractive to them. Therefore, our current regulations deny the proper framework for building interactive visual communications.

Since HDTV is likely to be a new type of digital technology, the development of HDTV affords us an opportunity to design the entire architecture for national interactive visual communications.

Interactive visual communications require an infrastructure similar to the current telephone network. However, in addition to small conference calls and person-to-person calls, a visual presentation might be usefully viewable as "receive-mostly".

Examples would be a class lecture, which might have thirty viewers, where the teacher and blackboard are visible on a high resolution screen. In addition, students asking questions should be able to be seen by other students. Thus, the majority of the imagery comes from the teacher, but occasional additional views are useful.

Although there are several methods of providing interactive visual communications, fiber optics is certainly the leading technology. HDTV digital signal designs should be appropriately constructed so as to allow many high and medium resolution picture streams to share a single channel. In addition to some necessary channel sharing, a general switching technology, similar to current telephone systems, would also be required. An HDTV system architecture which is conceived in this broader context would have substantially more social benefit than a system optimized for a single type of broadcast distribution.

Communications Infrastructure

It would benefit the United States in global competitiveness if the HDTV system architecture also provided a framework for a national communications infrastructure. It would be desirable for many regions of the country which have high unemployment rates to be able to provide a proper work support environment for able-bodied citizens of those communities. The current requirement that each person must live in the proximity of the workplace causes great hardship when factories close and regional income declines. However, if there were to be an ability to interact with professional and even blue-collar colleagues at a distance, the degree to which resources would have to be concentrated locally would be reduced. Many professionals travel a great deal, with a substantial amount of their time being wasted during the often tedious travel process. Further, when professional travel becomes a constant way of life, the family life can suffer severely, especially to the detriment of children. Even within major metropolitan areas, affordable and desirable suburban housing is often far enough from the workplace that one, two, or even more hours per day are spent in crowded commuting, which is again a waste of talented human abilities. These distance barriers are a fact of life, and have a direct effect on the gross national product, and on the quality of daily life for our citizens.

Expert human resources are often not located near a workplace which can use these resources, thereby resulting in people accepting lesser jobs where they are not making their largest contribution to society or to themselves. The number of specialist experts in many fields is less than one hundred people in the entire nation. As society continues to become more complex and specialized, we will experience more of the phenomenon where a small number of experts in a given field are located predominantly away from the regions where they are most beneficial.

An appropriately designed HDTV architecture could provide a mechanism to connect the talent with more optimal employment, for the substantial class of jobs which can operate with good remote visual communication. Teleconference meetings, whether with a group or just with a boss and a colleague, can potentially provide the interaction which now is only possible by working at the same location. Further, the ability to excerpt the meeting images for communication to colleagues in the form of "video mail", can potentially enhance productivity the way that Fax and answering machine (voice mail) technology has improved communication. The personal computer, fax, and the inexpensive copier have allowed a small proportion of our citizens to earn a living from their homes, and has allowed some of them to live in rural areas. With a more generally accessible display, which is designed for person-to-person interaction and is designed to support teleconference meetings, it is possible to substantially increase the number of people who can earn a living at home or at a remote office because of the development of such technology.

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improved information access, in general, is a very valuable piece of infrastructure to benefit the United States. Educational access to study aids, encyclopedias, news archives, and technical journals from a home or office can be very beneficial. Current libraries with sufficient size to provide significant technical and educational resources are often located at some distance, and usually require hours of time being dedicated to searching for appropriate information. Many libraries are difficult to use, and frustrating in their incompleteness. A user of an electronic library potentially need never find a key book or article was "checked out", as the culmination of a long and possibly tedious search. Eventual aids will be developed to ease the process of searching for relevant "jargon-free" articles and information, and even for accessing investigatory video magazines (like CBS's "60 minutes", PBS "Nova", or CNN's "Future Watch").

Even more significantly, training in new jobs for workers in regions with declining economies might be provided by firms which need these workers enough to provide appropriate training media. Literacy in written and spoken English could be improved by access to appropriate materials. Even easy access to learning other languages could be provided.

Local or regional political access to candidates, ballot issues, and access to the arguments pro and con is also a potential use of a visual HDTV communications infrastructure. Neighborhood safety, through improved communication with local law enforcement, neighborhood issues, such as proposed zoning changes or development proposals, and other issues of interest to the residents of a community could potentially be enhanced. Voting itself could someday be done via the system, much the way personal computers can do banking in addition to automated teller machines and bank personnel. Voting turnout and voter awareness on issues would certainly increase with improved access to the meaning of the issues, familiarity with the candidates without having to be glued to the television and newspaper, and to the voting process itself.

Adjustments to HDTV Ideas

One valuable and feasible attribute of HDTV systems would be the ability to extract lower-quality images off of the main high quality HDTV signal. This is possible with a small adjustment to the current digital HDTV systems. Such a lower resolution image could be useful for hand-held and mobile communications. A lower quality picture could be received on a much lower cost receiver. This would allow our citizens to afford a higher quality picture than NTSC video, but without paying for the highest quality system. A lower resolution extracted image would also be useful as an "insert window" on high resolution screens, sometimes called "picture-in-picture". This idea of supporting lower and higher resolution images in the same signal is called "scalability", or an imagery "hierarchy". It is also called a "compatible family of formats".

None of the current proposals before the FCC has this property of scalability. The HDTV proposals for terrestrial broadcast have been optimized solely for a single standard, without any ability to scale resolution or frame rate. Frame rate is the speed at which images are updated on the screen. The HDTV proposals for terrestrial broadcast which are before the FCC all operate at 59.94 images per second, like current (NTSC) television, which optimizes only for sports coverage. The major broadcasters in the United States are most concerned with covering sports and special events with their broadcast, where fast motion is a crucial aspect of the image. However, motion picture film, operates at 24 frames per second, and also makes up a substantial portion of the images presented on current television. High definition television will be presenting a large proportion of shows which are made on motion picture film, which include not only movies, but also prime time television shows, 80% of which are made on film.

Motion picture film inherently has the higher resolution that high definition television will be able to produce. The proportion of news coverage where an anchorperson is being shown, is also low in the amount of motion, and could also be at a low frame rate.

In addition to supporting lower resolutions and frame rates, it would also be worthwhile if future advances in picture quality were considered, so that continuing improvements in technology could be incorporated into the the HDTV systems and signals. Thus, as better cameras, displays, recorders, and compression techniques became available, it would be nice if these improvements could be applied to the HDTV signal without having to replace the entire system. This is called "extensibility". The ability to extend the system into the future as technical advances occur.

Another desirable attributed of future HDTV systems would be an ability to provide higher resolution for motion picture film than for sports. The current HDTV system proposals before the FCC operate at a constant resolution at 59.94 images per second. These systems, although some of them improve their compression techniques for film, do not improve resolution for motion picture films. Motion picture films, which comprise 80% of prime time television shows, and nearly the entirety of many premium cable channels, operate at 24 frames per second. Any television system which operates only at 59.94 images per second, wastes 2.5 times the quality available for motion pictures. It would be desirable if HDTV systems could offer higher resolution for the best quality signal, when showing 24 frame per second motion picture film. Since the bulk of high resolution imagery in existence in the world is motion picture film, this should be an important consideration.

Further, the United States has a trade surplus in the motion picture industry, and it is therefore worthwhile to make any HDTV technology which is developed useful to the production of motion pictures. Unfortunately, 59.94 images per second systems are not very useful in the production of motion pictures at 24 frames per second. Those systems which propose interlaced HDTV, are even more difficult to apply to film production.

Interlacing is the technique of showing alternate scan lines during each 60th of a second "field". This technique is in use in the current television format of NTSC, which was conceived around 1940, and is being proposed by some for HDTV. However, the technique of interlace is incompatible with both film production as well as computer displays.

New "multi-media" computers are being introduced in 1991 by all major U.S. computer manufacturers. These computers can display video on the screen in addition to the present types of computer screens. None of these computers can make use of displays which use interlace. Thus, the NTSC television must be converted to non-interlaced format before being displayed on computer screens. HDTV proposals before the FCC which use interlace will similarly have to be converted in each multi-media computer which displays them. Further, this conversion impairs quality. Interlaced HDTV systems, therefore, add cost and reduce quality. Also, since digital HDTV systems are more similar to computers than to television receivers, interlace can be seen to have been more appropriate to non-digital (analog) HDTV systems.

Another issue involved in computer display compatibility is the need for computer screens to refresh at rates higher than 59.94 images per second. There is a general trend to refresh rates above 70 images per second. This higher refresh is needed when the HDTV images are viewed in a bright lighting environment where the eye is more sensitive to flicker. A typical office, factory, or library environment, where there are bright fluorescent lights, will need these higher rates. Also, the larger screen of HDTV, with its wider field of view, is more likely to stimulate the flicker perception of the eye from the sides of the screen. The "peripheral vision" of the eye, to the sides of where a person in looking, is much more sensitive to flicker than the center of vision. Thus, larger screens need higher refresh rates in order to appear flicker-free. Even in the home environment, high definition displays might be bright enough to view in the daytime with the curtains open, as are many recent large screen television sets. Flicker becomes more important in these high-light-level environments. This becomes especially significant when considering spending many hours in front of a large screen display. Screen flicker from a large screen over a long period of time can result in Nausea.

Alternative Channel Sizes

The FCC HDTV examination process is focusing exclusively on a 6MHz terrestrial channel with its attendant noise and ghost (multipath) problems. Alternate channel sizes, both larger and smaller, with differing degrees of noise immunity, might also be useful for one or more HDTV formats. Satellite and cable systems can potentially use wider channels. Numerous narrow channels are potentially available as well, although the HDTV quality of a lower level of resolution or a lower frame rate will probably be more appropriate for channels narrower than 6 MHz. The ability to provide the best quality of picture signal for a variety of digital channel bandwidths is a desirable feature of an HDTV architecture.

Also, it would be useful to have the ability for a given HDTV signal to be able to interact with varying channel loads when sharing a channel with other HDTV signals. This is sometimes called "graceful degradation". Digital HDTV designs are naturally somewhat "elastic". The HDTV proposals before the FCC do not exploit this elasticity, with the exception of one proposal which was developed to be compatible with ISDN, the telephone digital signal standard. When a channel is heavily loaded with many simultaneous picture streams, it would be useful if each picture stream were still the best that it could be within its reduced allocation of data bandwidth. When the channel is lightly loaded, it would further be useful if the high definition images using the channel could expand to provide maximum quality during the light load conditions.

Such considerations optimize the use of communications channels. The HDTV digital signal structure must accommodate such techniques, however, and this has not been the case with most of the current proposals.

International HDTV Standardization

Another valuable potential attribute of HDTV system parameters would be an ability to easily exchange images internationally. The current proposals before the FCC are designed with a relationship to NTSC, the current television standard, but do not have an easy conversion relationship to PAL and SECAM, the standards of Europe and Asia. In Europe, the resolution 2048 x 1152 is being considered, since 1152 is twice the number of scanning lines of PAL and SECAM. The proposals of 1035, 960, and 720 active lines which are before the FCC inhibit convenient international program exchange.

Also, the numbers 2048 and 1024 for the horizontal picture resolution are seen by many as a natural values for compatibility with computers, whereas 1920, 1440, 1408, and 1280, which are the numbers before the FCC for terrestrial broadcast, are all less than ideal in digital systems, although 1280 is the best of these numbers.

Enhanced Definition Television

The enhanced definition television proposals, based on enhanced wide-screen NTSC, are analog transmission techniques which involve some amount of complex processing. These systems also are less than ideal for international program exchange, as well as being basically incompatible with potential digital uses of HDTV. The pursuit and adoption of these enhanced definition television proposals, one of which is now before the FCC, would not benefit any of the issues being discussed. Enhanced definition television is a technological dead-end. It would be better to stay focused on the HDTV standard design for the United States, and attempt to improve the current designs to allow these important uses other than just broadcast.

The FCC HDTV Review Process

Digital technology is advancing very rapidly, and is now crossing the threshold of capabilities for processing high resolution moving images. These technology changes require that technical development and testing be continually updated to reflect the current state of technology.

The technical testing process which is underway at the FCC was developed long before the four domestic proposals switched to digital technology. The testing process, therefore, was not conceived with the potentials for digital technology in mind. This one issue alone recommends a review of the testing process. Further, the testing process treats the HDTV processing equipment as "one unit". This precludes the examination of the various portions of the technology within the HDTV processing systems, which should be tested individually for quality, flexibility, and capability. The process of evaluating each portion of the system for its merits is much more likely to yield results where portions of a system are found to be applicable to all uses, and can therefore be accepted. This would also allow other portions of the HDTV systems, which may be too inflexible, or which may not produce optimal quality, to be adjusted in isolation, without having to re-test the entire systems.

The FCC process is reviewing five HDTV proposals for terrestrial broadcast. However, there is little or no consideration of other delivery or use of HDTV other than terrestrial broadcast using a standard (6 MHz) television channel. It seems evident that the large number of higher quality channels available via cable and direct satellite reception may be better ways to deliver high resolution imagery than is the terrestrial broadcast antenna. It is my opinion, although it has yet to be demonstrated, that digital terrestrial broadcast will be made to work well. However, the problems of area broadcast coverage from centrally located antennas, with attendant ghosts (multipath), atmospheric disturbance and noise, airplane flutter, car ignition noise, etc, result in the most severe test for delivery of HDTV. The wider, cleaner, and fairly plentiful channels available through cable television delivery, and direct broadcast satellite reception in rural areas, makes a much easier environment for the delivery of HDTV. Fortunately, the current digital HDTV proposals are all very suitable for both cable and satellite distribution at 6 MHz, the same channel size as current television. However, adjustments should probably be made to these systems to make use of channels of other sizes, which are available both from satellite and cable.

There is also no consideration in this HDTV testing process for efficient use of HDTV digital signals when sharing a long-haul fiber or microwave channel, as are commonly used in telephone distribution. Such fiber and microwave channels have very large capacities for carrying signals, which far exceed the capacities of current television channels at 6 MHz. Digital fiber optics, in particular, can be economically routed to every home and business, to provide individual two-way and teleconference access to high resolution moving imagery signals. The FCC process is not weighing the effects of the digital HDTV system designs when they are used on fiber optic connections.

In ten or twenty years, when the HDTV system is fully deployed, and is a part of everyone's everyday life, it is likely that fiber optics will be the primary way in which HDTV signals are sent and received. Cable, satellite, and video-tape may be used more to exchange HDTV pictures than terrestrial broadcast reception from an antenna. If terrestrial broadcast has the substantial possibility to become the least favored mode of reception, why should it be the focus of our technical evaluations?

It is possible that the majority of use of the high resolution display would involve work, education, interaction with colleagues and friends, and exploring new issues and ideas. If such becomes the case, then the exclusive focus of the HDTV system testing on terrestrial broadcast usage for news and entertainment, would also be quite inappropriate.

There has been no provision in the testing process for rating the ability to exchange the HDTV formats internationally. This is evident because all five systems are not very compatible with distribution in Europe. The four digital systems are very closely tied to current NTSC television, which is similarly incompatible with Europe.

The FCC testing process is not considering the usefulness of the HDTV standards under consideration for the production of motion picture film. Certainly if these HDTV formats are not useful to the motion picture production community, they will find little use other than sports coverage. Film would continue to dominate production for motion pictures and television, which is fine, but it provides no advances for the industry in the United States. It is also questionable the extent to which these HDTV proposals to the FCC are being examined with respect to suitability for high definition video production.

The FCC testing process has no provision for measuring whether the HDTV systems are scalable, extensible, or compatible with the broader range of uses being discussed. The testing has focused on the single broadcast use, with no interaction and a single resolution and scanning rate. The testing process is also not planning sufficiently broad testing of the proposals, because tests can be easily devised which will rule out the three interlaced proposals, leaving the two progressively scanned (non-interlaced) system proposals remaining. Further, since no system is taking advantage of higher resolution for the 24 frame per second film rate over the 59.94 frame per second rate of sports, no system is going to be able to demonstrate any advantage for film. The fact that this is not being tested is indicative of the very heavy broadcaster bias of the proposals which are currently before the FCC.

Since no proposals offer any picture scanning rates other than the 59.94 images per second favored by broadcasters, all other needs for alternative image rates are being ignored. Since 24 frame per second film is important, this should be at least one of the rates in a family of rates which are needed. Because of the requirement for computer displays to have rates higher than 70 images per second in order to avoid flicker, 72 displays per second may be a good choice, since it bears a natural relationship to 24 frame per second film, being exactly three times. Use of the rates of 24 and 72 images per second, along with 59.94, which is very near 60 frames per second, would make a much more useful HDTV set of image display rate formats.

The Need for HDTV to Serve Many Uses

The ability of an HDTV signal to operate with medical imagery, educational material, pages of text from a library, legal documents, computer images, fax pages, color photographs, scientific and engineering drawings, etc., would be clearly beneficial to the United States economy. Current HDTV proposals before the FCC do not provide for these capabilities, and even prevent them to varying degrees. However, these proposals could be modified somewhat in order to allow these capabilities. HDTV, has the potential to have sufficiently high resolution imaging capabilities to allow access to photographs, drawings, and pages of text. Current television cannot show a readable page of a magazine, but high definition television imaging can make such a page readable. It would be unfortunate if such a capability were ignored.

The ability to work collaboratively with colleagues in meetings via teleconferencing would clearly be beneficial. Such conferencing would be even more useful if could operate internationally. This capability also has not been provided by the current proposals before the FCC, although they contain many of the ingredients necessary to allow such conferencing and person-to-person meetings at a distance.

There is a potential for enormous usefulness for HDTV for the production and optimal presentation of motion pictures. However, none of the current proposals before the FCC are useful for motion picture production, and they are also less than optimal for the presentation of our large national library of high quality motion pictures. Adjustments to the HDTV system designs could allow them to be useful, however. Since the motion picture industry provides a trade surplus, and is still mostly owned within the United States, it would be in our best interests to adjust the design of HDTV to allow it to be useful to this important industry. It is also in the public interest to provide the best possible presentation of motion pictures, which have inherently high resolution.

The current HDTV proposals before the FCC have been optimized for the needs of the broadcasters. Although the broadcasters are a very important group, their needs should be met in addition to serving the public interest, rather than to the exclusion. Broadcasters needs can be met within an HDTV design which also meets all of the other needs and uses discussed here. It would benefit us all if the broadest spectrum of citizens were to be served, with benefit to their education, health, and workplace. HDTV must not be viewed as only an entertainment and broadcast news medium. It is a potential vehicle by which the United States can greatly improve the quality of life and economic stature of our citizens within a very short period of years.

biographical sketch

Gary Demos

Gary Demos is President and CEO of DemoGraFX, a small United States business, based in Santa Monica, California. Among DemoGraFX activities is the development of a high performance tape system, suitable for storing both supercomputer data and HDTV. The development of this tape system is being sponsored under a NASA Ames Research Center Small Business Innovation Research contract for installation and testing at the Numerical Aeronautical Simulator, involving both the Cray 2 and Cray YMP supercomputers. DemoGraFX also provides technical and strategic consulting services to computer companies such as Digital Equipment Corporation and NCR (just acquired by AT&T). DemoGraFX technical development specializes in computer graphics, high resolution imaging, and computer multimedia. Gary Demos has also been actively involved in investigating HDTV technology issues. Gary Demos is on the Advisory Board of MasPar computer corporation, a maker of massively parallel affordable supercomputers.

Prior to founding DemoGraFX in 1988, Gary Demos was co-founder and chief technical officer for Digital Productions in 1981, using a Cray XMP supercomputer, and Whitney/Demos Productions in 1986, using a Thinking Machine's "connection machine" supercomputer. During the late 1970's and for most of the 1980's, Gary was involved in the development of technology to make very high resolution computer generated images using supercomputers. Gary received the Academy of Motion Picture Arts and Sciences Engineering and Scientific Achievement Award in 1985 for "The simulation of motion picture photography by means of computer generated images". Gary has been involved in computing images with more than two thousand scanlines since 1975. Such images have been used in many motion pictures including "Futureworld", "Tron", "Meteor", "Looker", "The Last StarFighter", "2010", and "Labyrinth". Gary attended the California Institute of Technology, Engineering and Applied Science, 1971.

FCC STANDARDS SELECTION PROCESS FOR HDTV
-- SOME RECENT THOUGHTS --

D.H. Staelin - 5/16/91B

A ADVANTAGES OF UNBUNDLING THE FCC STANDARDS SELECTION PROCESS FOR HDTV

When the FCC selected NTSC and its predecessor, and when it contemplated selection of a new HDTV standard, it thought in terms of an analog system where the luminance, chrominance, and audio had to be carefully combined at the transmitter and distinguished at the receiver, with careful attention paid to frequency stability, cross-modulation, synchronization, and related issues. Only by thoroughly testing the integrated system could valid comparisons be made among the various competitors.

It is now clear that competition between various digital proposals could be conducted quite differently. In particular, the way in which the digital message is coded and the way the resulting bit stream is transmitted over the air (i.e. the choice of a modulation and demodulation scheme) can be chosen nearly independently. Even for advanced systems where the modulation scheme transmits some of the bits with greater protection than the others, most good digital coding schemes would benefit. Although different modulation schemes may send at different data rates, most contemporary digital video coding schemes accommodate this easily, operating over a range of rates with the highest rates yielding the sharpest images. Most competitive pure digital systems will employ similar data rates, given our HDTV objective and present transmission channel constraints, and the relative bit rates allocated for video versus audio should not vary too markedly. These similarities facilitate interchangeability of the audio and video coding parts.

Furthermore, the way in which the video data are coded can be handled independently of the way the audio data are coded. This is particularly so because the bandwidth to be allocated to audio almost certainly will be sufficiently small relative to the bit rate used for video coding (perhaps five percent) that even factor-of-two differences between the audio compression systems employed by various competitors should not impact video quality perceptibly.

Finally, it is very important for any standard that is truly interoperable and extensible to incorporate a concise, flexible, and extensible header. This too could be chosen separately, because the associated data rate should be small even in comparison to that of the audio channel, let alone the total signal.

Based on this assessment, it seems not only possible, but highly desirable, for the FCC to consider selecting from the competing systems those sub-elements which perform best in each of these four categories separately. These four categories are: 1) transmission modulation scheme, 2) digital audio coding method, 3) digital video coding method, and an 4) extensible and interoperable header. Thus the selected audio and video standards might belong to different competitors, and the modulation scheme to a third. There appears to be at this time no compelling reason why such an unbundling of the competition could not be quite successful.

Furthermore, if the competitive process is divided into two phases, a laboratory phase and an over-the-air phase, it seems likely that the separate winning approaches in the audio and video areas could be combined when the modulation schemes are ultimately tested in a more realistic transmission environment.

Further, this unbundling would also enable the FCC to delay approv any of the four elements of the standard if no acceptable method had yet been demonstrated. Selection of that portion of the standard might be delayed, permitting an additional round of testing. Examples of potential reasons the FCC might choose to delay some element of the standard include the possibility that the transmission technique yields excessive adjacent-channel interference, or that the testing procedures developed were felt to be inadequate to distinguish contestants differing in terms of their use of interlace or other techniques.

B. "ALLOCATABLE GROWTH", AN APPROACH TO INTEROPERABILITY AND EXTENSIBILITY

Once an FCC standard is selected, manufacturers will wish to begin developing HDTV receivers for sale to consumers. These early sets will probably incorporate limited flexibility. The grave danger here is that this flexibility will be so limited that in future years the header providing for flexibility may be misinterpreted by these old sets such that any tiny improvement may scramble the entire message received by these early receivers.

A simple remedy, at essentially zero cost to the manufacturer, can be incorporated, however. This is likely to happen only if both the FCC and the various competitors recognize its simplicity and potential to boost future performance as improved technology comes along. The main thing the set manufacturers would have to do is to employ circuitry which examines headers associated with video data packets so that headers unknown to it cause the set to ignore the associated data packet. In addition, either the number of packets per frame, or their length, should be variable so that there is room to add new ones unreadable to the receiver without confusing it. In this way, individual broadcasters can choose to augment the signal as they wish in the future with side channel data, knowing that the older sets will continue to operate.

Most digital coding schemes, such as adaptive sub-band coding, involve a series of messages during each frame that sequentially improve the quality of the picture. If this series of messages is truncated, the picture has the acceptability achieved to that point, which could be quite good provided the truncation process was not too severe. Thus, in principle, two data streams can be combined in each broadcasting station's signal at the election of that broadcaster.

Normally the second signal would enhance the first, for example permitting still higher resolution images, or side-channel data, to be transmitted using protocols not yet devised at the time the original standard was selected. Such enhancements might als. include, for example, additional audio information, information that would permit alternative frame rates (e.g. 24-fps film) or formats to be displayed more accurately than for the unaugmented channel alone, or extra resolution could simply be added in certain portions of the image. Other possibilities exist too.

One option does not exist, however. In particular, any superior method for coding motion estimation information could not be employed in the future because the bulk of the video data must depend on it, and must therefore correspond to the initially employed protocol. This suggests that the method initially chosen for conveying motion compensation information (and any built-in flexibility in that method) is extremely important. For example, in sub-band coding schemes the principal area for future improvement will be in strategies for choosing the sub-bands, for choosing the bit-allocations, and for conveying additional information such as the image prefilters which were used, special chrominance corrections, etc.

Two areas where future improvement can be expected are in the skill with which the transmitter and coder estimates motion, and in the skill with which sub-band coding (for example) is performed at the transmitter. The choice of vectors for vector-quantization schemes might also be made adaptive, and thus performance might improve in this case too.

Although one could pass these improvements exclusively to the owners of the initial class of receivers, it is also possible to allocate these improvements in quality to purchasers of more capable and progressively more modern and powerful receivers through use of the growth capacity provided by new headers The owners of the initial receivers in this case would observe no degradation, but also little improvement, the headroom opened by technical progress principally going toward enhanced services requiring improved sets. As the potential quality of transmission increases, the FCC could, for example, mandate that for the first three years 100 percent of the coding capacity be allocated to the initial class of receivers , and then as system performance continues to improve, the FCC could choose to slowly reduce this minimum allowed percentage so as to release the balance to the discretion of the broadcaster. The election of how much data would be coded in the initial way, and how much would be coded in new ways (such as being dedicated to new audio channels) could be made at the sole election of the broadcaster on a frame-to-frame basis, if desired, and certainly on longer time scales.

Additional audio channels, added at the individual broadcaster's election, might make programs multilingual, or they might add for the hearing impaired a signing panel tucked in one corner of the image, which could be displayed or enlarged at the option of future viewers. A more exotic example of such side-channel information could be text overlaid on a video program suggesting where various items of furniture or clothing displayed could be purchased.

One of the additional benefits of this approach, besides permitting gradual improvement of the FCC standard and the range of broadcaster-provided services, would be that there could be reduced pressure for abrupt obsolescence of older signal protocols (and the associated equipment), and a firm foundation would be established for interoperability between broadcast video and other video applications developed as technology advances.

COHRS Technical Nomograph 90/10

Questions and Information for Harmonization of HDTV/HRS Across Industries

FROM: Architecture Working Group (Chair: Gary Demos)
Committee On Open High Resolution Systems

As an informal group of professionals working in the computer, broadcasting, imaging and entertainment industries, we are highly supportive of recent CCIR initiatives to harmonize technical standards for high resolution/high definition television systems across industries. Concurrent with these CCIR developments, we too have been studying the technical questions that would facilitate the growth of cross-industry HRS/HDTV. Out of that experience, we offer the attached submission as an appropriate set of issues for IWP 11/9 to consider. The list is by no means complete and likely will need refinement in light of future consideration.

Considerations for Cross Industry Harmonization of HDTV/HRS

I. Scalable High Resolution Systems Issues

A. List of industries which could benefit from compatible HDTV/HRS system architectures.

B. List of current and possible future applications of HDTV/HRS across industries.

C. Design criteria, common parameters, and requirements in order for HDTV/HRS to operate across industries and applications.

Design criteria are not meant necessarily to be absolute constraints, but rather to offer a starting point for deliberations and a measure of the results of the deliberations. A list of criteria might include:

- application to film and video post production
- application to computer workstations and personal computers
- transmission/distribution through (and among) terrestrial broadcast (6 MHz), cable, satellite, fiber, computer networks, videotape, videodisk, theatrical release, etc.
- down conversion to NTSC, PAL, and SECAM
- high-quality flicker-free viewing in various environments (e.g., viewing distance, angle, lighting)
- handling of still frame images

The demands of different industries and applications vary. For example, some industries use imaging which is not spatially bandwidth limited, including computer displays containing text, windows, and graphics. Flicker rates higher than 70 Hz may be required for such imagery when displayed on CRT displays while active matrix flat panel displays may be flicker-free at much lower rates. It has also been found that interlace is not acceptable on CRT computer display screens. As another example, broadcast television motion update rates for sports and other coverage may have a minimal threshold which is possibly near 45-50 Hz.

D. Scalability in resolution, temporal rates, colorimetry, and intensity dynamic range, as a criteria for international standards for high resolution systems.

In an ideal world, one could scale from any resolution set (vertical, horizontal, temporal) to any other resolution set with no loss in image quality, and with minimal computational cost. Unfortunately, we do not live in an ideal world. Even if we could afford arbitrary complexity of filtering hardware to scale between any two resolutions, we still incur a certain amount of information loss during the resampling process among many transcoding sets. Indeed, it may turn out that only a small set of transcoding sets exist for which the transcoding cost and information loss is minimal. Nevertheless, different industries require imaging systems across a wide spectrum of resolutions and frame rates. It is desirable that such systems easily exchange data and program material between them. This feature of interope bility is critical and the confluence of computing, telecommunications, and entertainment demands a solution. What forms should the scalable video standard take? The issue is slightly more complex than for other standards, since it is intended to be very general, to cut across many industries, and to permit other imaging standards to be subsets of it.

E. Form of technical guidelines that would permit optimal scalability among members of a family of resolutions, temporal rates, colorimetry, and intensity dynamic ranges.

There are many interesting and important resolutions, temporal rates, colorimetry, and intensity dynamic ranges that will not be in a transcoding set which permits maximum signal preservation with minimal computation. For example, when using certain values as a base resolution for a transcoding set (and allowing factors of two or three for fractional or whole number scaling), neither NTSC, PAL or CCIR 601 fall into the set. Two options exist for such cases. Option 1 consists of acknowledging that such sets exist, but not recommending what to do about them. Option 2 consists of providing guidelines to be used when transcoding between these sets. Option 2 guidelines might include: (a) how to scale to resolutions not in the set (i.e., what are the appropriate filtering techniques at reasonable cost), (b) a rigorous quantification of the effective resolution loss for those transcoding sets/filters, and (c) alternatives for transcoding that could minimize information loss but which modify picture organization (such as the use of border areas or side cuts).

F. Planned extensibility of international standards and guidelines for these extensions for future improvements in resolutions, temporal rates, colorimetry, and intensity dynamic range.

To ensure a long-lived useful standard (or family of standards) in light of rapid technological advances, it seems desirable to accommodate future resolution increases -- thus, an extensible family of resolutions, temporal rates, colorimetry, and intensity dynamic range.

For example, when transcoding an image from sampling rate A to rate B, the higher the beat frequency from A to B, or the shorter the repeat distance of the cross sampling process, the simpler the required digital processor. Also, the shorter the repeat distance of the cross sampling process, the better the perceived quality of the resulting image, particularly for image features with high spatial frequencies approaching or above the Nyquist rate (e.g., alternate black and white pels).

A simple fraction rule characterizing the cross sampling ratio, such as:

$$a/b = 2^n * 3^m \quad \text{where } n=..,-1,0,1,.. \quad m=-1,0,1$$

yields filters which provide effective and convenient transcoding among signals. This produces ratios of the form of: 1/4, 1/3, 3/8, 1/2, 2/3, 3/4, 1, 4/3, 3/2, 2, etc. The ramifications of such a simple fraction rule are fundamental to digital signal processing (c.f., Nyquist, Shannon).

Qualitative considerations suggest that the penalty can be very large as one departs from a simple ratio of two small numbers. It is widely known that observers tend to judge images based on the quality of the worst (as opposed to the overall average) artifacts contained. Therefore, it is reasonable to focus on the highly aliased portions of resampled images, i.e., those portions where the ramifications of the simple fraction are most critical. The testing choices here are important to make quantitative measurements meaningful.

G. Qualitative and quantitative methods for choosing candidate base resolutions and temporal rates for an extensible standard.

The simple fraction rule suggests the selection of a basis value for resolution and temporal rate from which can be derived an extensible compatible family.

A list of criteria for selecting a basis might include: ease of constructing low cost frame buffer memories, ease of frame buffer memory addressing, ease of transcoding to international video or imaging standards, ease of converting from existing film/video libraries, ease of building cameras and production equipment, etc. Until such criteria are derived and priorities and ramifications are characterized across industries and applications, it is difficult to compare the merits of alternative basis proposals.

H. Use of linear, logarithmic, quasilog, and XA-11 transfer functions in the intensity representation used for digital pixel values across industries and applications.

I. Characterization of errors introduced in conversion between these different pixel representations, and guidelines for required number of bits allocated in each representation.

The digital representation of pixels using linear light (lux) can give excellent results for spatial filtering operations. However, a logarithmic representation seems more appropriate at times for storage in image memories and frame buffers. In graphics arts applications, a quasilog representation is common. Thus, it is important to try to characterize a representation that is amenable for use across industries and applications.

J. Merits of regional sync among multiple sources to minimize buffering and latency when accepting simultaneous signals from multiple sources.

Local transmission buffering to allow vertical retrace synchronization to the nearest temporal basis rate sync time could be beneficial as a global assist for efficiency and economy. Transmission buffering at the regional repeaters for signals, such as terrestrial broadcast transmitters, cable head ends, computer interactive video sources, and network nodes, would be beneficial. It would minimize buffering at every display, and would potentially minimize latency during channel or signal source switching. Also, it would enable multiple channels to be displayed simultaneously on a single screen without full frame buffering for each channel.

Certain signal sources, such as direct broadcast satellite, may not be able to synchronize regionally due to large coverage areas and inherently large propagation delays in the signal transit from satellite to receiver dish.

For those sources where local interlocked sync is possible, benefits to the capability and economy of the high resolution receiving system will accrue.

II. Signal, Compression, and Transcoding Issues

A. Relationships between various compression techniques and potentially different requirements across industries and applications.

Compression is expected to be an important part of high resolution system architectures in order to conserve storage, memory, and transmission bandwidth. Compression algorithms with a minimum of loss exist with broad applicability. High quality compression algorithms are showing continuous improvements and significant performance.

Since images may be compressed and decompressed at a number of digital processing steps, compression algorithms which do not significantly degrade the image after the first compression will be useful in applications where an image must be reconstructed close to the original such as in certain post-production activities, scientific imaging, etc.

B. Optimal transcoding between different compression algorithms for digital video data.

The maintenance of maximum signal when a compressed digital video sequence is converted from one compression format to another needs to be considered. Since compression will be a critical component of any digital video system and interoperable systems are desired, then how to transcode in the compression domain needs to be understood as well. Signal to noise ratio (SNR) degradation when performing compression transcoding operations might be a useful metric.

C. Definition of a quality space over which one can evaluate the merits of various transcoding schemes.

There are at least three metrics for evaluating the quality of compressed/transcoded imagery. These are: (1) linear information loss, such as signal-to-noise ratio (SNR) and peak signal-to-noise ratio, (2) structural information loss, such as degradation of edges or smooth surfaces, annoying quantization noise, etc., and (3) subjective and perceptual measurements. These metrics and others could form the basis for a test suite for different algorithmic approaches.

D. Scalable approaches in image transmission/storage systems based on block transform and/or sub-band decompositions.

High-frequency signal components can be used by receivers which have the necessary display resolution. Decoding of successively higher resolution imagery can be performed by receiver modules which increase in complexity and expense with signal bandwidth. A family of bandpass or lowpass signals transmitted by the source can greatly reduce the complexity of filters performing reconstruction in the receiver. For example, a full resolution signal can be accompanied, without compression, by a complete set of downsampled counterparts at powers of two ratios, at only a 1/3 increase in bandwidth. The question is, by what factor is it reasonable to increase tran ission bandwidth to minimize the cost of flexible reconstruction c a variety of different receivers? The answer greatly impacts the c estion of scalable resolution and the tactics for effecting it in the receiver.

E. Relative merits of using YUV encoding with unequal channel resolutions for data reduction (as compared to RGB with equal resolution) for different applications.

The eye's sensitivity to U and V resolution and brightness appears less than Y in many demonstrations. However, for the case of blond hair, flesh tones, gold lettering, or blue water, the reduced sharpness in V will often create a perceptible blur. That is, if a U or V channel is seen juxtaposed to a strong Y channel, its relative perceived information level will be higher. However, when the information is primarily contained in U or V, and these channels are isolated from changes in Y or each other, it has not yet been demonstrated that the degradation is acceptable. Also, the use of blue-screen composites or other special effects techniques may require U or V signal integrity beyond normal perceptual requirements. For these reasons further investigation of RGB formats, or other amounts of data reduction in the resolution of U and V, different from the usual 2:1 in U, and 2:1 or 4:1 in V, might be warranted.

Other color spaces are also commonly used such as Hue Saturation and Value (HSV), and Yellow, Cyan, Magenta, and Black (YCMK, used in printing). Investigation of the ramifications of conversions between different color spaces, in light of resolution differences in different color components, might be worthwhile.

F. Interlace and interoperability among systems and applications.

From a purely technical perspective, interlace may be viewed as a lossy form of image compression which is irreversible and prone to artifacts. Also, interlace may be less appropriate for certain applications, such as computer displays. An investigation of the difficulties which would come from an interlaced system in attempting to achieve interoperability across industries is warranted.

G. The role of frame buffers in system architectures, and their effect on decoupling transmission rate, display update/refresh rate, and capture rate.

Frame buffers are likely in many high resolution systems. These and other portions in the chain from image capture to image display need not necessarily operate identically, but rather may each be independently optimized. However, if links in the chain operate differently, it is potentially valuable to make each link be compatible through the chain as a family.

H. The role of pre- and post-filtering in the overall design of high resolution architectures.

High resolution images are typically sampled and then communicated or stored using a possibly noisy channel before being displayed. The resultant image quality can be substantially improved if the image is properly filtered prior to sampling (pre-filtered), and then properly filtered again prior to display (post-filtered). The nature of the filters giving optimum performance depend very much on the statistical character of the imagery, the nature of any channel (or other) noise, and the perceptual characteristics and preferences of the viewer. Since there is no single optimum pair of filters, certainly across multiple industries and applications, and since images may not be displayed until much later when displays and user preferences are different, it may be desirable to label high resolution data with the prefilter used to generate it and perhaps with the identity of the recommended postfilter. This information could be provided directly or indirectly via the universal descriptor discussed below.

I. Guidelines for image filtering in a scalable video system.

One possibility for how to offer guidelines for transcoding between different resolution sets (in and out of a family) is to provide a mechanism for a parameterized filter. The parameterized filter would take the desired source and target spatial resolutions for a transcoding operation and return the appropriate filter kernel and filter width. There could be two modes: transcoding with whole numbers and transcoding with fractional numbers.

J. Considerations with respect to the image-capture mechanism.

Transcoding from one video format to another generally involves filtering (interpolation) and resampling. In considering the entire process from the real-world original to the final real-world display, it is desirable to have precise knowledge of the complete processing chain. The focal plane image is often limited in quality due to quantum effects and/or optical deficiencies, either inherent or due to imperfections of components. It is also helptul to know the linear and/or nonlinear processing to which the optical image was subjected before the video signal was created. These effects depend, among other things, on the physics of the devices and the signal processing that was used. If presented with a video signal whose gestational characteristics are not well known, optimal transcoding may not be possible. To put it another way, there may well not be a single best way to transcode between two different formats if the video signals were derived in widely differing manners. Further study may produce recommendations for standard image-capture techniques to avoid these problems.

K. Relationships between flying spot analog systems and digital fixed pixel raster systems.

Flying spot digital systems do not have the same sharpness as fixed pixel raster systems. Flying spot analog systems may degrade upon being digitized, due to the spot motion and coverage being sampled on discrete pixels.

Examples of fixed pixel raster devices are CCD camera sensors and active matrix flat panel displays. Some CRT film scanning systems also use "point plot rasters" where the spot samples each pixel without motion. And in CRT computer displays, a flying spot CRT displays a frame-buffer digital image. All of these examples may produce complex relationships that need to be studied to determine optimum interoperability parameters.

L. Range of acceptable number of A/D and D/A transformations for various applications.

Each time an analog value is digitized, and each time a digital value is converted to analog, signal error is introduced. These errors are generally given the term "quantization error", but the nature of these errors can be very complex. In general, the error may be reduced when a greater number of bits are used for the digital representation, but issues such as logarithmic or linear representation, color, and other factors may be significant as well.

To minimize errors introduced at each analog to digital (A/D) and digital to analog (D/A) conversion, or for some specified level of signal preservation, recommendations may be required as to the number of conversions acceptable for different applications.

III. Universal Descriptor (Header and Subheader) Issues

A. The role of a universal descriptor (header/subheader).

Any standard properly serving multiple high resolution industries and applications over many decades must necessarily accommodate many variations in the nature of the image source, processing, and display. Therefore, any universal descriptor must support the conveyance of this information, even for situations unknown at the time the descriptor mechanism is established. As the world enters the digital era, consideration of these opportunities for interconnectivity and flexibility in high resolution equipment and data are not to be compromised.

In the context of the system's evolution over time, the header/subheader mechanism is the vehicle whereby extensibility is accorded to units in the field, to the extent that their architecture and implementation permit it.

The functions of the header and subheader should be explicitly organized orthogonally, meaning their functions are complementary in ways which maximize bandwidth utilization, efficiency, and functional flexibility. The functional goals of the header/subheader mechanism would establish the appropriate functional elements and their integrity.

The design of the header/subheader mechanism therefore implies two objectives:

- at every step, necessary and sufficient conditions for a prescribed level of operation and integrity of the target equipment must be fulfilled by the logic of the header/subheader mechanism; and

- the overhead of the header and subheader must be minimized consistent with achieving the necessary and sufficient conditions.

In essence, the design problem is a functional decomposition which assigns to the header the smallest set of data necessary to ensure the recovery with full integrity of the sufficient elements from the subheader and data packet.

B. Header structure to allow maximum utility and flexibility.

A list of header characteristics might include:

- it is the fundamental element establishing the integrity of the link
- it is invariably repeated at an appropriate interval
- it is "horizontal" with respect to the data stream (it cannot be interleaved or otherwise broken up)
- no substitution, indirection, or compression can be applied to it
- it therefore must be as small as possible
- if the header's integrity is established (or reestablished) the probability of establishing the integrity of the link is high
- it cannot limit arbitrarily the number of levels of indirection underlying it in the subheaders; the mechanism must be open-ended
- it must be machine independent

C. Subheader characteristics to allow flexible data specification.

The subheader's characteristics are complementary to those of the header, and might include:

- it is subject to multiple forms of implementation
- it may be compressed, omitted periodically, pointed to, or contain pointers
- its repetition rate and the mode of repetition may vary as a function of either the implementation or channel conditions or both
- it may be parsed or otherwise interpreted or expanded, in whole or in part
- it may contain different levels of coding and interpretive material
- its overt content may be machine dependent, machine independent, or a mixture
- it may be represented by a "ditto" token, in whole or in part, or it may optionally be repeated at a negotiated rate appropriate to the quality and integrity requirements
  - its aggregate size may be very large
  - it may be transmitted all at once, in segments, or continuously as a longitudinal adjunct of the header
  - it may embrace mechanisms like progressive error correction or decompression which map to extensible quality (in other words, it is a vehicle for implementing extensibility in the quality space)

D. Organization o .ieader and subheader information.

The specification of a standard for the header/subheader mechanism would specify:

- which elements are invariant with respect to form, together with the definition of their form and the range of their content (for example, header fields, error correction polynomials, alpha-numeric symbol sets, etc.)
- the nesting principles governing levels of indirection (furnishing invariably the necessary and sufficient conditions for correctly parsing indirect pointer structures no matter to how many levels they are allowed to extend)
- the modes of transmission of the subheader: unitary, segmented, longitudinal, etc.
- the parsing methods for unfolding large structures (complete standards, algorithm identifiers, machine specific code fragments, tables, error control lookup tables, functions, dereferencing methods, etc.)

Once the robustness of the design of the format is proved at this level, the admissible content at each subsequent level can be stipulated. The key design principle at this stage is cul de sac avoidance: no specification should be couched so as to preclude its later expansion, replacement, or extension.

E. Standards indentification in the header (and registration).

For example, it may be that a fixed-length 8-byte header could serve the purpose, where the first 4 bytes accommodate (uniquely identify) over 4 billion possible standards. The detailed descriptions of these standards could be indexed in a publicly available "global standards register". Nations and certain standards setting bodies could be authorized to assign standards numbers to petitioners, these numbers lying within preassigned ranges for each assigning entity.

F. Packet length indentification and error correction in the header.

For example, the other 4 bytes of an 8-byte header could provide 3-bit error correction for the header, and indicate the length of the packet described by the header, where this length could range from a few bytes of data, to many gigabytes, or more. Not all possible lengths need to be allowed; a specifiable lengths might differ by up to a few percent (e.g., a floating-point-like encoding).

G. Synchronization uses of a header.

The same header could also permit synchronization data streams in situations where the other levels in the protocol fail to do so; synchronization capabilities follow from proper interpretation of error correction bits, which make any such header an improbable word provided the signal is not too noisy.

H. Compression/decompression uses of a subheader.

I. Encryption and distribution protection uses of a subheader.

J. Unforeseen uses of a subheader.

If a standard requires more than the simple identification provided by the header alone, the standard can specify that additional information is included in a subheader. Such subheader information could include copyright information, distribution restrictions, auxiliary information concerning the primary high resolution data such as encoding format and compression parameters (which is useful because even billions of standards may not encompass all possibilities for certain types of information or coding), audio signals, and other data.

K. Error management techniques in the header to ensure data integrity.

L. Error control, management, and recovery mechanisms suitable for distinct data types, and for scaling quality as a function of target system implementation level.

One of the main divisions among the various video coding standards is the nature of the channel requirement. ATM, terrestrial broadcast, and satellite transmission channels are infected with various defects that the coding algorithm must overcome. For example, MPEG-I usually assumes that its channel is virtually error free. In general, to compensate for a distorted channel, the coding gain is decreased. MPEG-II is starting to consider making accommodation of a high error rate channel a requirement; that would be a first step toward harmonizing the main division between the standards.

IV. Communications Issues

A. Relationship of HRS/HDTV communications to OSI network protocols.

The OSI network model serves as the basis for communication architectures in many high resolution applications. The fundamental concept (and to a major extent much of the applicability, benefit, and flexibility) of OSI is embodied in the separation of functionality into independent layers. One benefit of the layering is the ability to operate a common higher-level protocol (i.e., session, presentation, and application layers) on any of a variety of lower-level protocols (i.e., physical, datalink, network, and transport layers) -- thereby, concerns are separated between the content of the communication (video, audio, text, etc.) and the method of communication (RF, cable, fiber, etc.). Since many industries depend on such a communication model, the mapping of HRS/HDTV communications to the OSI model bears extensive consideration.

B. Synchronous and asynchronous higher level protocols.

Often, content is transferred fully synchronous in realtime. Asynchronous transfer, though, broadens the range of applicability for many situations that are amenable and/or sensitive to price-performance tradeoffs. This raises questions of managing and negotiating transfer characteristics such as packet size, effective bandwidth, minimum service guarantees, explicit sequencing and timing, etc., and questions of negotiated graceful degradation of image quality, image resolution, update rate, etc.

C. Implications of connectionless and connection oriented protocols.

A connectionless protocol does not establish an explicit link between the sender and recipient; a connection protocol does. The breadth of applications (especially interactive multimedia) will require one or the other or a gradation between them (e.g., multicast). There are implications to managing both connectionless and connection oriented protocols with respect to how connection data is communicated and maintained (e.g., implicitly or explicitly).

D. Packet content elements and alternative organizations.

E. Inter-packet synchronization.

A logically single transmission can consist of multiple related data streams: some with continuous realtime content (e.g., multiple video and audio data streams, closed captioning, timecode), some with data attribute content (e.g., resolution, frame rate, colorimetry, compression parameters and algorithms), some with periodic content (e.g., program notes, cataloging information, copyright information), as well as some with connection management information. Related data streams could be organized as a single stream of large packets that implicitly binds the various streams, or they could be organized as several smaller packets that are bound explicitly. Various applications will require that alternatives in packet organizations be used.

F. Multiplexing audio and video data streams to enhance editability?

Editing digital video is very important. A mechanism is needed for interleaving of the audio/video streams that allows fast access to different parts of a video or audio sequence. Audio mixing and video compositing will form an important part of any entertainment/consumer /commercial system to b standardized.

G. Implications of a peer-to-peer client/server architecture.

A client/server architectural model (peer-to-peer as opposed to master/slave) has proven to be a successful and useful foundation in many application areas. Benefits to HDTV/HRS services (e.g., applicability, cost efficiency, performance efficiency) will result from consideration of client/server mechanisms (e.g., stateless or state oriented attributes and parameters of the data stream(s)) in the definition of HDTV/HRS communications.

Considerations for Cross Industry Harmonization of HDTV/HRS

V. Ergonomic Issues

A. Psychophysical criteria for artifacts created by transcoding images between various spatial, temporal, and compressed formats.

Because of the evolving proliferation of coding schemes, various filtering and processing techniques may have to be evaluated both independently and in various combinations across applications areas.

B. Perceptual delays allowed under various applications and imagery types for progressively decompressed or transcoded sequences.

Different applications may have different thresholds. Television viewers are accustomed to instantaneous access while changing channels, while computer system users are perhaps more tolerant of slower access.

C. Minimization of the perceptual impact of image and sequence construction delays through special image display techniques.

Extensibility and scalability may require a variety of progressive coding schemes. Among other groups, the MPEG-II committee (ISO/IEC JTC/SC2/WG8) is expected to evaluate various techniques for progressively decompressed image sequences. One approach may be for the most recent fully resolved key frame to be instantaneously available on a concurrent sidechannel.

VI. Standards Issues

A. Liaison mechanisms for harmonizing standards relating to high resolution imaging, video, and multimedia computing, telecommunications applications.

B. Integrated and/or factored standards.

A significant number of committees inside and outside the ITU are working variously together and autonomously on closely related issues regarding image, video, and multimedia computing and communications standards. Besides CCITT SGXV (transmission systems & equipment - audiovisual), SGXVIII (WP8 broadband ISDN), CCIR SG10 SG11 (broadcast sound and television, CMTT (joint CCIR/CCITT SG for network transmission of television and sound), ETSI NA3 NA5 (European network aspects for audiovisual and broadband), ECSA/T1S1.5(broadband ISDN) and T1Y1.1 (specialized video and audio services), there are other related committees in the FCC, ISO (ASN.1 for open systems interconnect descriptor protocols, JPEG, MPEG-I, -II, & -III, ISO 5/3-1984E for compressed still and motion picture images), SMPTE (a number of groups including sub group AHGDP 011 ad-hoc group on digital pictures, N.15.11 ad-hoc group on high quality digital image compression, and others), NCSA HDF (National Center for Supercomputer Applications -- hierarchical data formats for scientific and raster data sets), ANSI X3.542-D (for compound and multimedia computer documents), and many other formal and ad-hoc groups reviewing media, medical, graphic arts, defense, consumer electronics, computing, and other industry considerations.

Mr. VALENTINE. Thank you, Mr. Demos.

Mr. Deas.

Mr. DEAS. Thank you, Mr. Chairman, for this opportunity. I'm pleased to be here.

I have a statement that I would ask to have placed in the record and will then deliver a summary statement.

As stated in your request for comments, it is important that a new HDTV standard be forward-looking and take into account merging technologies. Southwestern Bell Corporation believes that HDTV should be compatible with digital and fiber optics technologies already deployed in the telecommunication network. We also believe it is essential for all potential competitors to be able to develop and deliver HDTV applications to consumers.

Digital technology is driving a convergence of technologies. Signals from telephones, televisions and computers can be translated into digital codes and transmitted through the airways or as beams of light over hair-thin glass fiber.

The emerging super highway for digital is fiber optics. A single glass fiber like this (indicating) can carry more than 35,000 simultaneous telephone calls, and it can replace 10 copper cables the size of this (indicating). Fiber optics is Southwestern Bell Telephone's technology of choice whenever it is cost competitive with copper systems. The company has installed more than 370,000 miles of fiber and invested more than $430 million in fiber optic systems.

To establish an HDTV standard that is not compatible with existing fiber systems and does not recognize fiber's potential would be a waste of a valuable national resource.

Southwestern Bell Telephone has introduced new services and conducted numerous trials demonstrating fiber's capabilities. In August of 1988, we arranged the first live HDTV broadcast of a sporting event. The HDTV transmission began at Busch Stadium during a St. Louis Cardinals baseball game. It traveled over fiber five miles to the Fox Theatre where 400 customers watched on a 28-foot screen.

In March of 1990, Texas Children's Hospital in Houston and Southwestern Bell began studying the use of HDTV in improving access to specialized medicine. The color fidelity and detailed picture capability of fiber optics connected to HDTV make it possible for specialists at Texas Children's to participate in the examination of patients in a remote location over two-way, closed-circuit television.

Southwestern Bell engineers worked daily with HDTV and fiber optic systems. It is our opinion that the FCC's HDTV standard should be digital and compatible with fiber technology. But under current Government regulations, it could take until the middle of the next century to deliver HDTV and fibers' other inherent benefits to virtually all consumers. In contrast, the Japanese say their national fiber optics network will reach every home and business by the year 2015, and they're hoping to move that date forward.

In a recent Harvard Business Review, George Gilder, a senior fellow of the Hudson Institute, identified three obstacles to fiber's rapid deployment. The first was information services, manufacturing and long distance restrictions on the Bell companies remaining from the AT&T breakup. The second major roadblock cited by Mr.

Gilder is regulation barring cross-ownership of cable television and telephone lines, and the third is the world's slowest depreciation rates required by regulatory commissions.

Removal of these obstacles will expedite the deployment of fiber optics. Delivery of HDTV and other video and information services is critical to fiber's growth. Business applications and home video offerings could pioneer a fiber-based information marketplace. Education, culture, medicine and research applications will become more widely available only after business and home video offerings light the path.

It is important that new services like HDTV be offered on as many media as possible to ensure a broad-based distribution and availability to consumers. This will narrow any possible gap between the information rich and the information poor of our country. A competitive HDTV offering provided over the public telecommunications network will bring additional benefits to American consumers regardless of whether they're in small rural communities or large metropolitan areas.

In conclusion, Mr. Chairman, Southwestern Bell Corporation agrees with your initial outline for these hearings. It truly is important that a new HDTV standard take into account numerous technologies. We hope that Congress, the courts and regulators also recognize the immense potential in the public network and allow Bell companies to more fully participate in the development and delivery of HDTV and other information-based products and services.

Thank you, Mr. Chairman, for the opportunity to testify today. I'll be happy to answer any questions that you might have.

[The prepared statement of David Deas follows:]

Statement of

David A. Deas

Director-Technology Planning

Southwestern Bell Technology Resources

Before the

Subcommittee on Technology

and Competitiveness

United States House of Representatives

on

High Definition Systems Implementation

Tuesday, May 21, 1991

Mr. Chairman and Members of the Subcommittee:

Introduction

I am pleased to have the opportunity to appear before the Subcommittee today to present Southwestern Bell Corporation's views on the implementation of High Definition Television (HDTV) systems.

As stated in your hearing charter, it is important that the new HDTV standards be forward-looking, taking into account merging television, telecommunications and computer technologies all producing and transmitting digitized information.

It is essential that these new standards be compatible with established digital and fiber optics technologies already deployed in the nation's information infrastructure. And it also is essential that all possible competitors be able to participate in developing and delivering HDTV applications to American consumers.

Emerging Telecommunications Infrastructure

Digital technology is the driving force behind the convergence of information-based industries. Signals from telephones, televisions and computers can be translated into digital form. Pictures, as well as voice and text, can be coded as bursts of zeros and ones transmitted through the airways and as beams of light over hair-thin glass fibers.

A compact disc, a call home on Mother's Day or a high definition movie can be translated into digital codes, sent across a digital telecommunications network and then regenerated as sounds, pictures, printed words or a combination of all three.

Currently voice communications dominates Southwestern Bell Telephone's local network in Arkansas, Kansas, Missouri, Oklahoma and Texas. But other forms of information traffic, such as data, images and video programming, are growing at a much faster rate than voice.

Respectively, voice, data and video currently make up 80 percent, 19 percent and one percent of the network's total traffic. Those percentages are expected to change to 45 percent (voice), 35 percent (data) and 25 percent (video) by the end of this decade. This will necessitate the incorporation of new technologies into the public network, primarily fiber optics.

The super highway for digital traffic is fiber optics. Tiny lasers flash digitized messages across glass fibers that resemble fishing line. A single fiber can carry more than 35,000 simultaneous telephone calls and can replace 10 copper cables four inches in diameter. Laboratory prototypes of future systems currently place more than 100,000 calls on a single fiber.

Fiber optics is becoming an increasingly integral part of Southwestern Bell Telephone's network. Fiber systems carry greater amounts of information, are less likely to be affected by adverse weather and provide a higher quality signal that can travel longer distances without regeneration.

For the past eight years, fiber optics has been Southwestern Bell Telephone's technology of choice whenever it is cost competitive with copper systems. Today it is used almost exclusively in replacement and expansion projects connecting central offices. Since 1986, fiber has proven to be the cost-effective technology in a majority of projects connecting central offices to residential neighborhoods and business districts.

Southwestern Bell economic studies indicate that by mid-1992 fiber systems will be the cost-effective choice in many projects covering the final mile to customers' homes and businesses. Once fiber extends from central offices to homes and businesses, its full benefits can begin to be realized by consumers.

Fiber Optics and HDTV Applications

As mentioned, Southwestern Bell Telephone's policy is to place fiber optics whenever it is the most cost-effective alternative. Engineers compare the initial capital investment of placing fiber versus the expense of placing copper. Cost studies do not include fiber's inherent ability to produce additional revenue through future telecommunications services.

For the past three years, Southwestern Bell Telephone has introduced services and conducted trials that demonstrate fiber's numerous applications and capabilities.

HDTV Broadcast (August, 1988)--The first live HDTV broadcast of a sporting event occurred August 4, 1988 in St. Louis. The HDTV transmission began at Busch Stadium during a St. Louis Cardinals-Philadelphia Phillies baseball game. It traveled over fiber optics five miles to the Fox Theatre where 400 customers watched on a 28-foot screen a demonstration of HDTV's capability in a closed-circuit environment.

Fiber-to-the-Home (October, 1988)--The first of 132 residence customers in the Hallbrook Farms subdivision in Leawood, Kansas began using fiber optic cable for voice transmission. Customers used standard telephone sets and customer premise wiring. Up to four separate telephone lines could be offered to each residence over a single fiber cable.

Video Classrooms (February, 1989)--A fiber optic transmission network linked St. Louis Community College's three campuses and headquarters complex, providing video, audio, voice and data transmission capabilities. The video portion of the system allowed the college to provide educational programs and training seminars where students or participants couldn't be physically located in the same place as the instructor.

Cable Television (March, 1989)--Southwestern Bell Telephone and a Dallas, Texas-based cable television company agreed to test the simultaneous transport of voice and cable television signals over fiber optic cable to the home. The year-long trial included all customers in the new Mira Vista subdivision of Ft. Worth, Texas.

HDTV Remote Medical Consultation (March, 1990)--Texas Children's Hospital in Houston and Southwestern Bell Telephone began studying the use of HDTV in improving access to specialized medicine for family and other primary care physicians and their patients outside major medical centers. The color fidelity and detailed picture capabilities of HDTV make it possible for specialists at Texas Children's to participate in the examination of a patient over two-way, closed-circuit television and provide medical consultation to the patient's physician.

Video School Network (March, 1990)--Fiber optic cable linked nine southwest Kansas school districts in the state's first interactive video school network. Southwestern Bell, in cooperation with United Telephone Association and The Haviland Telephone Company, made possible two-way, video instruction to students in the Ashland, Coldwater, Fowler, Greensburg, Haviland, Meade, Mullinville, Protection and Southwestern Heights school districts.

Fiber Ring (February, 1991)--An all-digital transport "ring" architecture was introduced in Houston to provide self-healing capabilities to Southwestern Bell Telephone's largest customers--long distance companies, large businesses and private-network providers. The fiber optic network provides continuous monitoring for service interruptions and automatically provides backup pathing when an interruption occurs.

Medical Imaging Network (April, 1991)--A full motion, interactive video and medical imaging network was demonstrated to 200 of the nation's foremost cardiovascular specialists attending the American Society for Cardiovascular Interventionists conference in Wichita, Kansas. Conferees watched on a high quality, large screen television as renowned authorities performed case demonstrations seven miles away in the Wichita Heart Center surgical suite. Physicians in Atlanta, Cleveland, Houston and Seattle joined the presentation via compressed video transmitted over a long distance company's network. Fiber optic systems in Southwestern Bell Telephone's local network provided the link between the hospital and conference site.

Fiber/HDTV Relationship

It took more than 25 years for monochrome television to be accepted, over 15 years for color television to become a widely accepted entertainment product and less than 10 years for the VCR to appear in more than 80 percent of American households. This decreasing acceptance interval of video technologies is a strong indicator of how short the time frame could be for fiber-transmitted video services such as HDTV, video-on-demand and video jukebox. If the public telecommunications network is allowed to serve as an Advanced Television (ATV) delivery system, it could accelerate the deployment of fiber to the home.

Bellcore, which provides research, engineering and other technical support to the Bell Holding Companies, is an active participant on the Federal Communications Commission's ATV committee establishing a U.S. standard for delivery of HDTV. Southwestern Bell Technology Resources managers in St. Louis continually monitor this committee's activities and progress.

New fiber optics systems will operate on a Synchronous Optic Network (SONET) standard. Managers at Southwestern Bell Technology Resources work daily with SONET and HDTV technology in a laboratory environment. It is our opinion that the FCC's HDTV standard should be digital. We also believe it can be efficiently integrated with current fiber and SONET technology.

Southwestern Bell Telephone has already invested more than $430 million in the deployment of fiber optic systems. To establish a U.S. HDTV standard that is not compatible with existing fiber systems or does not recognize fiber's potential would be a waste of a valuable national resource.

Fiber Optics Deployment

Due to the increased transmitting capacity of fiber optics, myriad services like those demonstrated, trialed and offered by Southwestern Bell Telephone are becoming available over the local telephone network. Once the telephone industry completes the full deployment of a modern, fiber-based network, consumers will be able to have control over what type of information services they receive and when they receive them.

With a push of a button, consumers will access movies, sports, videos, self-help and community programming and countless other offerings from numerous service suppliers. These services will do more than just entertain; they will teach, help people earn salaries, create new jobs, and stimulate social, cultural and economic development in both rural and urban communities.

How long will it take the U.S. telephone industry to complete the full deployment of fiber optics and deliver these consumer benefits? Under current regulatory procedures and using current fiber deployment guidelines, it could take until the middle of the next century to deliver fiber's benefits to virtually all customers. In contrast, the Japanese say their national fiber optic network will reach every home and business by the year 2015. And they're hoping to move that date forward.

George Gilder, a senior fellow of the Hudson Institute, discussed fiber deployment roadblocks in the March-April 1991 Harvard Business Review. Mr. Gilder points to the AT&T breakup and Modification of Final Judgement (MFJ) restrictions administered by U.S. District Court Judge Harold Greene in 1982. Mr. Gilder wrote:

"Rapid installation of fiber optics faces many government obstacles. . .Judge Greene has also prohibited the phone companies from entering information-based businesses, including transmission of TV programs. And a 1970 FCC ruling bars cross-ownership of cable and phone lines, preventing phone companies from transmitting video programs in their own regions.

Mr. Gilder goes on to say that the Bell companies "are compelled by state public utilities commissions (PUCs) to write off newly installed equipment at the world's slowest pace: for example, 27 years for fiber, compared with Japan's 10 years. They have no incentive to replace their current equipment. . .

"With notable exceptions, the 50 PUCs are devoted to preventing the Bells from 'gold plating the system.' The PUCs fear excessive investments in new technology will benefit rich computer users at the expense of high phone bills for the poor. With most Bell profits generated by business services, however, the chief threat of high phone rates comes from businesses bypassing the phone companies to reach fiber networks."

Fiber deployment to the home can be expedited by local telephone companies providing video programming and other information services. The only mature market for fiber's expanded capabilities in today's residential environment is entertainment video. Business applications and home video offerings will pioneer a fiber-based information marketplace. Education, culture, medicine and research applications will become more widely available only after business and home video offerings light the path.

Additional Fiber Benefits

In his Harvard Business Review article, Mr. Gilder estimates it is possible to install fiber to all U.S. homes and businesses for less than $200 billion. He says if maintenance costs are included, fiber is already as inexpensive as twisted-pair copper wires for providing plain old telephone service.

A recently quantified by-product of this $200 billion investment is reduced traffic congestion and harmful automobile emissions. An Arthur D. Little study, analyzing how investing in the U.S. telecommunications infrastructure could help solve some of the nation's major transportation problems, revealed that "telecommuting" (substituting telecommunications for transportation) could:

* Allow six million automobile commuters to work at home,
* Replace almost three billion shopping trips annually,
* And eliminate almost 13 million business trips annually.

Conservatively, these and other substitutions could provide $23 billion in annual benefits to the American public by:

* Eliminating 1.8 million tons of regulated pollutants produced by vehicles,
* Saving 3.5 billion gallons of gasoline,
* Freeing up 3.1 billion hours of personal time from reduced highway congestion, and elimination of commuting, shopping and business trips,

* And, reducing some half a billion dollars in maintenance costs for the existing transportation infrastructure.

As this February 1991 transportation study so vividly discerns, Americans can look increasingly to telecommunications for answers to social, economic and cultural concerns.

HDTV is a building block in the further development of the public network. It is important that new services like HDTV be offered on as many media as possible to assure broad-based distribution and availability to consumers. This will help to assure that the breach between the information rich and the information poor is as narrow as possible.

As discussed previously, a competitive HDTV offering provided over the public telecommunications network would bring additional benefits to American consumers, regardless of whether they're in small rural communities or large metropolitan areas.

Conclusion

In conclusion, Mr. Chairman, Southwestern Bell Corporation agrees with this hearing's charter. It truly is important that new HDTV standards be forward-looking and take into account the merging of numerous technologies. We hope that Congress, the FCC, the courts and state PUCs also recognize the immense potential in the public network and allow Bell companies to more fully participate in the development and delivery of HDTV and other information-based products and services.

Mr. VALENTINE. Thank you, sir. Thank you, Mr. Deas. We thank all of you.

Let me clarify something, Mr. Deas. Did I understand you to say that this is the old cable, this is the new fiber optic, and it would take how many of these to equal this?

Mr. DEAS. Actually, 60 of those cables would equal that one cable, one fiber cable. There are 12 fibers in that small fiber cable.

Mr. VALENTINE. This?

Mr. DEAS. That. And it takes two fibers to replace or to establish a two-way communication link. And each of those two fiber pairs, or six pairs, would—each pair would replace ten of those cables that you see before you, those copper cables. So, in essence, it would take 60 of those cables, and it could be replaced with the cable you have in your hand, 60.

Mr. VALENTINE. Now, this is a bundle of tiny copper cables?

Mr. DEAS. That's correct, 3,000 pair.

Mr. VALENTINE. And they are individually insulated?

Mr. DEAS. That is correct.

Mr. VALENTINE. Now, when we talk about the national network, the national network that has the capability of transmission of telephonic messages from city to city, are we talking about this kind of fiber optic cable laid along the interstate and other highway rights-of-ways in the country?

Mr. DEAS. Yes, we are.

Mr. VALENTINE. When we talk about connecting the Nation together, we are talking then about a completion of this task in the cities and towns of America, to each dwelling house and to each place of business, are we not?

Mr. DEAS. We are.

Mr. VALENTINE. Mr. Deas, was there a difference that was noted by the customers when fiber optics was installed in the residence?

Mr. DEAS. Yes, there was. The particular example that I'm familiar with in our rural areas, where we replaced long runs of thousands of feet of copper, many of the customers actually called in trouble reports because they didn't hear noise on their lines. As a result, it took a little bit of consumer awareness to realize that they were actually operating over fiber and that their telephone service actually improved as a result of it.

Mr. VALENTINE. Can what we know—can cable television service be transmitted on this cable?

Mr. DEAS. Yes, it can.

Mr. VALENTINE. And that might tend to eliminate the cable monopoly in some places?

Mr. DEAS. In some places, it could.

Mr. VALENTINE. In spades. Never mind.

Well, of course, when this capability is available in every household in the country, we will have laid a lot of cable, we will have done a lot of things, we will have spent a lot of money, the major use of which will be amusement, recreational, would it not?

Mr. DEAS. Not necessarily. In fact, the particular strategy of the telephone company, as with the decreasing cost of electronics and fiber, that it is rapidly approaching the same cost as that cable that you see before you. As a result, the cost to deploy just normal switch telephone service in the pursuance of the normal business will be the cost-effective thing to do in the context of fiber. And as a result of that infrastructure, the market will dictate what other services the consuming public might demand. But for all intents and purposes, the infrastructure would then begin to be put in place.

Mr. VALENTINE. Mr. Liebhold, in your opinion, who would generate the next standards for the total high definition systems, or who should?

Mr. LIEBHOLD. Well, that's an extremely complex problem. I'm sorry that I'm not able to make a forthright recommendation here. There does need to be some explicit mechanisms implemented, perhaps a steering committee or a high level task force, to look at the integration of broadcast electronics, computer imaging, telecommunications for fiber, as well as computer document architecture, the data standards.

So I would think that what has to happen is that each of the discrete bodies that are evaluating these incremental standards has to have some mechanisms for considering the work that's going on in parallel in other agencies.

Mr. VALENTINE. Is there anything that you would like to stress to the subcommittee that the Government should be doing that it's not doing to bring about the melding of computers, television and telephone?

Mr. LIEBHOLD. Well, one is to support the harmonization process. Another is, in fact, to accelerate the implementation of a fiber optic network, to allow a variety of multimedia communications, for medical applications, so that a television system could be used, for example, for a house call for an elderly person, or a disabled person or a school child who can't get into the clinic. Or the availability of multimedia library services, so that media-enriched instructional services can be distributed nationally to very remote and rural areas, to the inner cities, and to allow people to save transportation costs by engaging in multi-point video conference meetings from their homes and offices. These are all computing environments and video environments that I think will enable and increase American productivity.

So I think what Congress can do is at least establish a consensus that there is going to be a convergence between computing, telecommunications, consumer electronics, and then use that as a baseline for creation of new initiatives like the high-performance computing initiative, the national research and educational network.

Mr. VALENTINE. Mr. Demos, in your opinion, is there more active participation needed by the Government to identify the architecture for the high definition systems?

Mr. DEMOS. Yes. I think that one of the reasons that we're all here today is that there's a sense that the ongoing process is not necessarily leading in the broadest possible context, and I think the statement of what the hearing was looking into is evidence of this.

I think that a reorienting of the process rather than focusing on getting a specific implementation, as fine as that may be, to working in the context to allow some of the principles of harmonization with fiber, scalability, extensibility, are important, and in particular, we heard earlier this morning how when technology advances, you have to be able to adjust to this. That is the principle of extensibility. If the system is designed with an open ended ability to take into account technology advances as they develop, it has the chance to survive for some period of time. However, if it is closed or frozen as a particular implementation, it almost certainly will be obsoleted by technology in a very short period of time, making the whole effort perhaps a moot point. So I think that a refocus is required.

Mr. VALENTINE. Now the phone companies are not allowed to transmit television to homes. Do we need a common carrier, in your opinion, Mr. Deas, for high quality digital land line systems that carry all types of digital information from voice to data and television?

Mr. DEAS. I don't necessarily want to imply that a common carrier function in the same model or paradigm as we've looked at voice telecommunication. I think that what we would like to see is more freedoms in the opportunity to even consider as an opportunity high definition TV transport and switching for the various applications, be they education, be they medical, be they entertainment, and allow the marketplace to decide the acceptance of those and to ensure that we have a broad base of media, not just fiber but, of course, terrestrial and cable access to that medial also.

Mr. VALENTINE. Mr. Phillips, should the Government, NIST, be the facilitator to develop these standards that we are talking about, or should it be left to industry and private organizations?

Mr. PHILLIPS. I think that the Government need play a far greater role than it has in the past. As Mr. Liebhold alluded to, the nature of that role should be a coordinating one, so that the economic benefits do actually flow down to the end user.

One of the aspects that was neglected to call to your attention is that whereas, in the case of the thick cable in front of you, an individual dedicated pair of copper wires goes from every home all the way back to the telephone company's central office, aside from the economic benefits of fiber being able to carry perhaps the traffic of ten of those big cables, you need not, in actuality, bring a dedicated fiber from each home all the way back to the telephone company's central office. In fact, from an engineering standpoint, the optimal manner in which fibers are deployed is one in which there are remote nodes between the telephone company's central office and the subscribers. In those remote nodes, all sorts of services that I alluded to and have spoken to in more detail in the written testimony could be provided, from financial services, to digital libraries, to paperback movies, to alarm services and the like.

The notion is that, through the coordination of the standards, one could provide basic telephone service to the home for as little as three or five percent of the cost of that backbone facility and, in the process, telephone rates could drop precipitously.

To answer your question directly, a number of things have to happen. You alluded to one, which is the prohibition on the provisioning of entertainment by local exchange telephone companies. Indeed, we're going to need amendment to the Cable Act to allow that to happen. Cable, though, does have a future, and an important one, in the overall scenario. It is not, in most instances, one of providing interactive services because of the structure of most of the cable companies' networks in the United States.

Mr. VALENTINE. Mr. Demos, the television manufacturers tell us that open architecture would be expensive and would drive them out of business. What do you say to that?

Mr. DEMOS. I think there's a distinction between an open architecture in the standard, where the standard allows a variety of types of receiving devices and an open architecture in the receiver. If the standard is open, it would support both a closed box, like a specific packaged, single-function television unit, similar to the receivers we see today, as well as the more flexible box, but I think the bottom line is that the digital technology which is being pursued for HDTV is essentially computing hardware. This is integrated chips just like we're used to in computers.

The machine that receives the HDTV standards that we're looking at will be essentially a very high performance computer, much higher than we're typically used to for personal computers right now. This being the case, I think that there will be a significant number of people who wish to explore the other possibilities of that computer other than just receiving passive information from broadcasts.

Mr. VALENTINE. Mr. Phillips, is it necessary, or maybe I should say is it desirable, that all countries be on the same television standard? Would you favor incorporating foreign interests into U.S. standard deliberations?

Mr. PHILLIPS. Yes, clearly it's desirable. Whether or not it's a realistic objective that we can hope for remains to be seen. Clearly, there are millions of dollars being expended today simply converting entertainment back and forth between formats, but with the broadband and digital environment at hand, with ISDN being deployed internationally today through undersea fiber optic cables, the economic incentive to do this is increased manifold.

Mr. VALENTINE. All right. We thank you very much.

Mr. PHILLIPS. Thank you.

Mr. VALENTINE. The subcommittee stands adjourned.

[Whereupon, at 11:30 a.m., the subcommittee was adjourned.]

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