THE EVOLUTION OF TELEVISION TECHNOLOGY IN THAILAND

by

Ms. Napawan Jinsirivanich

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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Project Title	The Evolution of Television Technology in Thailand
Name	Ms. Napawan Jinsirivanich
Project Advisor	Dr. Chamnong Jungthirapanich
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

Approval Committee:

(Dr. Chamnon u[redacted]irapanich)
Dean and Advisor

(Prof Dr. Srisakdi Charmonman)
Chairman

(Asst.Prof Dr. Boonmark Sirinaovakul)
Member

(Assoc.Prof. Somchai Thayarnyong)
MUA Representative

April 2001

ABSTRACT

This research examines the evolution of television technology to observe the future trend of television broadcast technology in Thailand.

Internet is a powerful channel for reaching people worldwide, so it is one of many factors that force television to be evolved. People use television as a source of information and entertainment at home. The first practical television system was black-white system with 525 lines and later was changed into color system. Because of many weak points in transmission signal and the advancement of digital technology are all making analog television to the end. The arrival of digital terrestrial television broadcasting (DTTB) becomes the most significant development in television technology. It has the capability to provide clearer and sharper pictures as well as CD quality sound and it also allow television to enter to the Internet. There are three different standards in the world for DTTB as the ATSC system, DVB system, and the ISDB system. Television in Thailand also faces some problems in transmission signal as other countries. To overcome problems, the Mass Organization of Thailand (MCOT) has cooperated with the Public Relation Department (PRD), and private-run Independent Television (ITV) and United Broadcasting Corporation (UBC) in investigating Digital Video Broadcasting-Terrestrial (DVB-T), one subsystem of DVB standard, for trial basis. It is possible that Thailand will use this system as standard for digital television broadcasting in the future because it is fit to the geographical layout of Thailand, and its investment cost is lower than other systems.

To plan digital television broadcasting for Thailand in the future, the development should be started in Bangkok area first, then gradually expand system coverage nationwide. A set-top box, EDTV set, and HDTV set will be used for receiving digital channels. Thailand should commence digital television broadcasting in the year 2014.

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. INTRODUCTION

1.1 Origin of the Study

Our senses are assailed every day by the attraction of the visual message. Its all-pervasiveness and instantaneity are finely tuned to our way of thinking, whether we be hard-pressed or lazy. We expect from it effortless pleasure and hot news. A Chinese proverb tells us a picture is worth ten thousand words.

Television is the most widespread form of communication in the world. It has a variety of applications in society, business, and science. Though most people will never meet the leader of a country, travel to the moon, or participate in a war, they can observe these experiences through the images on their television. The most common use of television is as a source of information and entertainment for viewers in their homes. Security personnel also use televisions to monitor buildings, manufacturing plants, and numerous public facilities.

Public utility employees use television to monitor the condition of an underground sewer line, using a camera attached to a robot arm or remote-control vehicle. Doctors can probe the interior of a human body with a microscopic television camera without having to conduct major surgery on the patient. Educators use television to reach students throughout the world.

We can see that television has already modified our social behavior. It fosters, for example, our taste for thing visual the impact of the picture and its colors. It encourages in us a yearning for the big spectacle the razzmatazz and the forthright declaration. The effect can be seen in the way we react one to another and in the world of advertising.

Television is a powerful medium to influence our life and social behavior for many decades. However, in the fast moving world, people are aware with the digital technology in order to survive in the high competitive market. Because the computer is a significant technology and can be worked effectively, most people are changing the way they do the business into Internet platform.

Doing business or searching information through the Internet is opening up the new opportunity for business to increase their distribution channels as well as much more convenient.

After many decades of reinforcement, there are several factors that force analog television technology to be entirely renewed. As on-line computer systems become more popular, a means to integrate television and computers is being investigated.

In theory, this integration would combine the capabilities of personal computers, television, and telephones, and would greatly expand the services this equipment provides. Consumers may eventually need only one system, which they could use for entertainment, communication, shopping, and banking in the convenience of their home.

With the acceptance of digital television standards by the International Telecommunication Union (ITU) and supported by the industry, there are three competing standards in the world for digital terrestrial transmission. They are ATSC system, DVB system, and ISDB system. All of these systems will open the possibilities of more channels and better quality sound and picture to viewers.

DTV has the capability to provide clearer and sharper, cinema-like pictures as well as multi-channel, CD-quality sound. It can provide new uses such as multiple video programs or other services on a single television channel, including data services. The use of DTV technology will also allow television to enter the digital world of the personal computer and Internet.

For this project, I will emphasize on the brief history of television development and the basic knowledge of Internet. As the DTV technology is still new for us and it has not come yet into Thailand, it is needed also for forecasting.

1.2 Problem Statement

In order to successfully establish a new technology to television broadcast and make full use of this new technology, we need to develop a through understanding of this new technology: characteristics of television and broadcast technology, evolution of television and broadcast technology, and characteristics of digital television etc. This research study attempts to provide solution for all related problems. The topic is:

The Evolution of Television Technology in Thailand

In relation to this, we would like to examine the following questions:

(1) What are the problems related to television broadcast of present day in Thailand?

(2) Which system of DVB is suitable for Thailand?

(3) What are the advantages of DVB broadcasting?

1.3 Research Objectives

The objectives for this project can be stated as follows:

(1) To provide the brief history of television development and the Internet knowledge

(2) To provide reasons for changing today's TV system to Digital TV

(3) To forecast the feasibility of Digital Television Technology in Thailand

1.4 Scope

This research will focus on the development of television technology of Thailand in the digital era.

1.5 Limitations

Digital television technology is a new technology in Thailand and it is still in the process of trial basis. Therefore, there are some limitations as follows:

(1) Lack of information resources of Digital Broadcasting Technology in Thailand

(2) Obsolescence of television history in Thailand

II. LITERATURE REVIEW

2.1 Internet

2.1.1 Introduction

The Internet has revolutionized the computer and communications world like nothing before. The invention of the telegraph, telephone, radio, and computer set the stage for this unprecedented integration of capabilities. The Internet is at once a world-wide broadcasting capability, a mechanism for information dissemination, and a medium for collaboration and interaction between individuals and their computers without regard for geographic location.

The Internet today is a widespread information infrastructure, the initial prototype of what is often called the National (or Global or Galactic) Information Infrastructure. Its history is complex and involves many aspects - technological, organizational, and community. And its influence reaches not only to the technical fields of computer communications but throughout society as we move toward increasing use of online tools to accomplish electronic commerce, information acquisition, and community operations.

2.1.2 What Is the Internet? (Charmonman 1994)

The word 'internee is composed of the prefix 'inter-' which means 'between' or `among' and 'nee, an abbreviation for 'network'. It is an interconnected channel of communication. In more concrete terms, an Internet network comprises a group of computers connected together so that they can receive-and-transmit information from-and-to one another. The Internet, with a capital 'I', is a channel of communication zigzagging across the entire world. It is a collection of many individual university campuses, state, regional and national networks into one single network such that all of them can communicate with one another.

One way of looking at the Internet is to imagine yourself as a member of the world's largest library. Once you have obtained your membership card you are free to roam about in this library looking for specific information or just browsing. This library is open 24 hours a day, 365 days a year. In case you are lost, there are hundreds of librarians to assist you. In addition, the Internet makes it possible for you to post messages on scores of bulletin boards read by other Internet users from all over the world.

2.1.3 Origins of the Internet (Leiner 2000)

Some thirty years ago, the RAND Corporation, America's foremost Cold War think-tank, faced a strange strategic problem. How could the US authorities successfully communicate after a nuclear war?

Postnuclear America would need a command-and-control network, linked from city to city, state to state, base to base. But no matter how thoroughly that network was armored or protected, its switches and wiring would always be vulnerable to the impact of atomic bombs. A nuclear attack would reduce any conceivable network to tatters.

And how would the network itself be commanded and controlled? Any central authority, any network central citadel, would be an obvious and immediate target for an enemy missile. The center of the network would be the very first place to go. RAND mulled over this grim puzzle in deep military secrecy, and arrived at a daring solution.

The RAND proposal was made public in 1964. In the first place, the network would have no central authority. Furthermore, it would be designed from the beginning to operate while in tatters. The principles were simple.

The network itself would be assumed to be unreliable at all times. It would be designed from the get-go to transcend its own unreliability. All the nodes in the network would be equal in status to all other nodes, each node with its own authority to originate, pass, and receive messages. The messages themselves would be divided into packets, each packet separately addressed. Each packet would begin at some specified source node, and end at some other specified destination node. Each packet would wind its way through the network on an individual basis.

The particular route that the packet took would be unimportant. Only final results would count. Basically, the packet would be tossed like a hot potato from node to node, more or less in the direction of its destination, until it ended up in the proper place. If big pieces of the network had been blown away, that simply wouldn't matter; the packets would still stay airborne, lateralled wildly across the field by whatever nodes happened to survive. This rather haphazard delivery system might be "inefficient" in the usual sense (especially compared to, say, the telephone system) -- but it would be extremely rugged.

During the 60s, this intriguing concept of a decentralized, blastproof, packet-switching network was kicked around by RAND, MIT and UCLA. The National Physical Laboratory in Great Britain set up the first test network on these principles in 1968. Shortly afterward, the Pentagon's Advanced Research Projects Agency decided to fund a larger, more ambitious project in the USA.

The nodes of the network were to be high-speed supercomputers (or what passed for supercomputers at the time). These were rare and valuable machines which were in real need of good solid networking, for the sake of national research-and-development projects.

In fall 1969, the first such node was installed in UCLA. By December 1969, there were four nodes on the infant network, which was named ARPANET, after its Pentagon sponsor. The four computers could transfer data on dedicated high-speed transmission lines. They could even be programmed remotely from the other nodes. Thanks to

ARPANET, scientists and researchers could share one another's computer facilities by long-distance. This was a very handy service, for computer-time was precious in the early '70s. In 1971 there were fifteen nodes in ARPANET; by 1972, thirty-seven nodes. And it was good.

By the second year of operation, however, an odd fact became clear. ARPANET's users had warped the computer-sharing network into a dedicated, high-speed, federally subsidized electronic post- office. The main traffic on ARPANET was not long-distance computing. Instead, it was news and personal messages.

Researchers were using ARPANET to collaborate on projects, to trade notes on work, and eventually, to downright gossip and schmooze. People had their own personal user accounts on the ARPANET computers, and their own personal addresses for electronic mail. Not only were they using ARPANET for person-to-person communication, but they were very enthusiastic about this particular service -- far more enthusiastic than they were about long-distance computation.

It wasn't long before the invention of the mailing-list, an ARPANET broadcasting technique in which an identical message could be sent automatically to large numbers of network subscribers. Interestingly, one of the first really big mailing-lists was "SF-LOVERS," for science fiction fans. Discussing science fiction on the network was not work-related and was frowned upon by many ARPANET computer administrators, but this didn't stop it from happening.

Throughout the '70s, ARPA's network grew. Its decentralized structure made expansion easy. Unlike standard corporate computer networks, the ARPA network could accommodate many different kinds of machine. As long as individual machines could speak the packet-switching lingua franca of the new, anarchic network, their brand-names, and their content, and even their ownership, were irrelevant.

The ARPA's original standard for communication was known as NCP, "Network Control Protocol," but as time passed and the technique advanced, NCP was superceded by a higher-level, more sophisticated standard known as TCP/IP. TCP, or "Transmission Control Protocol," converts messages into streams of packets at the source, then reassembles them back into messages at the destination.

IP, or "Internet Protocol," handles the addressing, seeing to it that packets are routed across multiple nodes and even across multiple networks with multiple standards -- not only ARPA's pioneering NCP standard, but others like Ethernet, FDDI, and X.25.

As early as 1977, TCP/IP was being used by other networks to link to ARPANET. ARPANET itself remained fairly tightly controlled, at least until 1983, when its military segment broke off and became MILNET. But TCP/IP linked them all. And ARPANET itself, though it was growing, became a smaller and smaller neighborhood amid the vastly growing galaxy of other linked machines.

As the '70s and '80s advanced, many very different social groups found themselves in possession of powerful computers. It was fairly easy to link these computers to the growing network-of- networks. As the use of TCP/IP became more common, entire other networks fell into the digital embrace of the Internet, and messily adhered.

Since the software called TCP/IP was public-domain, and the basic technology was decentralized and rather anarchic by its very nature, it was difficult to stop people from barging in and linking up somewhere-or-other. In point of fact, nobody wanted to stop them from joining this branching complex of networks, which came to be known as the "Internet."

Connecting to the Internet cost the taxpayer little or nothing, since each node was independent, and had to handle its own financing and its own technical requirements.

The more, the merrier. Like the phone network, the computer network became steadily more valuable as it embraced larger and larger territories of people and resources.

A fax machine is only valuable if everybody else has a fax machine. Until they do, a fax machine is just a curiosity. ARPANET, too, was a curiosity for a while. Then computer-networking became an utter necessity.

In 1984 the National Science Foundation got into the act, through its Office of Advanced Scientific Computing. The new NSFNET set a blistering pace for technical advancement, linking newer, faster, shinier supercomputers, through thicker, faster links, upgraded and expanded, again and again, in 1986, 1988, 1990. And other government agencies leapt in: NASA, the National Institutes of Health, the Department of Energy, each of them maintaining a digital satrapy in the Internet confederation.

The nodes in this growing network-of-networks were divided up into basic varieties. Foreign computers, and a few American ones, chose to be denoted by their geographical locations. The others were grouped by the six basic Internet "domains": gov, mil, edu, com, org and net. (Graceless abbreviations such as this are a standard feature of the TCP/IP protocols.)

Gov, Mil, and Edu denoted governmental, military and educational institutions, which were, of course, the pioneers, since ARPANET had begun as a high-tech research exercise in national security. Com, however, stood for "commercial" institutions, which were soon bursting into the network like rodeo bulls, surrounded by a dust-cloud of eager nonprofit "orgs." (The "net" computers served as gateways between networks.)

ARPANET itself formally expired in 1989, a happy victim of its own overwhelming success. Its users scarcely noticed, for ARPANET's functions not only continued but steadily improved. The use of TCP/IP standards for computer networking is now global.

In 1971, a mere twenty-one years ago, there were only four nodes in the ARPANET network. Today there are tens of thousands of nodes in the Internet, scattered over forty-two countries, with more coming on-line every day. Three million, possibly four million people use this gigantic mother-of-all-computer-networks.

The Internet is especially popular among scientists, and is probably the most important scientific instrument of the late twentieth century. The powerful, sophisticated access that it provides to specialized data and personal communication has sped up the pace of scientific research enormously.

The Internet's pace of growth in the early 1990s is spectacular, almost ferocious. It is spreading faster than cellular phones, faster than fax machines. The Internet is moving out of its original base in military and research institutions, into elementary and high schools, as well as into public libraries and the commercial sector.

2.1.4 Internet Activities

You can use the internet to communicate with friends, family, colleagues, or participate in global discussions, play games, conduct scientific research, converse with doctors, get pictures from NASA spacecraft, read books, make copies of computer programs, search library catalogs around the world, find recipes, find out the latest in the world of sport, cinema, and music and do much more.

All this is possible because, through the Internet, one can connect to computers situated all over the world. These computers offer a multitude of databases, archives of information, discussion forums, and free software.

Generally speaking, the Internet activities can be divided into six types:

(1) You can exchange messages with other Internet users situated almost anywhere in the world using electronic mail or `e-mail' in a matter of seconds. No more reliance on the conventional mailing system. You can

also use e-mail to get information about almost all the subjects from experts on the particular subject, irrespective of where they reside.

(2) You can send-and-receive information to-and-from another computer situated at a remote site. This site could be another country or another continent. The 'File Transfer Protocol' or `FTP' provides access to millions of files resident in thousands of computers. You can copy these files to your own computer's disk storage and read them at leisure.

(3) You can access other computers on the Internet by a program known as `Telnef . Once connected to a remote computer through `Telnee, you can run programs on that computer or access databases, computerized library catalogs, weather reports, NASA reports, dictionaries, thesaurus and many other information services depending on the restrictions assigned on the particular computer by the systems administrators.

(4) You can search dozens of databases simultaneously through a program known as 'Wide-Area information Server' or 'WAIS'. Another program called 'Gopher' provides easy access to dozens of on-line databases and services by making a selection from a series of nested menus. Some newer application programs, like 'World-Wide Web' for instance, allow keyword searches of practically everything available! The next step will be asking a question in conversational English and getting an answer based on all that human beings know on the subject — yes, even that will soon be here.

(5) You can join one of many electronic global discussion groups if you so desire. If any existing group is not discussing the subject you are interested in, you can start a new group.

(6) Bored of sitting around doing nothing, join an on-going electronic party with 'guests' from all over the world, or conduct a 'live' conversation (or more appropriately a 'key-in-session') with friends or strangers anywhere. Besides, there are hosts of on-line games that let you match your skills against other players; there are recipes, humor and of course shopping!

(7) At university campuses, the Internet is widely used to serve the following functions:

(a) The Internet facilitates exchanges between faculty and students. E-mail is used to leave messages and seek clarification.

(b) Homework could be both assigned and submitted using the Internet. Examination grades could be accessed on-line using a PC from home.

(c) Users could post "Social Messages" on their network.

(d) The campus network is used to notify students about changes in classes schedules, examination dates, and other significant administrative matters.

(e) Registration formalities could be completed on-line from a remote PC situated off-campus.

(f) The university catalog, journals, and research papers could be made available on-line.

(g) Most university libraries cold be on-line so as to facilitate retrieval of books by students and faculty. On-line library catalogs permit users to check if a given book is available and make reservations.

2.1.5 Client-Server Model

All Internet activities can be done through the resources and services available on the Internet. You, as a user, can access these facilities with the help of various tools such as Telnet, Gopher, FTP, WAIS, World-Wide Web, Archie, etc. All these tools were developed for some specific purpose and most operate on a client-server model.

The 'Client-server' software model is an important concept in information retrieval from the Internet. A client-server model is one in which the client makes a request and the sever responds to the request. Both 'client' and 'server' refer to computer software programs. All client-server programs allow an interactive interface. They allow a particular database to reside in a particular host computer (server) and many other host computers (clients) to access this database. This way, the database is centralized and updating of the information on the database is done only on the server computer.

The client-server software programs could either be resident in the same computer or more commonly the client software is resident in one computer and the server software in another computer. The purpose of installing two versions (client and server) of the software indifferent computers is to facilitate communication which is achieved through a standardized procedure called a protocol.

For the user, it is not important to know whether it is the client or the server program that is currently running. The actual information is what the user is interested in and not the programs that retrieve it. The importance of the client-server model will become clearer when you begin to use the various tools on the Internet.

2.1.6 Internet in Thailand (Palasri and Huter 1999)

The Internet first appeared in Thailand in 1987. Thais studying in the US had the first contact with the Internet. In 1987 the country's first electronic mail (e-mail) system was set up by the Asian Institute of Technology (AIT, vvwvv.ait.ac.th), with assistance from Melbourne University in Australia (www.melbourne.edu). Chulalongkorn University (CU,www.chula.ac.th) set up its own system in 1991, making this the first official Internet gateway in Thailand. In February 1991 Thailand's first network system, ThaiSarn, began operating with two external telephone lines linked on a 24-hour basis using a Unix system.

In the same year Assumption University (AU,www.au.ac.th) set up a network system to connect with Cu' s network. Later serveral universities around Thailand joined this network. This was followed in 1992 by the establishment of the National Electronics and Computer Technology Center (NECTEC, www.nectec.or.th) which has as its main goal the development of Internet and e-mail systems.

2.1.7 University Opened Thailand's First Privately-Owned Internet Gateway

The next big step in the development of Thailand's Internet capability came in January 1995 when Assumption University started its own international Internet gateway(Mokaranuraksa 2000). This gave Thailand its first privately owned international gateway, a move that stimulated Internet usage throughout the country, especially at the university level.

AU was also the first university to offer Internet usage to its students. Not long after all AU students were required to set up an Internet account and pay a fixed Internet usage fee each semester. Many other universities followed suit and now most tertiary students have their own e-mail address and Internet account.

2.1.8 An Estimated One Million Internet Users in 1999 (Mokaranuraksa 2000)

No official organization records the number of Internet users in Thailand, but based on various estimates from different organizations, it is thought there were around 1m users by the end of 1999. But this figure is probably overstated, as it includes all the university students that are required to have an Internet account and anecdotal evidence suggests that less than 50% of students actually use their Internet account. We also believe that more than 50% of the existing Internet users are students. Therefore the total number of Internet users (e.g. those registered with ISPs and other user categories) who use Internet regularly is probably closer to 500,000 at present.

2.2 Television

2.2.1 Introduction

Television, system of sending and receiving pictures and sound by means of electronic signals transmitted through wires and optical fibers or by electromagnetic radiation. These signals are usually broadcast from a central source, a television station, to reception devices such as television sets in homes or relay stations such as those used by cable television service providers.

Television is the most widespread form of communication in the world. Though most people will never meet the leader of a country, travel to the moon, or participate in a war, they can observe these experiences through the images on their television.

Television has a variety of applications in society, business, and science. The most common use of television is as a source of information and entertainment for viewers in their homes. Security personnel also use televisions to monitor buildings, manufacturing plants, and numerous public facilities.

Public utility employees use television to monitor the condition of an underground sewer line, using a camera attached to a robot arm or remote-control vehicle. Doctors can probe the interior of a human body with a microscopic television camera without having to conduct major surgery on the patient. Educators use television to reach students throughout the world.

2.2.2 Process of Television

A television program is created by focusing a television camera on a scene. The camera changes light from the scene into an electric signal, called the video signal, which varies depending on the strength, or brightness, of light received from each part of the scene. In color television, the camera produces an electric signal that varies depending on the strength of each color of light.

Three or four cameras are typically used to produce a television program. The video signals from the cameras are processed in a control room, then combined with video signals from other cameras and sources, such as videotape recorders, to provide the variety of images and special effects seen during a television program.

2.2.3 Transmission of Television Signals

The audio and video signals of a television program are broadcast through the air by a transmitter. The transmitter superimposes the information in the camera's electronic signals onto carrier waves. The transmitter amplifies the carrier waves, making them much stronger, and sends them to a transmitting antenna. This transmitting antenna radiates the carrier waves in all directions, and the waves travel through the air to antennas connected to television sets or relay stations.

2.2.4 Television Standards (King 1995)

There are two Mains power frequencies widely used around the World, 50Hz and 60Hz. This immediately divided the worlds TV systems into two distinct camps, the 25 frames per second camp (50Hz) and the 30 frames per second camp (60Hz).

The majority of 60Hz based countries use a technique known as NTSC originally developed in the United States by a committee called the National Television Standards Committee. NTSC (often scurrilously referred to as Never Twice the Same Color) works perfectly in a video or closed circuit environment but can exhibit problems of varying hue when used in a broadcast environment.

This hue change problem is caused by shifts in the color sub-carrier phase of the signal. A modified version of NTSC soon appeared which differed mainly in that the sub-carrier phase was reversed on each second line; this is known as PAL, standing for

Phase Alternate Lines (it has a wide range of facetious acronyms including Pictures At Last, Pay for Added Luxury (re: cost of delay line), and People Are Lavendar). PAL has been adopted by a few 60Hz countries, most notably Brazil.

Amongst the countries based on 50Hz systems, PAL has been the most widely adopted. PAL is not the only color system in widespread use with 50Hz; the French designed a system of their own - primarily for political reasons to protect their domestic manufacturing companies - which is known as SECAM, standing for SEquential Cooler Avec Memoire. The most common facetious acronym is System Essentially Contrary to American Method, SECAM was widely adopted in Eastern Block countries to encourage incompatibility with Western transmissions - again a political motive.

Two basic standards have been adopted for the international exchanges of television programs are shown in Figure 2.1 and Table 2.1:

Figure 2.1. Picture of Television Standards (Comms Lab 1999).

Table 2.1. Table of Basic Television Standards (Whitaker 1999).

	FCC **Standard**	**CCIR Standard**
Lines/frame	525	625
Fields/s	60	50
Color System	NTSC	PAL/SECAM
Video Bandwidth	4.2 MHz	5/5.5/6 MHz
Color Subcarrier	3.58 MHz	4.43 MHz

2.2.5 Television's History (Peter 2000)

The scientific principles on which television is based were discovered in the course of basic research. Only much later were these concepts applied to television as it is known today. The first practical television system began operating in the 1940s. In 1873 the Scottish scientist James Clerk Maxwell predicted the existence of the electromagnetic waves that make it possible to transmit ordinary television broadcasts.

Also in 1873 the English scientist Willoughby Smith and his assistant Joseph May noticed that the electrical conductivity of the element selenium changes when light falls on it. This property, known as photoconductivity, is used in the vidicon television camera tube. In 1888 the German physicist Wilhelm Hallwachs noticed that certain substances emit electrons when exposed to light. This effect, called photoemission, was applied to the image-orthicon television camera tube.

Although several methods of changing light into electric current were discovered, it was some time before the methods were applied to the construction of a television system. The main problem was that the currents produced were weak and no effective method of amplifying them was known. Then, in 1906, the American engineer Lee De

Forest patented the triode vacuum tube. By 1920 the tube had been improved to the point where it could be used to amplify electric currents for television.

Nipkow Disk

Some of the earliest work on television began in 1884, when the German engineer Paul Nipkow designed the first true television mechanism. In front of a brightly lit picture, he placed a scanning disk (called a Nipkow disk) with a spiral pattern of holes punched in it. As the disk revolved, the first hole would cross the picture at the top. The second hole passed across the picture a little lower down, the third hole lower still, and so on. In effect, he designed a disk with its own form of scanning. With each complete revolution of the disk, all parts of the picture would be briefly exposed in turn. The disk revolved quickly, accomplishing the scanning within one-fifteenth of a second. Similar disks rotated in the camera and receiver. Light passing through these disks created crude television images.

Nipkow's mechanical scanner was used from 1923 to 1925 in experimental television systems developed in the United States by the inventor Charles F. Jenkins, and in England by the inventor John L. Baird. The pictures were crude but recognizable. The receiver also used a Nipkow disk placed in front of a lamp whose brightness was controlled by the signal from the light-sensitive tube behind the disk in the transmitter. In 1926 Baird demonstrated a system that used a 30-hole Nipkow disk.

Electronic Television

Simultaneous to the development of a mechanical scanning method, an electronic method of scanning was conceived in 1908 by the English inventor A. A. Campbell-Swinton. He proposed using a screen to collect a charge whose pattern would correspond to the scene, and an electron gun to neutralize this charge and create a varying electric current. This concept was used by the Russian-born American physicist

Vladimir Kosma Zworykin in his iconoscope camera tube of the 1920s. A similar arrangement was later used in the image-orthicon tube.

The American inventor and engineer Philo Taylor Farnsworth also devised an electronic television system in the 1920s. He called his television camera, which converted each element of an image into an electrical signal, an image dissector. Farnsworth continued to improve his system in the 1930s, but his project lost its financial backing at the beginning of World War II (1939-1945). Many aspects of Farnsworth's image dissector were also used in Zworykin's more successful iconoscope camera.

Cathode rays, or beams of electrons in evacuated glass tubes, were first noted by the British chemist and physicist Sir William Crookes in 1878.

By 1908 Campbell-Swinton and a Russian, Boris Rosing, had independently suggested that a cathode-ray tube (CRT) be used to reproduce the television picture on a phosphor-coated screen. The CRT was developed for use in television during the 1930s by the American electrical engineer Allen B. DuMont. DuMont's method of picture reproduction is essentially the same as the one used today.

The first home television receiver was demonstrated in Schenectady, New York, on January 13, 1928, by the American inventor Ernst F. W. Alexanderson. The images on the 76-mm (3-in) screen were poor and unsteady, but the set could be used in the home. A number of these receivers were built by the General Electric Company (GE) and distributed in Schenectady. On May 10, 1928, station WGY began regular broadcasting to this area.

Color Television

It was realized as early as 1904 that color television was possible using the three primary colors of light: red, green, and blue. In 1928 Baird demonstrated color television using a Nipkow disk in which three sets of openings scanned the scene. A fairly refined color television system was introduced in New York City in 1940 by the Hungarian-born American inventor Peter Goldmark.

In 1951 public broadcasting of color television was begun using Goldmark's system. However, the system was incompatible with monochrome television, and the experiment was dropped at the end of the year. Compatible color television was perfected in 1953, and public broadcasting in color was revived a year later.

Other developments that improved the quality of television were larger screens and better technology for broadcasting and transmitting television signals. Early television screens were either 18 or 25 cm (7 or 10 in) diagonally across. Television screens now come in a range of sizes, but many of them measure as large as 81 or 89 cm (32 or 35 in) diagonally. Projection televisions were introduced in the 1970s with screens as large as 2 m (7 ft) diagonally. Manufacturers have also developed very small, portable television sets with screens that are 7.6 cm (3 in) diagonally across.

Television in Space

Television evolved from an entertainment medium to a scientific medium during the exploration of outer space. Knowing that broadcast signals could be sent from transmitters in space, the National Aeronautics and Space Administration (NASA) began developing satellites with television cameras. Unmanned spacecraft of the Ranger and Surveyor series relayed thousands of close-up pictures of the moon's surface back to earth for scientific analysis and preparation for lunar landings.

The successful U.S. manned landing on the moon in July 1969 was documented with live broadcasts made from the surface of the moon. NASA's use of television helped in the development of photosensitive camera lenses and more-sophisticated transmitters that could send images from a quarter-million miles away.

Since 1960 television cameras have also been used extensively on orbiting weather satellites. Video cameras trained on the earth record pictures of cloud cover and weather patterns during the day, and infrared cameras (cameras that record waves radiated by warm objects instead of light waves) detect nighttime temperatures. The ten Television Infrared Observation Satellites (TIROS) launched by NASA paved the way for the operational satellites of the Environmental Science Services Administration (ESSA), which in 1970 became a part of the National Oceanic and Atmospheric Administration (NOAA). The pictures returned from these satellites aid not only weather prediction but also understanding of global weather systems. High-resolution cameras mounted in Landsat satellites have been successfully used to provide surveys of crop, mineral, and marine resources. See Table 2.2.

2.2.6 The First Public Broadcasting (Whitaker 2000)

In the early 1930s in Britain, the work of Zworykin and his collaborators was extended at EMI's laboratories in Hayes, near London, in a transatlantic partnership with RCA. Separate research also made progress in Germany and the Netherlands, and the resolution of images (indicated by the number of scanned lines on the screen) improved rapidly. The world's first high-definition, regular TV service was begun by the BBC from London in 1936, using both the EMI electronic system, of 405 lines, and the mechanical system Baird had developed, which by this point was of 240 lines.

In 1937 a British government committee rejected Baird's design for the electronic system, which was good enough to last until the introduction of a 625-line system, phased in from the late 1950s onward. Meanwhile, in the United States, after protracted battles between the RCA-owned National Broadcasting Company (NBC) and rival developers of TV systems, the US government's Federal Communications Commission (FCC) accepted NBC's 525-line, 30 pictures per second standard in 1941. This standard is to be known as NTSC standard. This technology is still the basis of the US system today, having been modified to include a compatible color system in 1954. See Table 2.3.

Table 2.2. Television Timeline (Microsoft Encarta Online 2000).

Year	Situation
1873	Two English telegraph engineers, May and Smith, experiment with selenium and light, giving inventors a way of transforming images into electrical signals.
1878	The British chemist and physicist Sir William Crookers, first noted cathode rays, or beams of electrons in evacuated glass tubes.
1884	Scanning disc for mechanical television invented by Paul Nipkow.
1888	The German physicist Wilhelm Hallwachs noticed that certain substances emit electrons when exposed to light. This effect, called photoemission, was applied to the image-orthicon television camera tube.
1897	First cathode ray tube scanning device constructed by German scientist, Karl Ferdinand Braun.
1904	Color television was possible using the three primary colors of light: red, green, and blue. Fleming developed Vacuum tube diode.
1905	Nipkow disc and Cathode-ray picture tube(CRT) demonstrated.
1906	The American engineer Lee De Forest patented the triode vacuum tube. Boris Rosing of Russia develops a system combining cathode ray with Nipkow disc, creating the world's first working television system.

Table 2.2. Television Timeline. (Continued)

Year	Situation
1908	The English inventor A.A. Campbell Swinton conceived an electronic method of scanning.
1923	Vladimir Zworykin patents the "Iconoscope", an electronic camera tube. By the end of 1923 he has also produced a picture display tube, the "Kinescope".
1925	John Logie Baird obtains the first actusl television picture.
1927	The American inventor and engineer Philo Taylor Fransworth transmits first electronic television picture; applies for patent in electronic television.
1928	The American inventor ERNST F.W. Alexanderson demonstrated the first home television receiver in Schenectady, New York, on January 13. John Logie Baird demonstrated color television using a Nipkow disk in which three sets of openings scanned the scene.
1938	DuMont company begins producing television sets for consumers. DuMont's method of picture reproduction is essentially the same as the one used today. First television set offered for sale.
1953	Compatible color television was perfected.
1956	Black-and-white portable television era begins.
1960	First rectangular screen television introduced.
1973	Giant-screen projection color TVs marketed.
1984	First color TVs with all-digital signal circuitry marketed.
1990	Production of giant-screen (over 27-inch) color television picture tubes starts.

Table 2.3. Broadcasting Timeline (Whitaker 2000).

Year	Situation
1930	The BBC begins regular television transmission.
1933	First TV broadcast from an educational institution(W9XK, State University of Iowa)
1934	Mutual Broadcasting System founded.
1935	First TV broadcasts in German and England. France begins broadcasting its first regular transmissions from the top of the Eiffel Tower.
1936	The BBC starts the world's first public high-definition electronic television service in London.
1937	A British government committee rejected the electronic system.
1941	The US government's Federal Communications Commission (FCC) accepted NTSC 525-lines, 30 pictures per second standard.
1953	Color-compatible system developed by NTSC.
1954	Color television broadcasting begins.
1959	PAL /SECAM standards announced.
1964	First television program automatic system installed.
1971	NHK (Japan) begins experiments with high line number television systems, and discusses the feasibility of an 1125-line system.
1974	First microprocessor used in broadcast equipment.
1976	World's first digital PAL television transmission via satellite.
1995	First television program delivered via internet.

Table 2.4. Television Broadcasting Standards (King 1995).

Standard Number of lines Field frequency	FCC 525 60 Hz	CCIR 625 50 Hz	British 625 50 Hz	OIRT 625 50 H
Standard code	M	BIG	I	D/K
Channel width	6 MHz	7/8 MHz	8 MHz	8 MHz
Vision/sound carrier spacing	4.5 MHz	5.5 MHz 5.74 MHz	6 MHz	6.5 MHz
Vestigial sideband	0.75 MHz	0.75 MHz	1.25 MHz	0.75 MHz (1.25MHz)
Vision IF	45.75 MHz	38.9 MHz	39.5 MHz	38.9 MHz (38 MHz)
Vision/Sound ratio	5:1	10:1, 20:1, 20:1:0.2	5:1	10:1

2.2.7 Recent Developments

Digital television receivers, which convert the analog, or continuous, electronic television signals received by an antenna into a electronic digital code (a series of ones and zeros), are currently available.

The analog signal is first sampled and stored as a digital code, then processed, and finally retrieved. This method provides a cleaner signal that is less vulnerable to distortion. The difference in quality between digital television and regular television is similar to the difference between a compact disc recording (using digital technology) and an audiotape or long-playing record.

A fully digital system was demonstrated in the United States in the 1990s. A common world standard for digital television, the MPEG-2, was agreed on in April 1993 at a meeting of engineers representing manufacturers and broadcasters from 18 countries. Engineers are also working on making digital television compatible with computers and telecommunications equipment so that digital television technology may be applied to other systems besides home television, such as medical devices, security systems, and computer-aided manufacturing (CAM).

As on-line computer systems become more popular, a means to integrate television and computers is being investigated. In theory, this integration would combine the capabilities of personal computers, television, and telephones, and would greatly expand the services these equipment provide. Consumers may eventually need only one system, which they could use for entertainment, communication, shopping, and banking in the convenience of their home. See Figure 2.2.

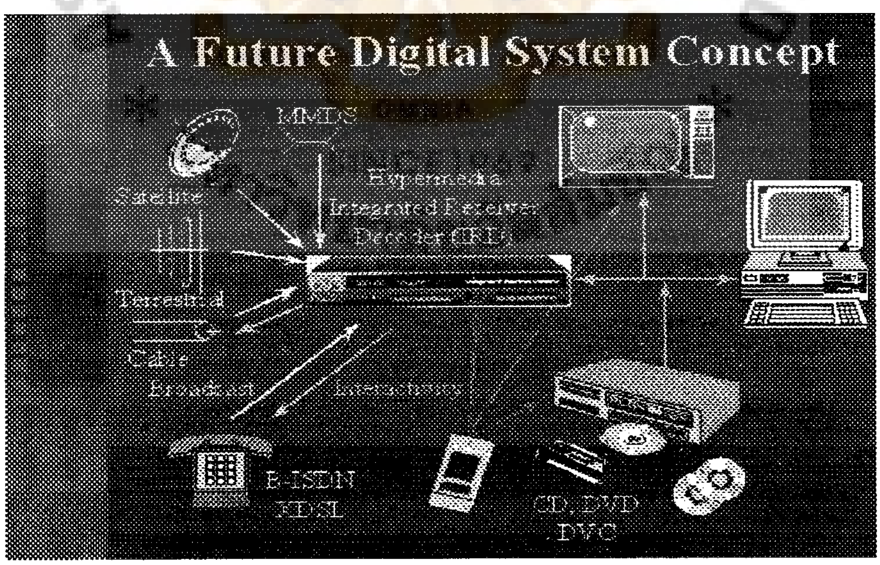


Figure 2.2. A Future Digital System Concept (Comms Lab 1999).

2.2.8 Television in Thailand (Scandlen 1973 and MCOT 2000)

Development of the Central Television System

In 1952 The Thai Television Company Limited, operating both radio and television, was established by legislation. Nine government agencies were shareholders, The Public Relations Department being the principal shareholder with 55%. The remaining were divided among The Army, The Air Force, The Navy, The Police Department, The Thailand Tobacco Monopoly, The Thai Sugar Organization, The Liquor Factory, and The State Lottery Bureau.

One year later, Thai Television Company Limited purchased the first transmitter and its equipments from Radio Corporation of America (R.C.A.), and installed them at the first Thai Television Station Channel 4, which its code was HST-TV. Channel 4 started broadcasting on June 24, 1955. At that time, it was the first modern television station in Asia. It used the NTSC standard 525 lines 60 fields black and white system. This NTSC standard was American standard. The transmitter had 10 Kilowatt of power in transmission. This system was compatible with Thailand 's electricity 110V 60 Cycles using at that time.

In January of 1958 the Army Television Station Channel 7 (black and white channel), using a 525 lines 60 fields black and white system, was established. With the 5-Kilowatt transmission power, the radius of coverage was very much less than that of the Channel 4.

Later Thailand changed the electricity system to use 220V 50 Cycles, this affected television system of Thailand to change its standard. In transmission the signal, there were problems with transmitters and receivers in coverting the electricity from 60 Hertz to 50 Hertz. The International Telecommunication Union or ITU recommended that Thailand's region used electric current 50 Hertz (or Cycle), so it was appropriated to use European CCIR standard with 50 fields rather than NTSC. standard of America. Thai government did according to the ITU's recommendation by gradually changing the television system from NTSC 525 lines standard to use CCIR 625 lines standard.

In 1967 bids were accepted for a color transmitter. The first color television was established by The Army Thai Television by using Channel 7 (color channel). Channel 7 was the first color television station using CCIR 625 lines 50 fields system. Within a month the equipments had been air mailed to Thailand and the system was operating so as to record the crowning of Miss Thailand.

One year later, the Thai Television Company provided the concession to the Bangkok Entertainment Company Limited to establish color television station Channel 3, using CCIR 625 lines 50 fields system. And the company, itself also set up its color television station with a 20-Kilowatt power using Channel 9. Later, The Army Television Station set up another color television station Channel 5.

Color Television Era

Thailand began to simulcast color channel with tradition black and white channel. Until in 1976, the black and white system was ceased. All television stations stopped their black and white channels and used only color channels up to present day. In 1977, the Thai Television Company changed its name to The Mass Communication Organization of Thailand or MCOT.

Development of Television Network in Up-Country Provinces (Thaiyadham 1971)

Main Stations: In 1962, the first main station for an up-country province was established at Khon Kaen, using Channel 5 with 6 kilowatt of transmitting power. This station was projected as a main station for the northeast region. In this same year the Lampang station was also set up, becoming the central main station in the North. This station with a 2 kilowatt power uses Channel 8 to broadcast television signals. Three other main stations were set up in the South, the TV-10 at Hat Yai in 1967, the TV-9 at Phuket in 1968, and the TV-7 at Surat-Thani in 1976.

Translator Stations: Translator stations perform the function of picking up the TV signal from one of the broadcasting stations and re-broadcasting for better local reception.

There are many factors in addition to distance that limit-telecasting radius:

(1) The height of the station antenna.

(2) Channels of lower bands higher frequency, being transmitted farther than channels of higher bands, lower frequency.

(3) The rate of power increase at the station antenna.

(4) Geographical areas. The mountain areas become an obstacle against the coverage of transmission radius.

(5) The height of the receiver antenna.

At that time, the Cabinet approved the change of the Thai television system from a 525-line system to a 625-line system and also planned to link up a number of microwave systems set up in strategic points in the kingdom. This project would provide for three sets of microwave radio channels, which could be used to transmit television signals without any loss in quality of transmission.

By the advancement of technology, the satellites played the important role in increasing the effectiveness and efficiency of transmission signal from station to cover all regions of Thailand. The color television stations Channel 3 and Channel 9 using international satellite named Intelsat and the Army Television Station Channel 5 and 7 used Indonesia's satellite named PALAPA.

In 1985, the government allowed the Public Relation Department or PRD to establish non-profit television station in Bangkok for education using Channel 11. In order to provide more alternative channel for Thai people to get information from television, in 1995 the government provided the concession to the Siam TV Group to establish the Independent Television station (ITV) broadcasting in UHF bandwidth.

In addition to the said 6 station channels, in 1998 the International Broadcasting Corporation merged with the Universal Cable TV Network Company Limited to form the UBC (United Broadcasting Corporation), operating cable television station or Pay TV. Thailand uses medium wave AM and VHF FM transmissions with channel width 7 MHz for its domestic broadcasting service. Television Broadcasting in Thailand nowadays can be divided into 2 types. (Public Relations Department 2000)

Free TV

For this type, the viewers do not need to pay any additional fees for viewing program. There are totally 14 stations in Thailand that serve as Free TV. In Bangkok, they are Channel 3, Channel 5, Channel 7, Channel 9, Channel 11 and ITV. For region, there are 8 stations.

Pay TV

For this type, Broadcast Company charges the viewers additional fees for viewing program. In Thailand, the United Broadcasting Corporation (UBC) is only one station that broadcasts variety programs to its customers.

2.3 Digital Television

2.3.1 Overview

Television has stimulated the development of an international consumer electronics industry that has not only made television receivers inexpensive enough for them to be universal in industrialized countries, but has also brought high-density magnetic recording, high-resolution displays and low-cost imaging technologies from the laboratory into the living room. A vast array of related production and processing technologies make high-quality programming an everyday reality, real time on-site video news the norm rather than the exception, and video the historical medium of record throughout the world. However, after 50 years of refinement, there are several functions that force the analog or conventional television technology to be entirely renewed. These forcing functions include: (Netravali 1995)

(1) Direct consumer access for content providers

(2) Convergence with other information sources such as print

(3) The emergence of a consumer market for personal computing that is growing faster than business markets

(4) The extension of the Internet and other networks in the commercial domain.

The arrival of digital television is one of the most significant developments in television technology since the advent of color television in the 1950s. DTV has the capability to provide clearer and sharper, cinema-like pictures as well as multi-channel, CD-quality sound. It can provide new uses such as multiple video programs or other services on a single television channel, including data services. The use of DTV technology will also allow television to enter the digital world of the personal computer and the Internet.

2.3.2 Digital Television Function

A digital broadcast signal is simply a different way of encoding information to be broadcast. The signal is converted into a binary code, that is, a code as a series of 2 states, 1 and 0, or On or Off. This type of signal allows a more effective form of compression so that the new digital broadcast signal will have the capacity to transmit a greater amount and rage of media content to the consumer. The additional content that is not actually traditional TV broadcast content is collectively referred to as datacasting. (Whitbourn2000)

To receive the full extent of the datacasting content, a High Definition Television set (HDTV) is required. Aside from the reception of datacasting services, the main feature of the technology is the vast improvements to the quality of the televisual signal; a screen resolution of 1000, a wider picture ratio of 16:9, and the signal will come encoded with Dolby Digital or MPEGII Standard audio.

For an initial period during the transition to the digital signal, set-top-boxes will be made available that allow a standard TV to receive the digital signal, however not having the capacity to realize the full extent of the televisual improvements.

2.3.3 Types of Digital Television

High Definition Television (HDTV) (Commonwealth of Australia 2000)

The high definition television (HDTV) system was developed in 1981 when the Japanese company, NHK demonstrated a video system composed of 1125 interlaced lines in a 16: 9 wide-screen up the picture-existing conventional television pictures use a 4:3 aspect ratio and 625-lines.

Since HDTV offers approximately twice the vertical and horizontal of a PAL signal, it provides a cinema quality images and a sound quality approaching that of a compact disc. Therefore, HDTV provides a significantly clearer picture than traditional 525-lines and 625-lines television screens.

Enhanced Definition Television (EDTV) (Pickford 1999)

(a) Intermediate step to HDTV.

(b) Doubled scan rate, so it reduces flicker.

(c) Double line on picture

(d) Image processing to prevent ghost

(e) Wider aspect ratio (16:9)

(f) Multi-channel sound

Standard Definition Television (SDTV) (Pickford 1999)

SDTV is also a digital television system in which the picture quality is approximately equivalent to the current PAL television system. It has the same format and definition as the current PAL analog system (e.g. 576 active lines vertically, 720 pixels per line, 25 frames per second using interlace scanning). Although the same resolution as analog television, SDTV pictures are free from ghosting and snow common on analog broadcasts. See Table 2.5.

Table 2.5. Types and Characteristics of Digital Television (Pickford 1999).

Standard Definition Television (SDTV)	**High Definition Television (HDTV)**
(1) The current television display system. (2) 4:3 aspect ration picture, interlace scan. Australia / Europe (a) 625 lines - 720 pixels x 576 lines displayed. (b) 50 frames/sec. 25 pictures/sec. (c) 414720 pixels total. USA / Japan (a) 525 line - 704 pixels x 480 lines displayed. (b) 60 frames/sec. 30 pictures/sec. (c) 337920 pixels total.	(1) Not exactly defined — number of systems. (2) System with a higher picture resolution. (3) Greater than 1000 lines resolution. (4) Picture with less artifacts or distortions. (5) Bigger picture to give a viewing experience. (6) Wider aspect ration to use peripheral vision. (7) Progressive instead of interlaced pictures.

Analog TV's sensitivity to noise and interference is typical of all analog systems: They're unable to distinguish noise in the physical quantity representing information from the information itself. Electrical noise in the video signal appears immediately on the screen as visual noise-snow, tick marks, and patterns are common. Likewise, delayed reflections of the signal itself produce ghost images.

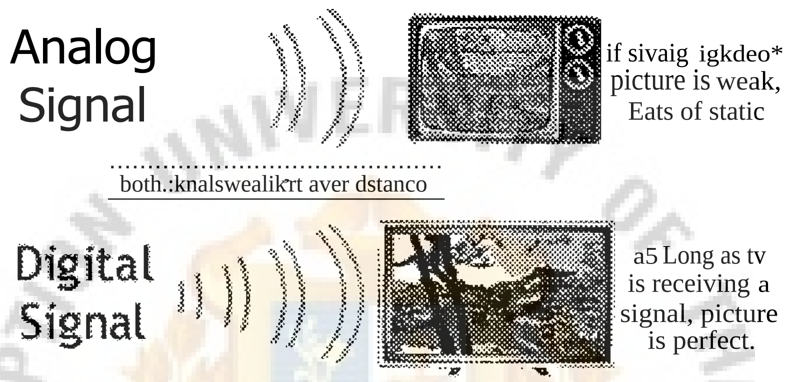


Figure 2.3. Ghost Effect (Cringely 1998).

Digital TV is much less sensitive to noise, because imperfections in the signals passing through the front end of the receiver can be completely and reliably removed before they have any effect on the displayed images.

By using quantized values for the physical quantities conveying information, the digital approach prevents low-level noise on those physical quantities from affecting the information. With the help of error correction and digital filtering, digital TV is able to display perfect images even when the electromagnetic signals reaching the set have a fair amount of noise in them. (Bloomfield 1999) The comparison picture between Analog System and Digital System will be shown in Figure 2.4:

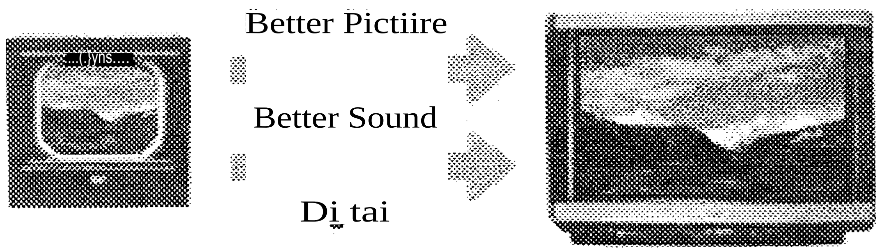


Figure 2.4. Digital Versus Analog (Cringely 1998).

2.4 Digital Terrestrial Television Broadcasting (DTTB): Digital Broadcasting Technology

Digital terrestrial television broadcasting (DTTB) is a new type of broadcasting technology that provides a more effective way of transmitting television services.

DTTB can: (Commonwealth of Australia 2000)

(1) Provide for better reception of television services than the current analog systems.

(2) Deliver higher quality picture and sound than the PAL system;

(3) Provide high definition television (HDTV) programs or a number of standard definition television (SDTV) programs within the standard broadcast channel

(4) Reconfigure services (i.e. change from a single HDTV program to a number of SDTV programs) at any time;

(5) Carry a range of multi-media service in the form of audio, images, data and text.

2.4.1 Digital Terrestrial Television Broadcasting Perspective

DTTB systems use advanced digital techniques to convert an analog signal to a digital signal which is then compressed, along with other signals, before being broadcast from a transmitter. With digital transmission, sound and pictures are processed electronically and converted into binary digits (bits)-a series of zeros and ones. This code is then transmitted as a bit stream and the receiver converts the digital transmissions back to graphics and sound (or text etc). Video compression allows the transmitter to send only the data needed to pass on the difference between each picture frame, rather than the whole picture, therefore removing repetitive information and enabling several digital services to be transmitted within the same frequency.

A multiplex brings together all the television programs (and associated data and sound services) on a single frequency channel. DTTB brings to an end the direct relationship between one television program and one frequency. It is capable of carrying either one HDTV program, or up to five or six services using SDTV, or as many as ten services with lesser definition formatting. As with computer technology, it is possible to trade off the bit rate, the channel width and picture quality. Channel bandwidth can be used in different ways. See Figure 2.5.

A DTTB channel can be reconfigured at any time to allow for either HDTV or multi-program services. The number of services that is provided depends upon the picture format quality desired at the time. For example, fast-moving live sports could utilize the full HDTV capacity, but for a 'talking head' newsreader SDTV or a lower quality could be used.

Essentially, the type of picture determines how much of the channel's capacity is needed for transmission. A DTTB channel can carry up to 20Mbits/sec of data. HDTV services would use most if not all this capacity, but an SDTV service would use considerably less depending on the nature of the service, e.g. fast moving sport could require up to 10Mbits/sec data rate and hence possibly only two of these services could be delivered at the one time. By comparison, a 'talking head' picture would utilize about 5Mbits/sec of data.

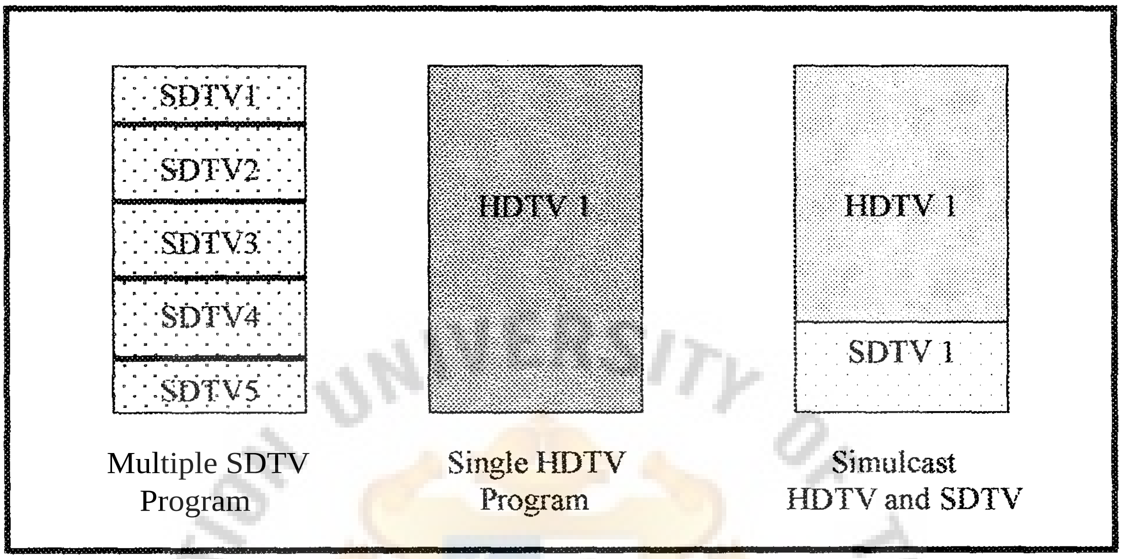


Figure 2.5. Example of DTTB Data Containers (Simons 1998).

Table 2.6. Video Program Capacity (Pickford 1999).

Video Program Capacity (For a payload of around 19 Mb/s)
(1) 1 HDTV service = sport and high action
(2) 2 HDTV service = both film material
(3) 1 HDTV + 1 or 2 SDTV = non action / sport
(4) 3 SDTV for high action and sport video
(5) 6 SDTV for film, news and soft opera
* More services means less quality

2.4.2 Bandwidth Requirement

DTTB systems can accommodate 6, 7 and 8MHz channel spacing with minimal or no apparent cost disadvantage. The picture will show in Figure 2.6:

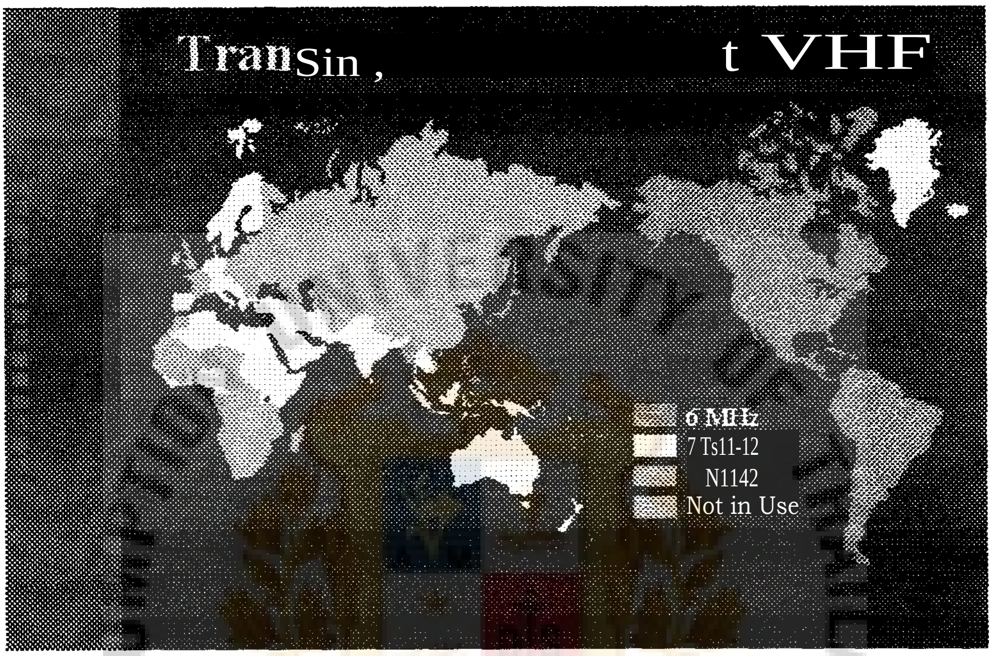


Figure 2.6. World Map of VHF Transmission Bandwidth (Pickford 1999).

2.4.3 Spectrum Use

DTTB can be accommodated within the existing broadcasting frequency bands, generally in UHF and also in VHF bands, using vacant channels adjacent to analog services.

These channels often cannot be used for additional analog services, because of technical constraints inherent in analog systems, but can be used for DTTB as DTTB receivers are expected to tolerate higher levels of co-channel and adjacent channel interference.

2.4.4 Type of Digital Terrestrial Television Broadcasting System

At present, there are 3 major systems of Digital Terrestrial Television Broadcasting which the International Telecommunication Union (ITU) has now been considering for setting as standard. (Thong 1999) These are as following:

(1) DVB (Digital Video Broadcasting) developed by the European Union.

(2) ATSC (Advanced Television Systems Committee) developed by the USA.

(3) ISDB (Integrated Services Digital Broadcasting) developed by NHK, Japan.

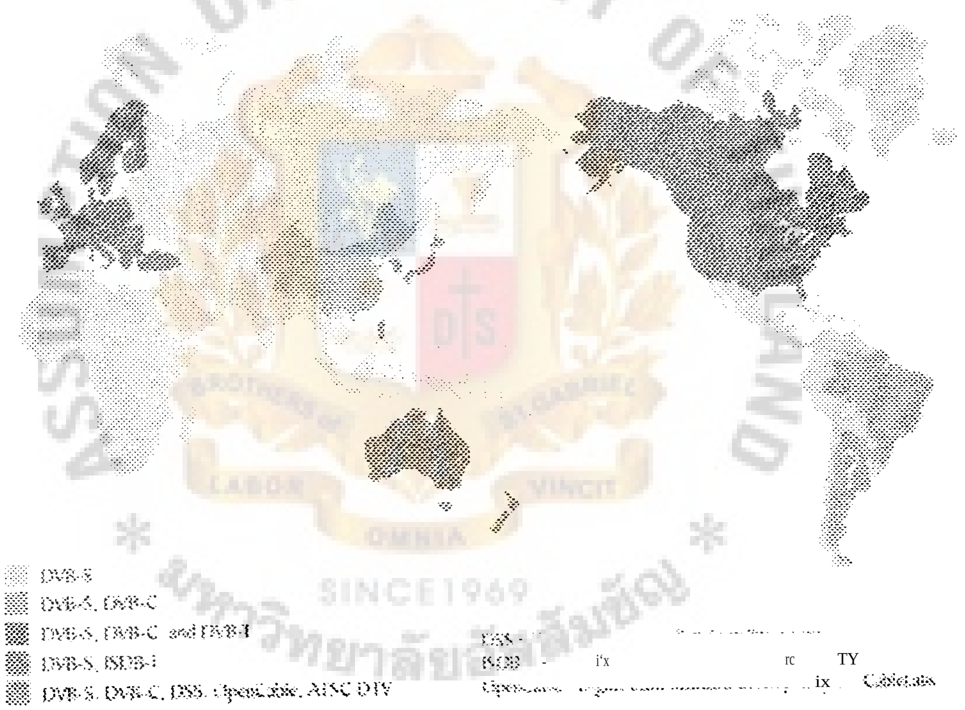


Figure 2.7. Current Adoption of World Broadcasting System
(Jacklin and Macavock 1998).

DVB System (Apicharttrisorn 2000)

Before describing the concept of designing the DVB system, it is necessary to understand the problems and basic needs of the European Union. The European continent consists of more than ten countries. Each country's area is not so vast, but it could develop most advanced technology. However, these countries are facing problems related to the congested wave bands in particular, the radio and television's broadcasts. Their broadcast channels therefore are limited.

The concept of designing the DVB system hence aims to expand broadcasting channels as many as possible without interference.

The DVB group standard comprises a core system which is intended to provide for a family of systems covering all transmission media as follows:

(1) Satellite Broadcasting (DVB-S)

(2) CableBroadcasting (DVB-C)

(3) Terrestrial Broadcasting for 7 to 8MHz bandwidths (DVB-T)

The DVB system uses the common family of picture coding and compression based on MPEG-2. DVB uses a transmission system based on Coded Orthogonal Frequency Division Multiplexing (COFDM) modulation. See Figure 2.9.

This modulation has designed into two types for serving particular cases as follows: (Apicharttrisorn 2000)

(1) 2K carriers mode — with 1705 frequency carriers. It is suitable for receiver installed in moving car.

(2) 8K carriers mode — with 6817 frequency carriers. It is suitable for establishment of television station network using single frequency all over the country.

The DVB uses MPEG-2 standard as its own audio/video compression algorithm, and a multiplexing system for datacasting For audio encoding transmission, DVB will use MEPG-1 layer II which is based on the MUSICAM sub-band coding system for transmission.

The advantages of DVB are as follows:

(1) It can be used for frequency which has bandwidth ranging from 6MHz, 7MHz and 8MHz which are able to display good standard picture same as that of the currently used standard TV, but can broadcast 5-6 program channels simultaneously. For the widescreen TV receiver (16:9 EDTV), it can broadcast 4 programs whereas the HDTV with 1 program.

(2) DVB can broadcast the multimedia data interfaced the program picture. Such datacasting can be stock exchange, airline and train schedules, etc. It can also be connected to Internet which viewers can download software or information from the DVB communication. In addition, viewers can download data from radio and television stations as the so-called "Interactive TV". For example, while a viewer is watching a personal interviewing program, he can also download the interviewee's bibliography data through accessing telephone line at the same time. Such a new digital communication service in the future will appear on the television screen or PC's monitor screen.

(3) DVB can transmit as a network by using many transmitters with single frequency (Single Frequency Network). (Ministry of Post and Telecommunications 1999). When broadcasting the signal from only one transmitter in the areas with lots of sky scrapers, there will be some areas which can not service transmission with single bandwidth can be installed as supplementary to the blind spot of the area. Otherwise, large network covering nationwide with single bandwidth by utilizing the clock signal from GPS satellite to control the operation of radio and TV transmitter in all networks as depicted in the following.

(4) The sound system is of stereo type and surround sound.

(5) DVB can be compatible with TV installed in a car, bus or train with clear pictures even at high speed movement as fast as 275 km/hr.

(6) Digital TV broadcasting systems with power of 12 dB or about 16 times lower than analog one being used nowadays will service nearby areas. For instance, the present radio and TV transmitter with power 10 kilowatts which is changed into DVB digital system, it will use transmission power only 160 watts to service the same areas.

(7) Using the integrated Receiver Decoder (IRD) or one set-top box can receive programs broadcasting from DVB in all system. In addition, DVB-Card is available to facilitate the TV set to receive programs broadcast from digital TV also.

Figure 2.8. World Adoption of DVB System (Jacklin and Macavock 1998).

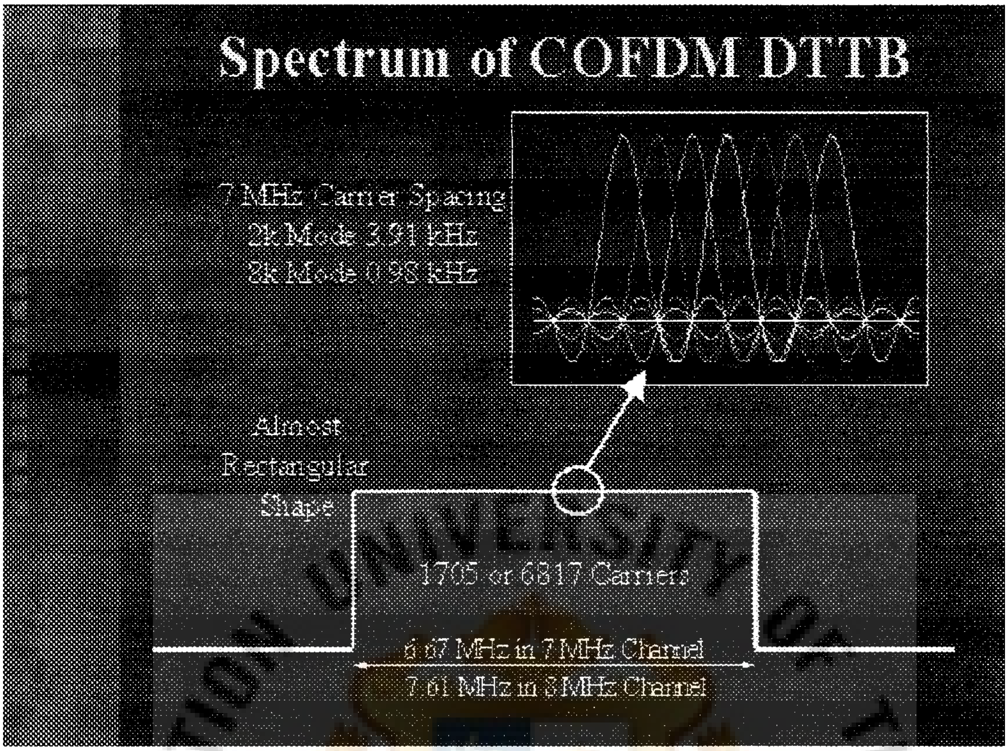


Figure 2.9. Coded Orthogonal Frequency Division Multiplexing (Pickford 1999).

ATSC System (Government Public Relations Department 2000)

The United States of America is a country having vast area with two neighboring Countries: Canada and Mexico. Only one organization administrating bandwidth is the Federal Communication Commission (FCC). It is therefore no problems related to bandwidth as in Europe. The main purpose of TV broadcasting is for entertainment.

In December 1996, the US Federal Communications Commission adopted the DTTB standard submitted by the Advanced Television System Committee (ATSC). The standard provides for the transmission of DTTB in a 6MHz channel.

It provides for a range of video image formats based on MPEG-2 (Motion Picture Experts Group) video compression. Audio compression is based on the Dolby AC-3 system supporting five surrounding channels plus a subwoofer channel and the transport subsystem is based on the MPEG-2 transport stream.

The RF Modulation is 8 VSB (Vestigial Side Band) using single frequency. Bandwidth can be selected from 6 MHz, 7 MHz, or 8 MHz, depending on the data capacity or picture quality.

The Analog system will be used for a period of time before canceling out by the year 2006. The advantages of Digital TV Broadcasting under ATSC system are almost the same as DVB:

(1) Broadcast SDTV program for 2-6 programs, depending on the kind of programs

(2) Broadcast HDTV for two programs simultaneously or HDTV/SDTV simultaneously

(3) Provide Data Broadcasting Services such as internet to watch TV programs from computer, a capability to download software and so on.

The differences between DVB and ATSC are as follows:

(1) The protection from a shadow appearance (ghost) in ATSC system is not as complete as in DVB system. Each time when IRD receiver is installed, it has to be fine-tuned, whilst this can be automatically protected in DVB system. Consequently, to watch a TV program installing in a car, a bus or a train is not possible.

(2) ATSC is not designed for a network with the single bandwidth like DVB. So, it is not possible to establish this network in ATSC.

(3) ATSC is designed with well interference protection from analog transmission signal.

ISDB System (Government Public Relations Department 2000)

The geography of Japan is an island separated from terra of Asia Continent. It has no territory with neighboring countries. Generally, its landscape is mountainous. The country is highly populated as well as advanced in high technology.

Methods to design a radio and TV digital signal transmission in Japan, ISDB, are as follows:

(1) It can be used as a single frequency network (SFN) so as to obtain optimal use of frequency resource.

(2) It can manage the allocation of bandwidth with flexibility.

(3) It can well receive good quality of TV signal with no ghost or degrading pictures.

(4) It can locally broadcast lots of TV programs.

(5) Can broadcast radio programs simultaneously by using the same technology in a digital TV and a digital broadcast.

(6) It can service a HDTV or SDTV TV programs transmission together with a multimedia information service.

(7) Customer can watch TV in fast moving car, bus and train or from a TV with a general attenna on a roof. A pocketsize radio and TV can also receive the transmission.

ISDB techniques are very much the same like DVB used in Europe but different signal patterns and technical details are as follows:

(1) Using COFDM with numerous frequency wave carrier. It is identified into 2 groups. That is, Mode 1 using wave carrier 1405 frequencies and Mode 2 with 5617 frequencies. Whilst, DVB will use 1705 and 6818 frequencies respectively.

(2) Using simultaneous broadcast modulation technique like DVB.

(3) Classifying TV signal into several parts called Segment-OFDM and adding signal code for identification types of TV receiver called BST (Band Segmented Transmission). Generally, this technique is called BST-OFDM.

(4) Using Error Correction and protection called Reed-Solomon pattern like DVB.

(5) Using MPEG-2 standard to compress picture signals

(6) Using MPEG-2AAC as a TV sound system (DVB uses MPEG layer 2 or MPEG-2 (Audio)

The pros of ISDB are the same as DVB system. The difference is that digital radio and TV receivers, car radio and TV receivers, computer, and pocket size radio and TV receivers are able to get all ISDB signals.

2.4.5 DTTB Receiver Equipment

DTTB can offer viewers more choice, new types of interactive services, improved reception, and better picture and sound quality. Manufacture of receivers is commencing to meet demand in Europe and the USA.

The likely options for consumers will include:

(1) Wide-screen and HDTV sets which will accommodate the full effects of DTTB

(2) Standard screen digital set which will still receive HDTV but not with full HDTV effect

(3) A set top unit or IRD (Integrated Receiver Decoder) to covert the digital signals for existing PAL sets, which will still receive HDTV but not with the full HDTV effect; and computer monitors/television receivers which will still receive HDTV but not with the full HDTV effect.

2.4.6 Digital Terrestrial Television Broadcasting (DTTB) Technology in Thailand

To broadcast by using digital system is not the newest topic for Thailand. If we carefully consider, we will see that this system has been already launched in Thailand.

For satellite system or DVB-S (Digital video Broadcasting Satellite System), the communication satellites receive television signals from a ground station amplify them, and relay them back to the earth over antenna that covers a specified terrestrial area. Instead of a normal aerial antenna, receiving dishes are used to receive the signal and deliver it to the television set or station. The dishes can be fairly small for home use, or large and powerful. However, there are some limitations of using satellite such as circumstance of bad climate, which causes loss to the signal, and have the high cost. In Thailand, the United Broadcasting Corporation (UBC) has launched this system. (MCOT 2000)

The Mass Communication Organization of Thailand (MCOT) cooperated with the government-run Public Relation Department (PRD), and private-run Independent Television (ITV) and United Broadcasting Corporation (UBC), in launching a new ground digital television broadcasting system, namely DVB-T the subdivision of DTTB system on a trial basis. This field trial will be conducted with the cooperation and support of the NTL Company, the standard agency and supplier who makes possible the loan of expensive equipment free of charge. This new ground digital system would be another step of evolution of television broadcasting in Thailand, from the satellite-based system to the antenna-based one.

The launch of the trial ground digital TV broadcasting system marked the nationwide celebration of His Majesty the King's 73-birthday anniversary, which fell on December 5, 2000. The project will test only to investigate the capacity of transmission signal from stations to transmitters and also to see the geographical of Thailand whether has the potential to improve and develop television broadcast to be digital system. So

Transmission Location :	Bai Yok Tower II
Transmission Channel :	Frequency channel No. 47
Transmission Equipment:	1 Kilowatt capacity power
Transmission Power	(a) 5 Kilowatt ERP
	(b) use SLOT ANTENNA
	(c) Omnioid Pattern
	(d) 11.5 dB additional signal power
Target	(1) Bangkok and its suburb areas
	(2) BTS Sky Train
	(3) Moving with high speed vehicle
Starting Date	December 5, 2000

III. FORECASTING

3.1 Problems Related to Television Broadcast of Present Day in Thailand

Television broadcasting in Thailand at present is under analog communication system. Although television-broadcasting stations today have expanded their networks to cover most areas of the country, viewers at home in general still receive unclear pictures. The clearness here could be compared with a photograph, which is clear and sharp, pleasant to looking. Most home television receivers in Bangkok and other big cities or provinces have the multipath effect. See Figure 3.1. The degree of picture overlapping depends on density of high building in the area.

Moreover, program pictures are interfered with the electricity appliances used in house such as sewing machine, water pumps or fluorescent lamp. In remote areas, the unclear pictures are worsen by appearance of dotted plots or snow. TV viewers have solved the problems by installing low quality booster to the television receiver. As a result, it is further interrupted by the radio ghost wave FM in the area. The unclear television picture has been one of the daily problems which people are getting used to it.

The problem described above happens not only in Thailand, but also in other countries worldwide. TV broadcasting stations and other agencies concerned have tried to solve it. The Digital TV broadcasting trial has been developed over the past ten years. It was found that the picture image has been improved to be as clear as looking photographs the numbers of TV channels or programs also could be increased.

A limitation of TV broadcast at present is that in the same area, only discrete numbers of channels can be broadcasting so as to avoid wave interference. For example, in Bangkok, since the initial channel is number 5, then the next will be 7, 9, 11, etc. This has limited the expansion of TV network over the country. TV stations cannot establish additional channels but search for other bands such as UHF.

In brief, broadcasting with analog system in Thailand post such problems as follows:

(1) In service areas with high buildings, the picture quality will have multipath effect.

(2) In remote areas, picture quality will degrade, as the service areas are further distance from the broadcasting station.

(3) In car moving condition, the broadcast picture will be shuttling.

(4) Television transmission signals will be easily interfered by electric appliance at work nearby or a sparking plug.

(5) In the same service area, all the bandwidths can not simultaneously broadcast. To resolve the interference problem, it is necessary to have vacant frequency interval between each broadcasting band.

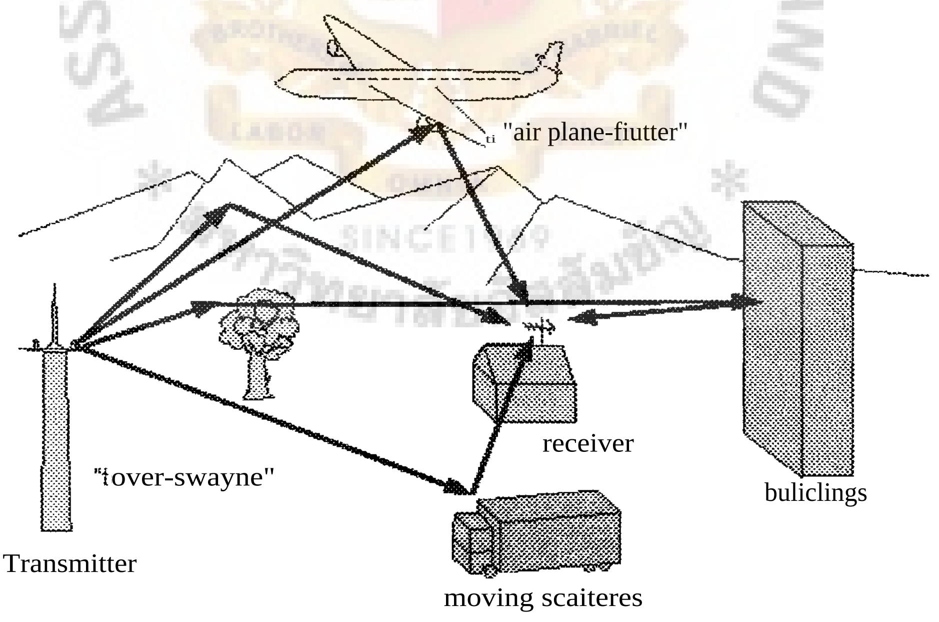


Figure 3.1. Multipath Transmission Effect (Speth 1999).

3.2 Factors for Determination of DTTB in Thailand

When some techniques and special features of DTTB signal transmission in various systems are already acknowledged, we have to consider which system is suitable for Thailand. Before considering this mentioned issue, the truth concerning the determination has to be accepted as follows:

(1) In the future, it is unavoidable to use a digital system as replacing all analog system.

(2) TV digital signal receiver equipment as so called **IRD** (Integrated Receiver Decoder) is designed for use of specific. The IRD prices will depend on amount of production. If one system is popularly used in many countries, price of **IRD** will have more chance to be cheaper. Moreover, an IRD price is one of the key factors for making buying decision.

(3) When the TV digital signal transmission has been introduced, people have to consider well the country's economic situation before changing to use a digital TV instead of the present model. Because TV receivers in the market nowadays are about many million sets and Thailand has to import them because of inability to domestically produce. Thailand has to spend large amount of money for non-income generating investment. This will certainly further slow down the economic condition in the country.

(4) Bandwidth is a limited resource. In the future, when technology has more progress, bandwidth will be used more in various enterprises. This trend should be more concerned in the planning process so as to avoid the need of changing new system again in undue time. Otherwise, it will be the same problems as computer set which needs to be replaced since new models keep coming into the market approximately 4-5 types a year.

3.3 Which System Is Suitable for Thailand?

Taking account of prices of **IRD** receiver in DVB and ISDB-T systems, these two systems are rather complicated than that in the ATSC system. However, **IRD** installation with ATSC system must be tuned every time before using it.

Countries choosing to use **DVB** system have more advantages than others due to several outstanding points particularly the use of single frequency as a network nationwide. The system also serves to support a blind spot. For Japan, the **ISDB-T** system is designed especially for this country. There are not many countries using this Japanese system because the prices are higher than those of other systems.

According to the bandwidth utilization, DVB and ISDB-T have more advantages than ATSC system because these systems can use single frequency as a network nationwide and provide service in bus and train. When the country uses higher technology, and competitions are also increasing, it is necessary to follow up information all the time.

Considering the utilization from these systems, they are all the same because they can produce high resolution TV pictures, many normal resolution programs can be watched, and multimedia information can be transmitted in all systems.

From the above said reasons, therefore, in author's point of view the DVB system is most suitable for Thailand.

3.4 The Advantages of DVB Broadcasting

(1) Television broadcastings in the same area, the adjacent frequency channels such as 6, 8, 10, etc., can be used.

(2) In existing areas which have experienced TV receipt problems such as ghosting, snowy pictures and interference. These are all hard for viewers to overcome. One method that has been used to improve the situation has been

the provision of translator services to repeat broadcast signals into hidden areas, including Bangkok, which has density of high buildings. However these are limited by cost. See Figure 3.2. By its very nature, DVB has a dramatic effect on these problems. DVB allows each service area to use the same frequency, freeing up large amounts of spectrum and making installation of receivers easier. With digital broadcasting, people throughout the receipt areas receive a consistent signal. The cutoff point to a no reception area is clear cut, making it easier to plan transmission coverage. This technique of transmission with the same frequency is known as Single Frequency Network (SFN) technique. See Figure 3.3. With this technique, it is possible to allow the system to use the same frequency at transmission stations and relay stations by adopting COFDM, a modulation system that is resistant to interference by multipaths. This feature will contribute to effective use of frequency resources.

(3) Each channel of the DVB broadcasting can provide 4-6 programs for Standard Definition TV (SDTV), and provide 1-2 programs for High Definition TV (HDTV) which has highly sharp pictures as clear as watching the 35 mm. Movie. See Figure 3.4.

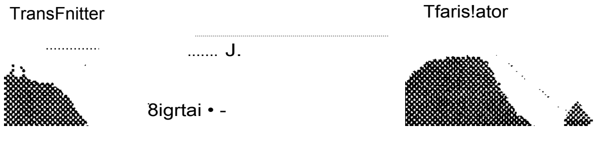


Figure 3.2. The Provision of Translator Services for Hidden Areas (Simons 1998).

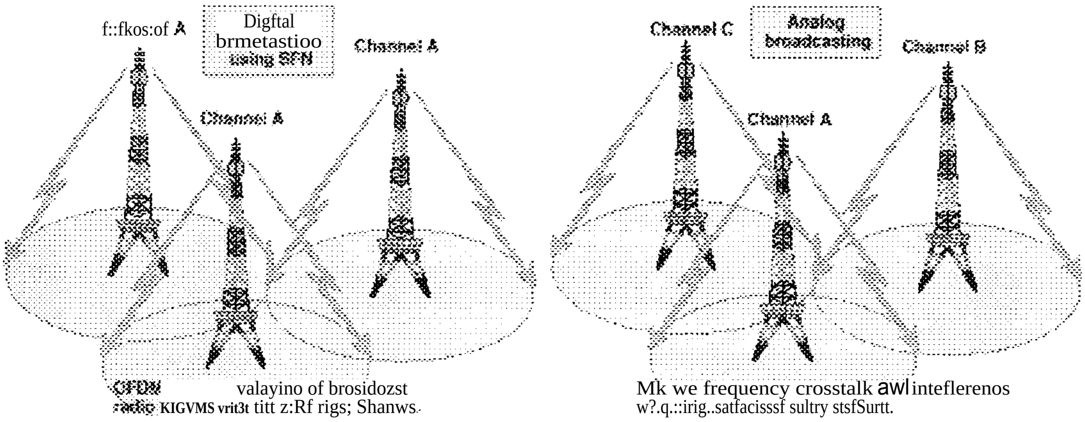


Figure 3.3. Single Frequency Network (SFN) Technique
(Ministry of Posts and Telecommunications 1999).

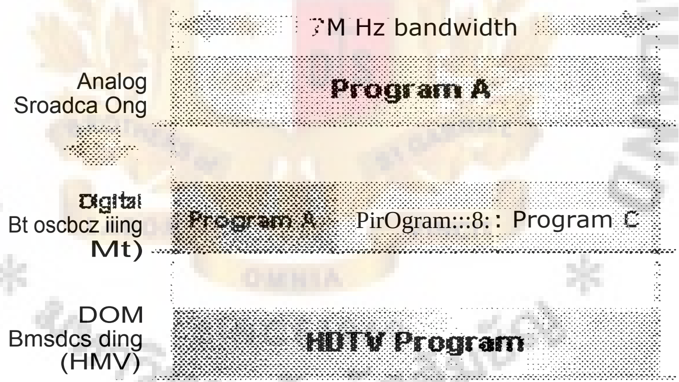


Figure 3.4. HDTV and Multi-Channel SDTV Broadcasting
(Ministry of Posts and Telecommunications 1999).

(4) In addition to program broadcasting, the DVB system can be used for sending multimedia information on various areas such as data on stock market, airlines, train and coaches' schedules. It can be connected to Internet, or viewers can communicate or interact with TV network to search for important data information.

(5) Some DVB system could cast clear picture even if the receiver is installed in the car, route buses or high speed trains. The modulation best suited to mobile terminals and a power error correction have been adopted to improve conditions for programming reception in mobile terminals. See Figure 3.5.

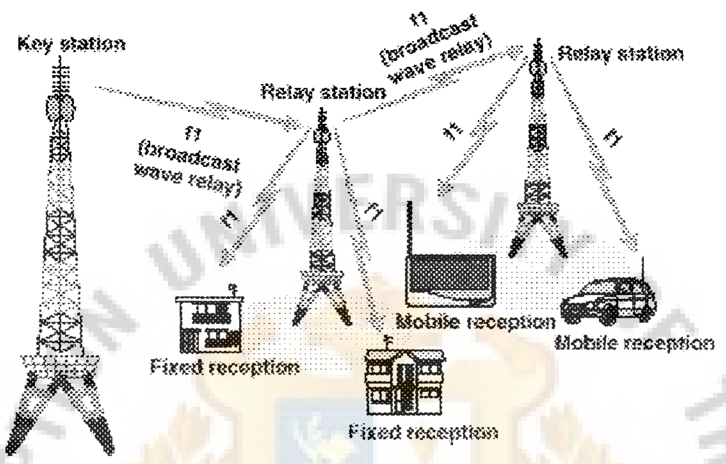


Figure 3.5. Improved Programming Reception in Mobile Terminals (Ministry of Posts and Telecommunications 1999).

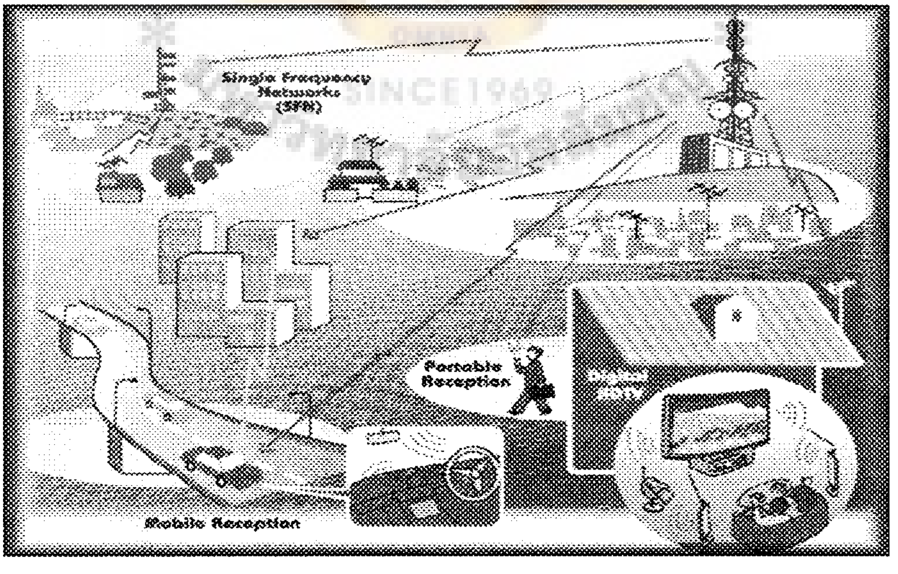


Figure 3.6. The Conclusion of All Advantages of DVB System (Ministry of Post and Telecommunications 1999).

3.5 The Revolution of Television Technology Perspective

From the literature part, we can see that television technology has been evolved for many decades. In the Incubation Era, the television set had not been introduced yet. There were only experiments and researches. The experiments were done only in the field of researching the way to transform image to electric signal, and also what component elements should be within television set.

The Black and White TV Era began when John Logie Baird demonstrated his electro-mechanical TV system. The first television system was black and white system with 240 scan lines, and later it was developed to be 343-scan lines system. This system was been used in America during 1934-1941.

It was developed again to be 525-scan lines black and white system with NTSC standard. This NTSC standard is still being used at present, but its system is improved to be color system.

While United States had their black and white television sets, the European country like United Kingdom also invented its own black and white television system using Marconi/E.M.I System 405 lines. British used this system simultaneously with CCIR 625 lines system PAL standard until the year 1986. Then they stopped their conventional 405 lines system and used only CCIR 625 lines system up to present.

The European countries fixed the CCIR 625 lines system as their television standard since 1950. It was in the same year that America commenced the cable television. So the Cable TV Era began at that time. American households' anttenas were changed to be cable line. The television signal was transmitted through cable line. However, every program was still black and white color.

The Color TV Era was arrived in few year later, when the U.S. government's Federal Communications Commission or FCC announced to change its black and white system to be color system, this transition of technology made other countries to change their black and white television system to color later.

The European standard CCIR 625 lines system is color system. It can be divided into SECAM or PAL system. PAL system is the most favorite system for most countries in the world. The television set also had its own development.

In 1960, the transistor was used to substitute the electro-mechanical part in TV set. The TV set with transistor would be lighter weight than the conventional TV set.

The advancement of digital technology makes television technology changed again. The satellite, computer and Internet were invented. People can communicate without physical contact.

The benefit of transmission signal in digital form makes television technology arriving in Digital Era. Not only television set that will be developed to be digital system, but also the standard of broadcasting television signal that will be changed to digital. The new standard for digital broadcasting system is called the Digital Terrestrial Television Broadcasting or DTTB. This DTTB standard has three subsystems as America's ATSC system, European DVB system, and the Japanese ISDB system. All of these systems commence to operate since the year 2000.

Generally, the countries that use NTSC system will select ATSC system and those countries using PAL or SECAM system will choose DVB or ISDB system. It is certain that in the future all television technology will be changed to digital system, and the traditional analogy system will end.

Thailand is the one of many countries that follows the advancement of technology. Thailand began television broadcast after NTSC standard introduced about more than ten years. Firstly Thailand used NTSC standard 525 lines 60 filed black and white system as the standard system in broadcasting. This NTSC standard was compatible with electric current 110V 60-Hertz system using in Thailand at that time. However, after the government announced to change the electric current to 220V 50 Hertz, this caused many television channels to change the system from NTSC 525 lines 60 fields to CCIR 625 lines 50 fields.

The CCIR 625 lines standard is more compatible with Thailand's electric current because it uses electric current 50 Hertz for transmission signal. In addition, this system is color system. This feature ceased the traditional black and white television system with NTSC standard. In the old days Thailand expanded its television technology development gradually from central Bangkok area to local province areas.

By setting main transmitters in each region and using microwave media to support transmission of signal from main transmitters to distance area, this could help the stations to broadcast signal coverage of all regions of Thailand. In addition, Thailand also used the international satellite in broadcasting.

Since the digital era for television broadcasting technology is coming, Thailand is also alerted with this transition. While the author is writing this project, Thailand is on the process of testing the Digital Video Broadcasting-Terrestrial (DVB-T) in trial basis.

In the author's point of view, it is possible that Thailand will use this DVB-T system. Since this system is not only compatible with PAL system used in Thailand, it is also suitable with Thailand's geography.

By its features, DVB-T system will be the system that most countries adopt and use. In the future, therefore, its equipment's price should be cheaper when comparing with other systems.

With economic situation at present, it may take time for Thailand to adopt this technology, as the cost of infrastructure investment is very high. Government, broadcasters, and Thai people have to invest a lot in this transition.

So Thailand should wait and invest when economic situation becomes better, and the cost of those digital equipments become low.

Table 3.1. The Revolution of World's Television Technology.

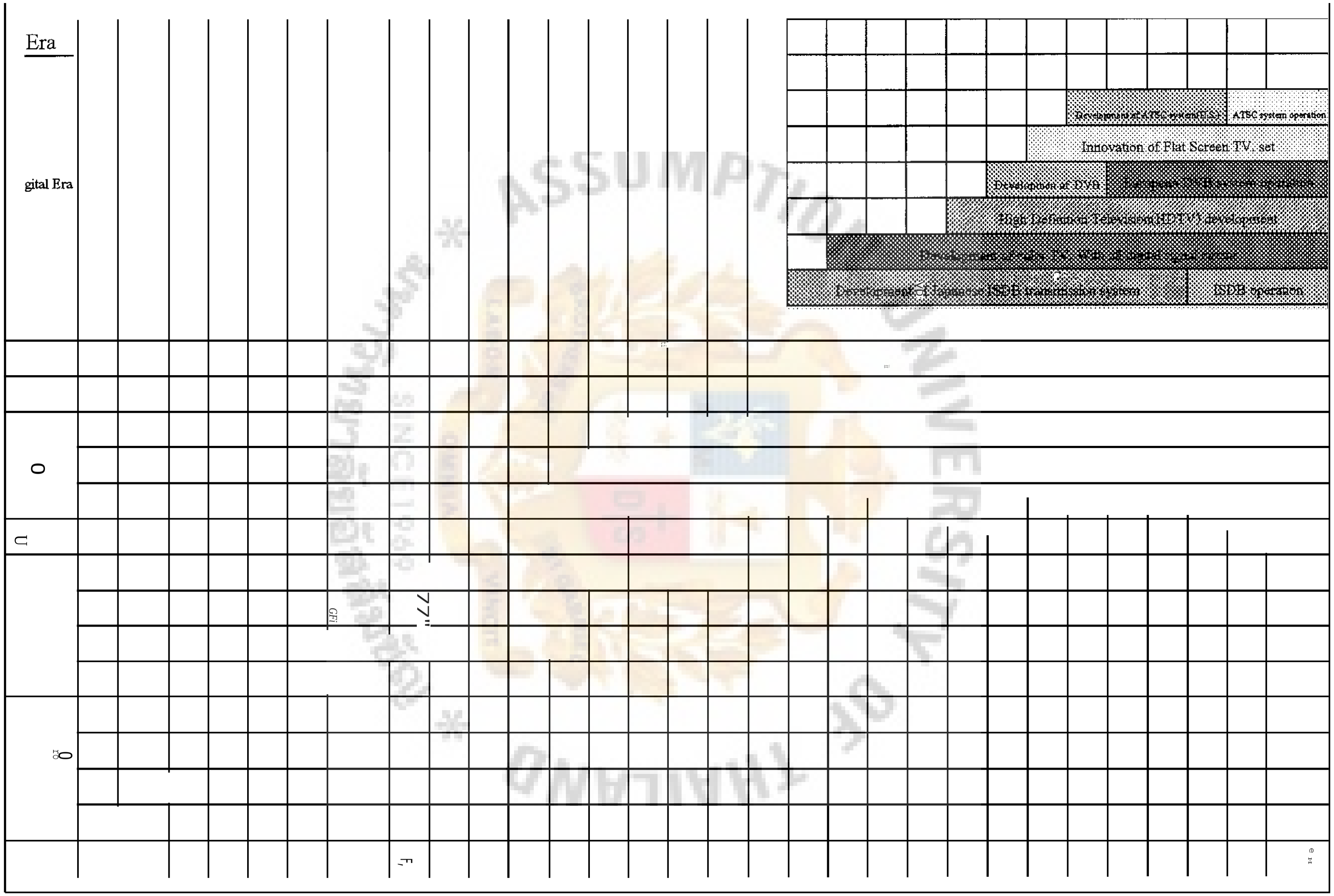
Analog Era		
Era	Contribution	Date
Incubation	Transformation of Image to Electronical Signal	1873
	Nipkow-Disc	1884
	Innovation of Cathode-Ray Tube	1897
	Electro-Mechnical TV system	1926
Black&White	Birth of U.S. B&W TV system (U.S. 240 lines system)	1928-1934
	Birth of British B&W TV system (Marconi/E.M.I. System 405 lines)	1930-1986
	Birth of U.S. B&W TV system (U.S. 343 lines system)	1934-1941
	U.S. NTSC 525 lines standard B&W System	1941
Cable TV	Beginning of Cable TV in U.S.	1950
	European CCIR 625 lines standard	1950
Color TV System	Beginning of NTSC 525 lines Color standard in U.S.	1954
	Introduction of SECAM and PAL system	1959
	Innovation of Transistor Television set	1960
Internet	Beginning of Internet	1960s
Satellite	The first Asia-America satellite link	1965
	The cease of B&W television in U.S.	1965

Table 3.1. The Revolution of World's Television Technology. (Continued)

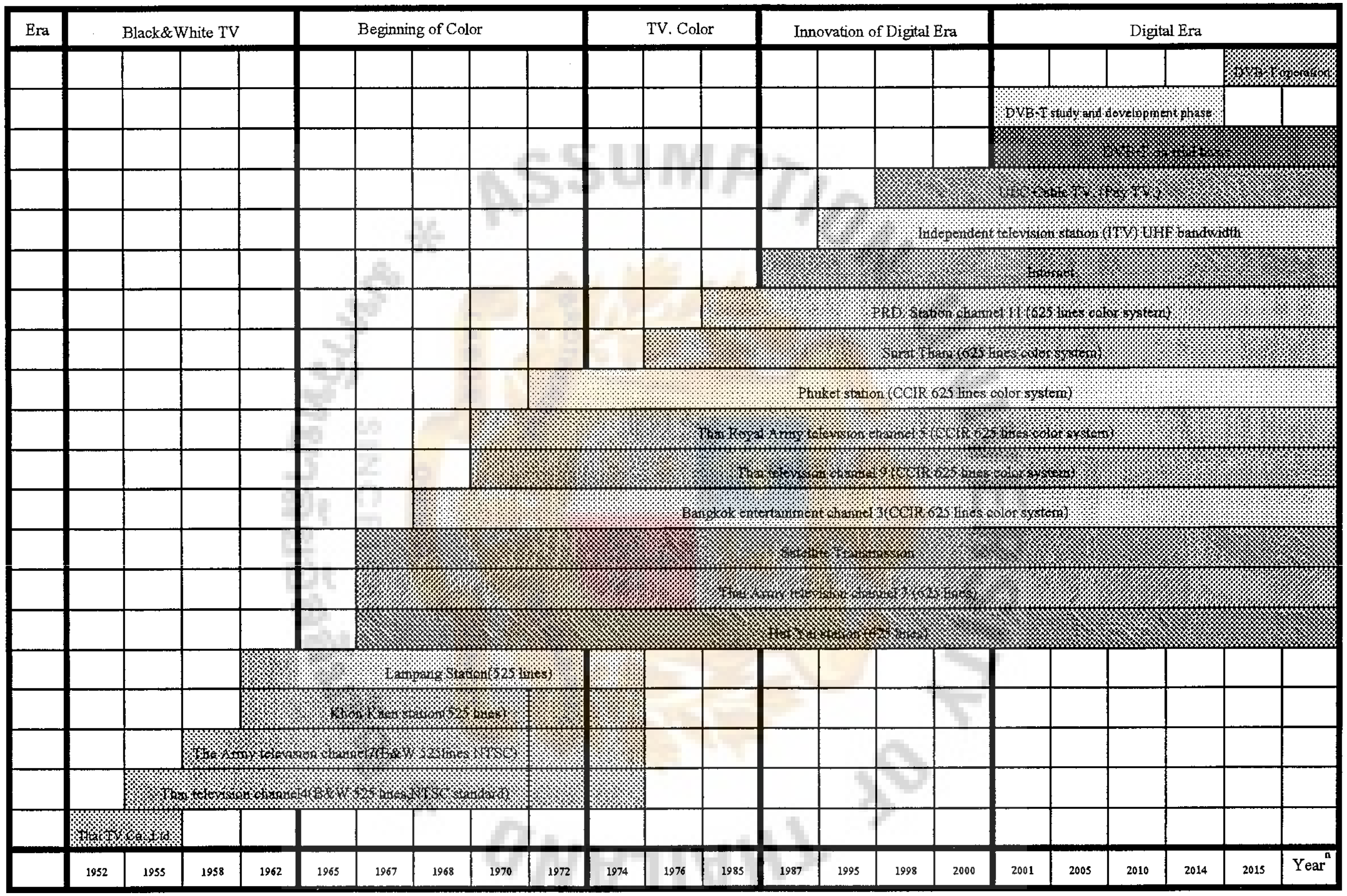
Digital Era		
Era	Contribution	Date
Digital Innovation	Experiment of Digital Television	1972
	Development of Japanese ISDB transmission system	1982
	Development of color TV with all digital signal circuit	1984
	High definition television (HDTV) development	1987
	Development of European DVB transmission system	1991
	Innovation of flat screen TV set	1995
	Development of U.S. ATSC transmission system	1996
DUB Technology	European DVB transmission system operation	1997
	HDTV release to market	2000
	Japaese ISDB transmission system opertion	2000
	U.S. ATSC transmission system operation	2001

Table 3.2. The Revolution of Television Technology in Thailand.

Era	Contribution	Date
B&W TV	Thai Television Company Limited operation	1952
	Thai TV Channel 4 (NTSC 525 lines B&W system)	1955-1974
	The Army TV Station Channel 7 (NTSC 525 lines B&W system)	1958-1974
	Khon Kaen Station (NTSC 525 lines B&W system)	1962-1974
	Lampang Station (NTSC 525 lines B&W system)	1962-1974
Beginning of Color TV	The replacement of CCIR 625 Standard	1965
	Hat Yai Station (CCIR 625 l nes Color system)	1967
	The Army TV Station Channel 7 (CCIR 625 lines Color system)	1967
	Beginning of satellite transmission	1967
	Bangkok Entertainment Channel 3 (CCIR 625 lines Color system)	1968
	Thai Television Channel 9 (CCIR 625 lines Color system)	1970
	Thai Army TV Station Channel 5 (CCIR 625 lines Color system)	1970
	Phuket Station (CCIR 625 lines Color system)	1972
Color TV	The cease of Black and White TV System	1974
	Surat-Thani Station (CCIR 625 lines Color system)	1976
	PRD Station Channe111 (CCIR 625 lines Color system)	1985
Innovation of Digital Era	Internet	1987
	Independent Television Station (UHF bandwidth)	1995
	UBC Cable TV (Pay TV)	1998
Digital Era	Digital Video Broadcasting-Terrestrial (DVB-T) on trial basis	2001
	DVB-T study and development phase	2001-2014
	DVB-T operation phase	2015



The Evolution of World's Television Technology.



The Evolution of Television Technology in Thailand.

IV. CONCLUSIONS

Around the world, governments are contemplating giving policy recognition to the technological inevitability represented by the digital revolution. Analog technology, which has sustained global broadcasting since its beginnings in the first quarter of the twentieth century, is about to give way to the ubiquity of digital.

Analog television, broadcast terrestrially in the VHF or UHF bands, is still the major method of delivering video entertainment to the home. Virtually every household in the developed world is equipped with a conventional analog television receiver using one of three color television standards - PAL, NTSC or SECAM, although PAL/SECAM has evolved as a compatible standard as a result of the inclination towards global standards for television. This technology has remained substantially unchanged since the 1930's.

Conventional television uses analog transmission, which means the signal level transmitted varies in accordance with the color and brightness of the elements of the pictures. Any disturbance to this signal along the transmission path introduces false information, or removes information, that cannot be repaired, reducing received pictures to lower quality than those transmitted.

In digital transmission, false data, or errors, can, within certain limits, be identified and corrected, thereby eliminating interference. The received picture is a faithful replica of the transmitted picture. The major obstacle with digital systems has been the difficulty in processing and transmitting the large volume of digital data needed to faithfully code a moving picture. During the past 35 years there have been major developments in digital techniques for the transmission, storage and processing of images, sound and data. Much of this progress has been made possible by advances in computing technology and in microcircuit design.

Today, digital technology is in everyday use in most television studios but it has not been technically feasible to transmit these digital signals over the air within the confines of existing channels.

Advances in the compression of digital image data have now made that possible. the International Telecommunications Union (ITU) developed objectives for global standards for the new generation of television broadcasting.

The system was required to provide for wide aspect ratio (16:9) pictures with at least double the resolution of analog television services. The service was intended to approach the viewing experience offered by 35mm film in the cinema.

The initial focus of this work - throughout most of the 1980's - was on increasing the capability of analog technology. In the mid 1980s the continual expansion of the telecommunications business had encouraged research into optical fiber as a method of carrying communications. This medium promised an enormous increase in capacity but needed digital technology to reach its full potential.

The computer industry was also expanding rapidly as a result of improvements in materials technology that allowed larger integrated circuit chips for processing and electronic memory to be manufactured with increasing levels of capability at lower cost. Both the computer and telecommunications industries were heading towards capacities large enough to handle video images routinely.

The turning point in shaping the future of the television business came at the beginning when the United States Federal Communications Commission (FCC) determined to encourage HDTV in the existing broadcasting bands. The ITU established a world standardization of digital terrestrial television broadcasting technology (DTTB). Digital Terrestrial Television Broadcasting (DTTB) is the general term used to describe the digital transmission systems which are set to replace existing analogue transmission.

DTTB has eventuated out of developments in digital technology, which are more spectrum efficient than analogue systems.

At the present stage of DTTB development it is possible to accommodate useful data streams of 20 Mbs/s and 24Mbs/s respectively into 6 MHz and 8 MHz wide terrestrial television channels. This is sufficient to carry one HDTV (High Definition Television) signal or 3-4 SDTV (Standard Definition Television) signals as well as other services such as datacasting (viewer-initiated multiple views of sporting events), multichanneling, advanced information services and Internet access.

DTTB systems have been designed to operate on the same channel bandwidth (7 MHz) as conventional PAL television systems so that they can be easily integrated into the current spectrum.

Digital broadcasting brings to an end the relationship between one television channel and one frequency. It also signals a new era of convergence of services, which challenges the relation between broadcasting, telecommunications, information technology and on-line services. This is likely to change the industry's structure and regulation policies, therefore much time is being allocated for the transition from analogue to digital transmission.

Under DTTB technology, three system have been developed:

(a) The US system developed by the Advanced Television System Committee (ATSC).

(b) The Europe system developed by the Digital Video Broadcasting (DVB) group. They developed a set of digital television standards covering all main forms of delivery-satellite (DVB-S), cable (DVB-C), and terrestrial (DVB-T).

(c) The last one is ISDB system developed by Japan.

The hunt for HDTV had irrevocably turned from analog to digital. the introduction of digital technology to the production and reception parts of television broadcasting dramatically changed the traditional broadcasting model, moving broadcasting into the mainstream of telecommunications and computing, and enabling major innovations in services available to the viewer.

In production the traditional linear approach is being replaced by the non-linear, random access approach enabled by large servers, compression technology and sophisticated high-speed broadcasting and telecommunications networks. The monolithic production facility can readily be distributed into specialized service units linked by the network over large geographical areas.

The use of digital technology in delivery, whether by cable, by satellite or over-the-air, can dramatically increase quality and the number of services available, while opening the way for a wide range of innovative new ones, such as high speed data delivery, interactivity and narrowcasting of niche services.

The use of digital technology in the receiver offers the flexibility and processing power to decode and display services from a range of sources on wide-screen displays - whose performance is independent of the transport scheme - and to include interactivity and conditional access. Digital signals have a much greater resistance than analog signals to noise and interference, and can be easily manipulated by using advanced digital electronics. Digital technology offers the viewer far better quality pictures and sound. With the technology of MPEG2 standard for digital video and audio compression; digital television offers CD-quality sound options that equate to the cinema's Sensurround' .

MPEG seeks to define standards for the techniques used in achieving digital compression and the way the output binary information is arranged. Standards for digital video and audio are essential to enable manufacturers to successfully manufacture and supply digital receivers to the mass market. The initial MPEG standards have three basic parts: part 1 relates to video; part 2 to audio, and part 3 to system standards.

The latter describes the way in which binary numbers for video and audio are combined or multiplexed together to form one binary bit stream. MPEG standards apply to program streams that can be combined or multiplexed into transport streams for delivery by, for instance, satellite, cable or terrestrial schemes.

Therefore, The work of MPEG in formulating standards is obviously crucial in coordinating the worldwide introduction of digital television.

Although the utilization of digital technology has become reasonably widespread in studio equipment, in production and in cable and satellite environments, the consumer of terrestrial television could be forgiven for wondering what all the fuss was about. This is because analog television receivers are incapable of receiving a digital signal, digital-capable receivers have only recently appeared in the consumer markets of some countries (having limited functionality).

Currently operators who provide programs transmitted in digital mode also provide the consumer with a set-top unit that converts the digital signal so that it might appear on the viewer's analog screen. Since around the world nations are moving to adopt policies in relation to digital terrestrial television broadcasting that place an emphasis on new capabilities, including HDTV and interactive capability.

Analog television receivers cannot accommodate such capabilities and the era of the multi-functional digital television receiver is about to begin.

The Mass Communication Organization of Thailand (MCOT) cooperated with the government-run Public Relation Department (PRD), and private-run Independent

Television (ITV) and United Broadcasting Corporation (UBC), in launching a new ground digital television broadcasting system, namely DVB-T, on a trial basis for three months started from December 5, 2000.

In this trial term, the project will test only to investigate the capacity of transmission signal from stations to transmitters and also to see the geographical layout of Thailand whether it has the potential to improve and develop television broadcast to digital.

So the viewers will not recognize any change with their television sets. Results of the three-month trial projects and other factors, namely implication on the people and incurred expenses, would be factors the government would carefully consider whether the newly developed system could be widely used in the future.

V. RECOMMENDATIONS

5.1 When to Start Digital Television in Thailand?

Nowadays, IRD receiver prices rank between 7,000-10,000 Bahts per set. As people living in some areas in Bangkok cannot watch TV with clear pictures, they have to install a satellite signal receiver or subscribe to cable TV. Such expenditures have higher than the cost of IRD.

Therefore, it is possible for Bangkok people to invest in this system. By adding on digital channel into the TV stations daily broadcast programs people can watch good quality pictures. The cost for TV stations to invest in digital broadcasting system without changing whole equipments in operation room is about a few million Bahts.

In the next few years, IRD will be more popular worldwide and the price will be cheaper than at present. Thailand should wait for that time to invest so that the cost of investment will not be high. At present, many TV stations in Thailand should do the study and plan for installation of digital TV broadcasting system in the future.

5.2 How to Plan Digital Broadcasting?

The investment cost by TV stations is not so high compared with the investment cost by people to buy a new TV set for watching programs with high resolution (HDTV). They are pleased to watch a TV with clear pictures same as watching from the VDO master cassette.

Moreover, the expense for the movie copyrights to broadcast for HDTV is still too high. The plan for digitally broadcast in the first phase (see Figure 5.1) is for people to be pleased with change at no additional investment costs. In addition, it takes time for the readiness of TV plants in Thailand to produce wide screen TV (picture ratio 16:9) in EDTV or HDTV. Thailand has a potential to make it in the future.

5.3 Recommendation Steps of Operational Planning

(1) The system for digitally broadcasting in Thailand is installed, and using the signal from TV channels, that is, 3, 5, 7, 9, 11 and ITV broadcast in Bangkok first. All TV stations are not necessary to change their whole equipments. Technicians will have time to study and develop skill from this system. These may be done by trial doing datacasting and multimedia together at the same time. It is the investment for mutual study. Expanding to other large provinces is the next step afterwards. Normally, it will take 3-5 years for the higher quality development with cheaper prices being expanding services to cover countrywide.

(2) Around 3-5 years to come, when plants in Thailand are able to produce a wide screen TV (16:9) EDTV, the analog equipment in TV broadcast station and conventional television set at home will become worn out and lack of spare parts. To fix it will not be worth trying. It is necessary to change equipment in the broadcast room into a digital one. Moreover, TV stations should start broadcasting EDTV programs, which allows people who buy new TV set with new system can watch it.

(3) When TV plants in Thailand can produce HDTV, each TV station should be able to start broadcasting in HDTV programs.

5.4 When to Stop Broadcasting Analog Television in Thailand?

According to the plan, television stations will operate two channels during the transition: an existing analog channel as well as a new DTV channel. The analog will allow customers to continue to use their current TV sets to receive traditional analog programming during the transition. The DTV channel will allow customers to receive new and improved services with special converter boxes (IRD) or new DTV sets that will allow some DTV programs and services to be viewed on existing analog sets.

Approximately in the year 2011-2013, it will be the third phase to complete digital broadcast TV system. Additionally, the UHF bandwidth can broadcast a large number of TV programs. The analog broadcasting system with VHF will be unnecessary. Therefore, it should be stopped to broadcast in this system and divert these frequencies into other sectors, which would generate more benefits to the country.

However, the transition schedule is subject to periodic review by the National Board of Broadcasting and can be extended beyond predetermined period if certain conditions relating to the number of consumers who can receive DTV signals are not met.

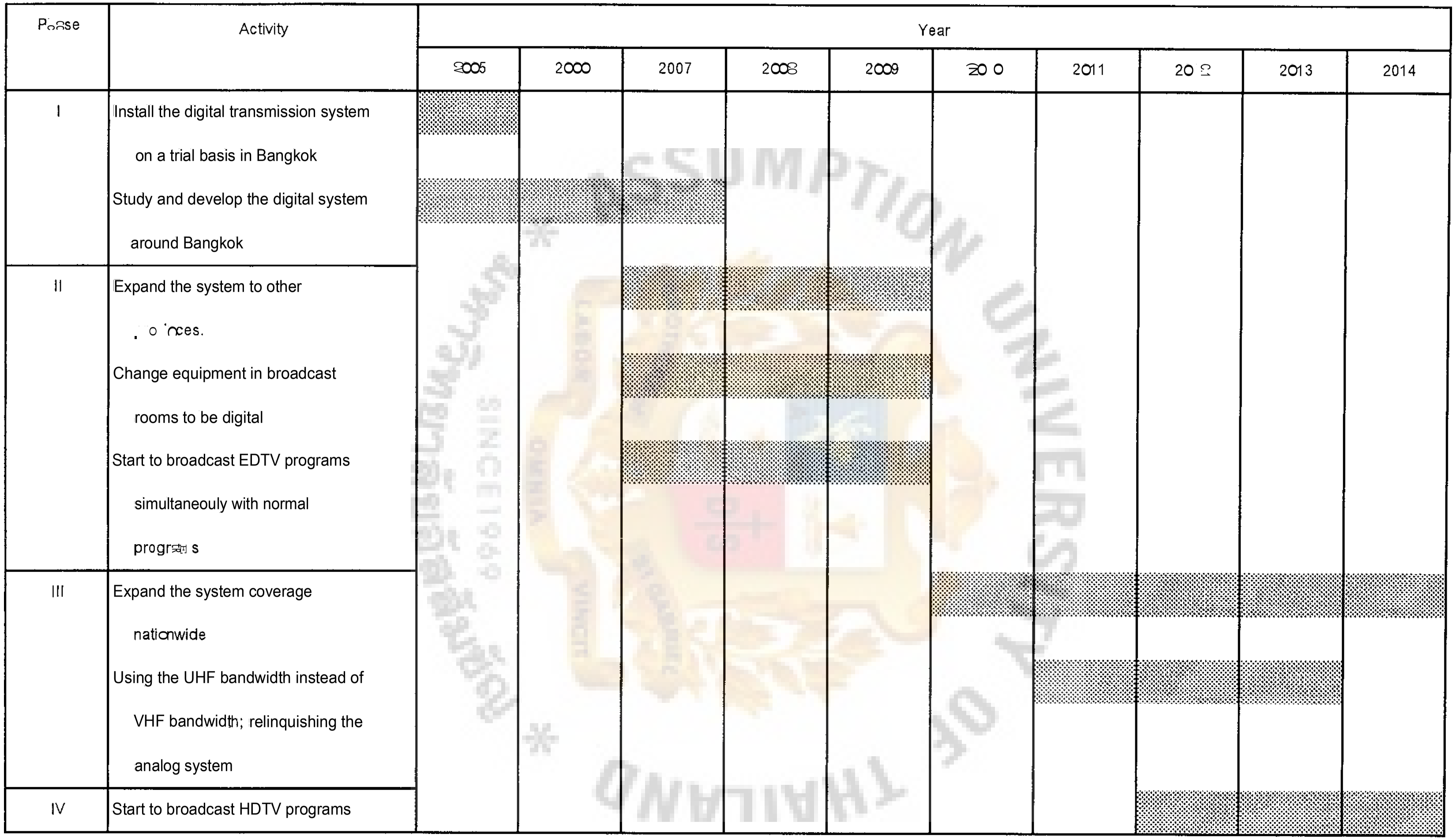


Figure 5.1. Gantt Chart Planning.

APPENDIX A

THE WORLD COLOR TELEVISION

Table A.1. Asia & Oceania.

Country	AC Supply		Color System	Broadcasting System		Channel System
	Voltage	Frequency		VHF	UHF	
Australia	240/250V	50Hz	PAL	B		Australian
Bangladesh	240V	50Hz	PAL	B		West European
Bhutan	220V	50Hz				
Brunei	230V	50Hz	PAL	B		West European
China	220V	50Hz	PAL	D		Chinese
Fiji	240V	50Hz	PAL	B		
Hong Kong	200/220V	50Hz	PAL	I		British
India	230/240V	50Hz	PAL	B		West European
Indonesia	110/240V	50Hz	PAL	B		West European
Japan	100/120V	50/60Hz	NTSC	M		Japanese
Korea(dem)	100/200/220V	60Hz	DRIT	D	K	East European
Korea(rep)	110/220V	60Hz	NTSC	M		American
Laos	220V	50Hz	PAL	M		American
Malaysia	240V	50Hz	PAL	B		West European
Mongolia	220V	50Hz	SECAM	D		East European
Myanmar	220V	50Hz	NTSC	M		Japanese
Nepal	220V	50Hz	PAL	B		West European
New Caledonia	220V	50Hz	SECAM	K1	-	French O.S.T
New Zealand	230/240V	50Hz	PAL	B		New Zealand
Papua New Guinea	240V	50Hz	PAL	B	G	[redacted]
Philippines	220/230/240V	60Hz	NTSC	M		American
Saipan	110V	60Hz	NTSC	M		American
Singapore	230V	50Hz	PAL	B		West European
Solomon Islands	240V	50Hz				
Sri Lanka	220V	50Hz	PAL	B		West European
Tahiti Islands	127V	60Hz	SECAM	K1		French O.S.T
Taiwan	110V	60Hz	NTSC	M		American
Thailand	220V	50Hz	PAL	B	M	West European
Vietnam	220V	50Hz	SECAM	D	K	East European

Table A.2. Europe and Russia.

Country	AC Supply		Color System	Broadcasting System		Channel System 1
	Voltage	Frequency		VHF	UHF	
Austria	230V	50Hz	PAL	B	G	West European
Belgium	230V	50Hz	PAL	B	G	West European
Bosnia/Hercegovina	220V	50Hz	PAL	B	G	West European
Bulgaria	220V	50Hz	SECAM	D	K	East European
Czecho	220V	50Hz	PAL	D	K	West European
Denmark	230V	50Hz	PAL	B	G	West European
Estonia	220V	50Hz	SECAM	D	K	East European
France	230V	50Hz	SECAM	L	L	French
Finland	230V	50Hz	PAL	B	G	West European
Germany	230V	50Hz	PAL	B	G	West European
Greece	230V	50Hz	PAUSECAM	B	G	West European
Hungary	220V	50Hz	SECAM	D	K	East European
Iceland	230V	50Hz	PAL	B	G	West European
Ireland	230V	50Hz	PAL		I	Irish
Italy	220V	50Hz	PAL	B	G	Italian
Latvia	220V	50Hz	SECAM	D	K	East European
Luxemburg	230V	50Hz	PAUSECAM	B	G	West European
Netherlands	230V	50Hz	PAL	B	G	West European
Norway	230V	50Hz	PAL	B	G	West European
Poland	220V	50Hz	SECAM	D	K	East European
Portugal	230V	50Hz	PAL	B	G	West European
Romania	220V	50Hz	PAL	D	K	East European
Russia	127/220V	50Hz	SECAM	D	K	East European
Slovenia	220V	50Hz	PAL	B	G	West European
Spain	127/220V	50Hz	PAL	B	G	West European
Srbia	220V	50Hz	PAL	B	G	West European
Sweden	230V	50Hz	PAL	B	G	West European
Switzerland	230V	50Hz	PAL	B	G	West European
UK	240V	50Hz	PAL		I	British

Table A.1 North and Central America.

Country	AC Supply		Color System	Broadcasting System		Channel System
	Voltage	Frequency		VHF	UHF	
Bahamas	120'240V	60Hz	NTSC	M		American
Belize	120V	60Hz	NTSC	M		American
Canada	120V	60Hz	NTSC	M	M	American
Costa Rica	110/220V	60Hz	NTSC	M	M	American
Cuba	110/220V	60Hz	NTSC	M		American
Dominican(rep)	110V	60Hz	NTSC	M		American
El Salvador	110/220V	60Hz	NTSC	M	M	American
Guatemala	120/240V	60Hz	NTSC	M		American
Haiti	110/220V	60Hz	NTSC	M		American
Honduras	110V	60Hz	NTSC	M		American
Jamaica	110/220V	50Hz	NTSC	M		American
Mexico	110/120V	60Hz	NTSC	M	M	American
Nicaragua	120/240V	60Hz	NTSC	M	M	American
Panama	110/220V	60Hz	NTSC	M	M	American
Honduras	110/220V	60Hz	NTSC	M	M	American
U.S.A	120V	60Hz	NTSC	M	M	American

APPENDIX B

GLOSSARY OF DIGITAL TELEVISION PERM

Glossary of Digital Television Terms

3:2 pull-down: Method used to map the 24 fps of film onto the 30 fps (60 fields) of 525-line TV, so that one film frame occupies three TV fields, the next two, etc. It means the two fields of every other TV frame come from different film frames making operations such as rotoscoping impossible, and requiring care in editing. Some sophisticated equipment can unravel the 3:2 sequence to allow frame-by-frame treatment and subsequently re-compose 3:2. The 3:2 sequence repeats every five TV frames and four film frames, the latter identified as A-D. Only film frame A is fully on a TV frame and so exists at one time code only, making it the editable point of the video sequence.

4fsc: Four times the frequency of SC (subcarrier). The sampling rate of a D2 digital video signal with respect to the subcarrier frequency of an NTSC or PAL analog video signal. The 4fsc frequency is 14.3 MHz in NTSC and 17.7 **MHz** in PAL.

4:1:1: This is a set of sampling frequencies in the ratio 4:1:1, used to digitize the luminance and color difference components (Y, R-Y, B-Y) of a video signal. The four represents 13.5 MHz, the sampling frequency of Y, and the ones each 3.75 MHz for R-Y and B-Y.

With the color information sampled at half the rate of the 4:2:2 system, this is generally used as a more economical form of sampling for 525-line picture formats. Both luminance and color difference are still sampled on every line. But the latter has half the horizontal resolution of 4:2:2, while the vertical resolution of the color information is maintained. For 525-line pictures, this means the color is fairly equally resolved in horizontal and vertical directions.

4:2:0: A sampling system used to digitize the luminance and color difference components (Y, R-Y, B-Y) of a video signal. The four represents the 13.5 MHz sampling frequency of Y, while the R-Y and B-Y are sampled at 6.75 MHz--effectively between every other line only (one line is sampled at 4:0:0, luminance only, and the next at 4:2:2).
This is generally used as a more economical system than 4:2:2 sampling for 625-line formats so that the color signals have a reasonably even resolution in the vertical and horizontal directions for that format.

4:2:2: A commonly used term for a component digital video format.

A ratio of sampling frequencies used to digitize the luminance and color difference components (Y, R-Y, B-Y) of a video signal. It is generally used as shorthand for ITU-R 601. The term 4:2:2 describes that for every four samples of Y, there are two samples each of R-Y and B-Y, giving more chrominance bandwidth in relation to luminance compared to 4:1:1 sampling.

ITU-R 601, 4:2:2 is the standard for digital studio equipment and the terms "4:2:2" and "601" are commonly (but technically incorrectly) used synonymously. The sampling frequency of Y is 13.5 MHz and that of R-Y and B-Y is each 6.75 MHz providing a maximum color bandwidth of 3.37 MHz--enough for high-quality chromakeying. The format specifies eight bits of resolution.

The details of the format are specified in the ITU-R BT.601-2 standard document. See also: ITU-R BT.601-2.

4:2:2:4: Same as 4:2:2, but with the addition of a key channel that is sampled four times for every four samples of the luminance channel.

4:4:4: Similar to 4:2:2, except that for every four luminance samples, the color channels are also sampled four times.

4:4:4:4: Similar to 4:2:2:4, except that for every four luminance samples, the color and key channels are also sampled four times.

48sF: 48 segmented frames. The process of taking 24-frame progressive images and deconstructing them to produce 48 interlaced frames each with half of the number of lines of resolution to allow some HDTV processors to pass the signal and for viewing on an interlaced monitor without flicker.

5.1: A type of surround sound. Six discrete audio channels are used: Left, Center, Right, Left Rear (or side) Surround, Right Rear (or side) Surround, and a subwoofer (considered the ".1" as it is limited in bandwidth).

See also: **Dolby Digital.**

601: See: **ITU-R BT.601-2.**

8-VSB: Eight discrete amplitude level vestigial side-band broadcast transmission technology, used in the ATSC digital television transmission standard. See also: ATSC, VSB and the Engineering & Transmission chapter.

AC-3:See: **Dolby Digital.**

ADC (A-D, A/D, A-to-D): Analog to Digital Conversion. Also referred to as digitization or quantization. The conversion of an analog signal into the digital data representation of that signal--normally for subsequent use in a digital machine. For TV, samples of audio and video are taken, the accuracy of the process depending on both the sampling frequency and the resolution of the analog amplitude information--how many bits are used to describe the analog levels. For TV pictures eight or 10-bits are normally used; for sound, 16 or 20-bits are common, and 24-bits are being introduced. The ITU-R 601 standard defines the sampling of video components based on 13.5 MHz, and AES/EBU defines sampling of 44.1 and 48 kHz for audio.

For pictures, the samples are called pixels, each containing data for brightness and color.

See also: **Binary, Bit.**

AES: Audio Engineering Society that promotes standards in the professional audio industry. International Headquarters--60 East 42nd Street, Room 2520, New York, New York 10165-2520.Tel: 212-661-8528. Fax: 212-682-0477. Email: FIQZaes.org. Internet: htipiilwww.aes.orgi.

AES/EBU: Informal name for a digital audio standard established jointly by the AES (Audio Engineering Society) and EBU (European Broadcasting Union) organizations. The sampling frequencies for this standard vary depending on the format being used; the sampling frequency for D1 and D2 audio tracks is 48 kHz.

AIF (Audio Interchange File): An audio file format developed by Apple Computer to store high quality sampled sound and musical instrument information. The AIF files are a popular format for transferring between the Macintosh and the PC.

See also: **AU, WAV.**

Algorithm: A formula or set of steps used to simplify, modify, or predict data. Complex algorithms are used to selectively reduce the high digital audio and video data rates. These algorithms utilize physiologists' knowledge of hearing and eyesight. For example, we can resolve fine detail in a still scene, but our eye cannot resolve the same detail in a moving scene. Using knowledge of these limitations, algorithms are formulated to selectively reduce the data rate without affecting the viewing experience.

See also: **Compression, MPEG.**

Aliasing: Defects or distortion in a television picture. In analog video, aliasing is typically caused by interference between two frequencies such as the luminance and chrominance frequencies or the chrominance and field scanning frequencies. It appears as moir or herringbone patterns, straight lines that become wavy, or rainbow colors. In digital video, aliasing is caused by insufficient sampling or poor filtering of the digital video. Defects are typically seen as jagged edges on diagonal lines and twinkling or brightening (beating) in picture detail.

Alpha channel: A relative transparency value. Alpha values facilitate the layering of media object on top of each other. In a four digit digital sampling structure (4:2:2:4) the alpha channel is represented by the last digit.

Analog: 1. An adjective describing any signal that varies continuously as opposed to a digital signal, which contains discrete levels. 2. A system or device that operates primarily on analog signals.

Anti-aliasing: The smoothing and removing of aliasing effects by filtering and other techniques. Most, but not all, DVEs and character generators contain anti-aliasing facilities.

Archive: Off-line storage of video/audio onto backup tapes, floppy disks, optical disks, etc.

Artifacts: Undesirable elements or defects in a video picture. These may occur naturally in the video process and must be eliminated in order to achieve a high-quality picture. Most common in analog are cross color and cross luminance. Most common in digital are macroblocks, which resemble pixelation of the video image.

ASCII: American Standard Code for Information Interchange. A standard code for transmitting data, consisting of 128 letters, numerals, symbols, and special codes each of which is represented by a unique binary number.

ASIC: Application specific integrated circuit. An integrated circuit designed for special rather than general applications.

Aspect ratio: The ratio of television picture width to height. In NTSC and PAL video, the present standard is 4:3. In widescreen video, it is typically 16:9, however, 14:9 has been used as a transition.

Asynchronous: Lacking synchronization. In video, a signal is asynchronous when its timing differs from that of the system reference signal. A foreign video signal is asynchronous before it is treated by a local frame synchronizer.

ATM: Asynchronous Transfer Mode. A data transmission scheme using self-routing packets of 53 bytes, 48 of which are available for user data. Typically 25, 155, and 622 Mbps--the latter of which could be used to carry non-compressed ITU-R 601 video as a data file.

ATSC: Advanced Television Systems Committee. Formed to establish technical standards for advanced television systems, including digital high definition television (HDTV). 1750 K Street NW, Suite 800, Washington, DC 20006. Tel: 202-828-3130. Fax: 202-828-3131. Email: atsc@atsc.org. Internet: riftp://www. atsc_oral.

The U.S. digital television transmission standard using MPEG-2 compression and the audio surround-sound compressed with Dolby Digital (AC-3). So that a wide variety of source material, including that from computers, can be best accommodated, two line standards are included--each operating at 24, 30, and 60 Hz.

The Consumer Electronics Manufacturers Association (CEMA) has said that all receivers will be capable of operating with all of the formats.

All pixels are square and pixel sampling rates vary, but all are around 75 MHz. There is a Transport Layer that packages video, audio and auxiliary data and allows their mix to be dynamically varied--opening the door to new services and forms of programming (e.g., many channels of stereo audio, distribution of computer software, or very high resolution images). The data is compressed to 19.39 Mbits per second and delivered using a 6 MHz bandwidth channel. HD and SD assignments are per ATSC announcement on February 20, 1998.

Note that 1,088 lines are actually coded in order to satisfy the MPEG-2 requirement that the coded vertical size be a multiple of 16 (progressive scan) or 32 (interlaced scan).

See also: **HDO, HD1, HD2, MPEG-2, HDTV.**

Attached: A physical channel of a digital picture manipulator is attached to a logical channel of a controller if the physical channel is successfully acquired by the controller. A physical channel may be attached to only one logical channel of one controller at a time.

ATV: Advanced television. Digital television, including standard, enhanced and high-definition versions.

AU (also SND): Interchangeable audio file formats used in the Sun Sparcstation, Nest and Silicon Graphics (SGI) computers. Essentially a raw audio data format proceeded by an identifying header. The .au file is cross-platform compatible.

See also: **AIF, WAV.**

Autotiming: Capability of some digital video equipment to automatically adjust input video timing to match a reference video input. Eliminates the need for manual timing adjustments.

AVI: Audio video interleaving. The Microsoft Video for Windows file format for combining video and audio into a single block in time such as a 1/30th second video frame. In this file format, blocks of audio data are woven into a stream of video frames. ASF is intended to supersede AVI.

AVO: Audiovisual object. In MPEG-4, audiovisual objects (also AV objects) are the individual media objects of a scene--such as video objects, images, and 3D objects. AVOs have a time dimension and a local coordinate system for manipulating the AVO are positioned in a scene by transforming the object's local coordinate system into a common, global scene coordinate system.

Axis: Relating to digital picture manipulation, the X axis is a horizontal line across the center of the screen, the Y axis is a vertical line, and the Z axis is in the third dimension, perpendicular to the X and Y axes, and indicates depth and distance.

B frames: Bi-directional predictive frames used in the MPEG-2 signal. These are composed by assessing the difference between the previous and the next frames in a television picture sequence. As they contain only predictive information, they do not make up a complete picture and so have the advantage of taking up much less data than the I frames. However, to see that original picture requires a whole sequence of MPEG-2 frames to be decoded.

See also: **I frames, P frames, MPEG.**

Back channel: A means of communication from users to content providers. At the same time that content providers are transmitting interactive television (analog or digital) to users, users can connect through a back channel to a Web site--for example, for the original content provider or an advertiser. The back channel can be used to provide feedback, purchase goods and services, and so on. A simple type of back channel is an Internet connection using a modem.

Bandwidth: 1. The complete range of frequencies over which a circuit or electronic system can function with minimal signal loss, typically less than 3 dB. 2. The information-carrying capability of a particular television channel. In PAL systems, the bandwidth limits the maximum visible frequency to 5.5 MHz, in NTSC, 4.2 MHz. The ITU-R 601 luminance channel sampling frequency of 13.5 MHz was chosen to permit faithful digital representation of the PAL and NTSC luminance bandwidths without aliasing. In transmission, the United States analog and digital television channel bandwidth is 6 MHz.

Baseband: A signaling technique in which the signal is transmitted in its original form and not changed by modulation. Local Area Networks as a whole, fall into two categories: baseband

and broadband. Baseband networks are simpler and cheaper; the entire bandwidth of the LAN cable is used to transmit a single digital signal. In broadband networks, the capacity of the cable is divided into channels, which can transmit many simultaneous signals. Broadband networks may transmit a mixture of digital and analog signals, as will be the case in hybrid fiber/coax interactive cable television networks.

Baud: A unit of signaling speed equal to the number of signal events per second. Baud is equivalent to bits per second in cases where each signal event represents exactly one bit. Often the term baud rate is used informally to mean baud, referring to the specified maximum rate of data transmission along an interconnection. Typically, the baud settings of two devices must match if the devices are to communicate with one another.

BCD: Binary coded decimal. A coding system in which each decimal digit from 0 to 9 is represented by four binary (0 or 1) digits.

Bel: A measure of voltage, current, or power gain. One bel is defined as a tenfold increase in power. If an amplifier increases a signal's power by 10 times, its power gain is 1 bel or 10 decibels (dB). If power is increased by 100 times, the power gain is 2 bels or 20 decibels. 3 dB is considered a doubling.

BER: Bit error rate.

Betacam: An analog component VTR system using a 1/2-inch tape cassettes. This was developed by Sony and is marketed by them and several other manufacturers. Although recording the Y, R-Y and B-Y component signals onto tape many machines are operated with coded (PAL or NTSC) video in and out. The system has continued to be developed over the years to offer models for the industrial and professional markets as well as full luminance bandwidth (Betacam SP), PCM audio and SDI connections. Digital versions exist as the high-end Digital Betacam and Betacam SX for **ENG** and similar applications.

Betacam SX: A digital tape recording format developed by Sony which uses a constrained version of MPEG-2 compression at the 4:2:2 profile, Main Level (422P@ML) using 1/2-inch tape cassettes.

BIFS: Binary format for scenes. In MPEG-4, a set of elements called nodes that describe the layout of a multimedia layout BIFS-Update streams update the scene in time, BIFS-Anim streams animate the stream in time. BIFS are organized in a tree-lined hierarchical scene graph node structure derived from VRML.

Binary: A base-2 numbering system using the digits 0 and 1 (as opposed to 10 digits [0 - 9] in the decimal system). In computer systems, the binary digits are represented by two different voltages or currents, one corresponding to 0 and the other corresponding to 1. All computer programs are executed in binary form.

Binary representation requires a greater number of digits than the base 10 decimal system more commonly used. For example, the base 10 number 254 is 11111110 in binary.

The result of a binary multiplication contains the sum of digits of the original numbers. So:

10101111 x 11010100 = 1001000011101100

(In decimal 175 x 212 = 37,100)

(From right to left, the digits represent 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384, 32768)

Each digit is known as a bit. This example multiplies two 8-bit numbers to produce a 16-bit result--a very common process in digital television equipment.

See also: **Bit, Byte, Digital.**

BISDN: Broadband integrated services digital network. See: **ISDN.**

Bit: Binary digit. The smallest unit of data in a digital system. A bit is a single one or zero. A group of bits, such as 8-bits or 16-bits, compose a byte. The number of bits in a byte depends upon the processing system being used. Typical byte sizes are 8, 16, and 32.

Bit bucket: Any device capable of storing digital data--whether it be video, audio or other types of data.

Bit budget: The total amount of bits available on the media being used. In DVD, the bit budget of a single sided/single layer DVD5 disk is actually 4.7 GB.

Bit depth: The number of levels that a pixel might have, such as 256 with an 8-bit depth or 1,024 with a 10-bit depth.

Bitmap: 2-D array of pixels representing video and graphics.

Bit parallel: Transmission of digital video a byte at a time down a multi-conductor cable where each pair of wires carries a single bit. This standard is covered under SMPTE 125M, **EBU** 3267-E, and ITU-R BT.656 (CCIR 656).

Bit rate reduction: See: **Compression.**

Bit serial: Transmission of digital video a bit at a time down a single conductor such as coaxial cable. May also be sent through fiber optics. This standard is covered under ITU-R BT.656 (CCIR 656).

Bit slippage: 1. Occurs when word framing is lost in a serial signal so that the relative value of a bit is incorrect. This is generally reset at the next serial signal (TRS-ID for composite and EAV/SAV for component). 2. The erroneous reading of a serial bit stream when the recovered clock phase drifts enough to miss a bit. 3. A phenomenon that occurs in parallel digital data buses when one or more bits get out of time in relation to the rest. The result is erroneous data. Differing cable lengths is the most common cause.

Bit stream: A continuous series of bits transmitted on a line.

Block: Rectangular area of picture, usually 8 x 8 pixels in size, which are individually subjected to DCT coding as part of a digital picture compression process.

Artifact of compression generally showing momentarily as misplaced rectangular areas of picture with distinct boundaries. This is one of the major defects of digital compression, its visibility generally depending on the amount of compression used, the quality of the original signal, and the quality of the coder. The visible blocks may be 8 x 8 DCT blocks or "misplaced blocks"--16 x 16 pixel macroblocks, due to the failure of motion prediction/estimation in encoder or other motion vector system, such as a standards converter.

See also: **DCT, JPEG, Macroblock, MPEG-2.**

Boot up: To start up. Most computers contain a system operating program that they read out of memory and operate from after power up or restart. The process of reading and running that program is called boot up.

BPSK: Biphase shift keying. BPSK is a digital frequency modulation technique used for sending data over a coaxial cable network. This type of modulation is less efficient--but also less susceptible to noise--than similar modulation techniques, such as QPSK and 64QAM.

Broadband: 1. A response that is the same over a wide range of frequencies. 2. Capable of handling frequencies greater than those required for high-grade voice communications (higher than 3 to 4 kilohertz).

Broadcast FTP Protocol (BFTP): A one-way IP multicast based resource transfer protocol, the unidirectional Broadcast File Transfer Protocol (BFTP) is a simple, robust, one-way resource transfer protocol that is designed to efficiently deliver data in a one-way broadcast-only environment. This transfer protocol is appropriate for IP multicast over television vertical blanking interval (IPVBI), in IP multicast carried in MPEG-2, like with the DVB multiprotocol encapsulation, or in other unidirectional transport systems. It delivers constant bitrate (CBR) services or opportunistic services, depending on the characteristics and features of the transport stream multiplexor or VBI insertion device.

Buffer: 1. A circuit or component that isolates one electrical circuit from another. 2. A digital storage device used to compensate for a difference in the rate of flow of information or the time of occurrence of events when transmitting information from one device to another. 3. In telecommunications, a protective material used in cabling optical fiber to cover and protect the fiber. The buffer material has no optical function.

Buffer overload: See: Video coder overload.

Bus: A group of conductors that together constitute a major signal path. A signal path to which a number of inputs may be connected to feed to one or more outputs.

Bus address: A code number sent out to activate a particular device on a shared communications bus.

BWF Broadcast WAV: An audio file format based on Microsoft's WAV. It can carry PCM or MPEG encoded audio and adds the metadata, such as a description, originator, date and coding history, needed for interchange between broadcasters.

See also: **WAV.**

Byte: A group of data bits that are processed together. Typically, a byte consists of 8, 16, 24 or 32 bits.

1 Byte = 8 bits = 256 discrete values (brightness, color, etc.)
1 kilobyte = 210 bytes = 1,024 bytes: (not 1000 bytes)
1 Megabyte = 220 bytes = 1,048,576 bytes: (not 1 million bytes)
1 Gigabyte = 230 bytes = 1,073,741,824 bytes: (not one billion bytes)
1 Terabyte = 240 bytes = 1,099,511,627,776 bytes: (not one trillion bytes)

A full frame of digital television, sampled according to ITU-R 601, requires just under 1 Mbyte of storage (701 kbytes for 525 lines, 829 kbytes for 625 lines). HDTV frames are 4-to-5 times as large and digital film frames may be that much larger again.

Cable modem: A data modem that uses the bandwidth of a given cable system, which promise speeds of up to 80 times faster than an ISDN line or six times faster than a dedicated T1 line (the type of connection most large corporations use). Because cable modems provide Internet access over cable TV networks (which rely primarily on fiber optic or coaxial cable), they are much faster than modems that use phone lines. Bandwidths are typically up to 30 Mbps in the downstream direction.

Cache: Local or temporary storage.

CBR: Constant bit rate. CBR refers to the delivery of multimedia where there is dedicated bandwidth and the data can be delivered at a guaranteed constant bit rate. MPEG-1 and 2 are designed for CBR delivery. Constant bit rate cannot be assured on the Internet or most Intranets. Protocols such as RSVP are being developed and deployed to provide bandwidth guarantees.

CCD: Charge coupled device. A device that stores samples of analog signals. Used in cameras and telecines as an optical scanning mechanism. Advantages include good sensitivity in low light and absence of burn-in and phosphor lag found in CRTs.

CCIR: Comite Consultatif International des Radiocommunications (International Radio Consultative Committee), an international standards committee no longer in operation and replaced by the International Telecommunications Union (ITU).

CCIR-601: See: **ITU-R BT.601-2.**

CCIR-656: See: **ITU-R BT.656.**

CDDI: Copper data distributed interface. A high speed data interface--like FDDI but using copper.

See also: **FDDI.**

Channel: 1. A digital effects processing path for video. 2. A particular signal path. 3. A portion of the television broadcast spectrum assigned to a particular broadcasting station.

Channel coding: Data encoding and error correction techniques used to protect the integrity of data that is being transported through a channel. Typically used in channels with high bit error rates such as terrestrial and satellite broadcast and videotape recording.

Checksum: A simple check value of a block of data, calculated by adding all the bytes in a block. It is easily fooled by typical errors in data transmission systems; so that for most applications, a more sophisticated system such as CRC is preferred.

See also: **CRC.**

Chromakeying: The process of overlaying one video signal over another, the areas of overlay being defined by a specific range of color, or chrominance, on the foreground signal. For this to work reliably, the chrominance must have sufficient resolution, or bandwidth. PAL or NTSC coding systems restrict chroma bandwidth and so are of very limited use for making a chromakey which, for many years, was restricted to using live, RGB camera feeds. An objective of the ITU-R 601 digital sampling standard was to allow high quality chromakeying in post production. The 4:2:2 sampling system allowed far greater bandwidth for chroma than PAL or NTSC and helped chromakeying, and the whole business of layering, to thrive in post production. High signal quality is still important and anything but very mild compression tends to result in keying errors appearing--especially at DCT block boundaries. Chromakeying techniques have continued to advance and use many refinements, to the point where totally convincing composites can be easily created. You can no longer "see the join" and it may no longer be possible to distinguish between what is real and what is keyed.

See also: **Digital chromakeying.**

Chromininance: The color component of a video signal that includes information about hue and saturation.

See also: **Luminance.**

CIF: Common image format used to trade content worldwide. 1. For computers the size is 352x240 pixels. 2. For digital high definition, ratified by the International Telecommunications Union (ITU) in June 1999, the 1920x1080 digital sampling structure is a world format. All supporting technical parameters relating to scanning, colorimetry, transfer characteristics, etc. are universal. The CIF can be used with a variety of picture capture rates: 60p, 50p, 30p, 25p, 24p, as well as 60i and 50i. The standard is identified as ITU-R BT 709-3.

Cinepak: A high-quality medium bandwidth compression that is not real-time but can play back in software. Its 24-bit format produces high-quality video at

320 x 240 resolution and 15 frames per second at a 150 Kbps data rate. Commonly a CD-ROM solution developed a number of years ago and not a competitor to more modern techniques.

Click and drag: A computer term for the user operation of clicking on an item and dragging it to a new location.

Cliff effect: Refers to the abrupt failure of a system over a few dB or less of increasing impairment. In digital television, when a receiver can no longer receive a viable signal.

Clip: 1. In keying, the trigger point or range of a key source signal at which the key or insert takes place. 2. The control that sets this action. To produce a key signal from a video signal, a clip control on the keyer control panel is used to set a threshold level to which the video signal is compared. 3. In digital picture manipulators, a menu selection that blanks portions of a manipulated image that leave one side of the screen and "wraps" around to enter the other side of the screen. 4. In desktop editing, a pointer to a piece of digitized video or audio that serves as source material for editing.

Clip sheet: A nonlinear editing term for the location of individual audio/video clips (or scenes). Also known as a clip bin.

Clock frequency: The master frequency of periodic pulses that are used to synchronize the operation of equipment.

Clock jitter: Undesirable random changes in clock phase.

Clock phase deviation: See: **Clock skew.**

Clock recovery: The reconstruction of timing information from digital data.

Clock skew: A fixed deviation from proper clock phase that commonly appears in **D1** digital video equipment. Some digital distribution amplifiers handle improperly phased clocks by reclocking the output to fall within D1 specifications.

Clone: An exact copy, indistinguishable from the original. As in copying recorded material, for example a copy of a non-compressed recording to another non-compressed recording. If attempting to clone compressed material care must be taken not to decompress it as part of the process or the result will not be a clone.

C/N (also CNR): Carrier-to-noise ratio.

C/N threshold: The C/N at threshold of visibility (TOV) for random noise.

See also: **TOV**

Codec: Coder-decoder. A device that converts analog video and audio signals into a digital format for transmission over telecommunications facilities and also converts received digital signals back into analog format.

Co-channel interference: The interference from a signal on the same channel.

Coding: Representing each video signal level as a number, usually in binary form.

COFDM: Coded orthogonal frequency division multiplexing. Orthogonal Frequency Division Multiplexing (OFDM) is a modulated multi-carrier transmission technique, which splits the available bandwidth into many narrow sub-band channels (typically 2000-8000). Each carrier is modulated by a low rate data stream. The modulation scheme can vary from a simple QPSK to a more complex 64-QAM (or other) depending on the required binary rate and the expected transmission robustness.

For those familiar with Frequency Division Multiple Access (FDMA), OFDM is similar. However, OFDM uses the spectrum much more efficiently by providing a closer packing of the sub-band channels. To achieve this, all the carriers are made orthogonal to one another. By providing for orthogonality of carriers, each carrier has a whole number of cycles over a given symbol period.

By doing this, the occupied bandwidth of each carrier has a null at the center frequency of each of the other carriers in the system. This results in minimal interference between the carriers, allowing then to be spaced as close together as is possible. Each individual carrier of the OFDM signal has a narrow bandwidth (for example 1kHz), and the resulting symbol rate is low. This results in the signal having high immunity to multi-path delay spread, as the delay spread must be very long to cause significant inter-symbol interference (> 500 milliseconds).

Coded Orthogonal Frequency Division Multiplexing (COFDM) has the same principle as OFDM except that Forward Error Correction (FEC) is applied to the signal prior to transmission. This overcomes errors in the transmission as a result of lost carriers from multiple propagation effects including frequency selective fading and channel noise.

COFDM can transmit many streams of data simultaneously, each one occupying only a small portion of the total available bandwidth. This approach can have many advantages with proper implementation: 1. Because the bandwidth occupied by each sequence of symbols is relatively small, its duration in time is bigger. As a result, the immunity against multi-path echoes can be higher. 2. Frequency selective fades are spread over many carriers. Instead of completely destroying a number of adjacent symbols, many symbols are instead distorted only slightly. 3 By dividing available bandwidth in multiple narrow sub-bands, the frequency response over each of the individual sub-band channels is essentially flat even with steep multi-path induced fade. This can mean easier equalization requirements.

See also: **DVB and the Engineering & Transmission chapter.**

Collision: The result of two devices trying to use a shared transmission medium simultaneously. The interference ruins both signals, requiring both devices to retransmit the data lost **due** to the collision.

Co-location: In transmission, one or more transmitters located on the same antenna mast.

Color depth: The number of bits used to represent the color of a pixel and thus how many colors can be displayed. Color depth is typically 8-, 16-, or 24-bit. 8-bit would give 256 colors. A high color pixel requires at lest 24-bit color (1.1164 billion colors).

Color space: The color range between specified references. Typically references are quoted in television: **RGB,** Y, R-Y, B-Y, YIQ, YUV and Hue Saturation and Luminance (HSL). In print, Cyan, Magenta, Yellow and Black (CMYK) are used. Moving pictures between these is possible but requires careful attention to the accuracy of processing involved. Operating across the media--print, film and TV, as well as between computers and TV equipment--will require conversions in color space.

Color space conversion: The translation of color value form one color space to another. Since different media types, like video and computer graphics, use different color spaces, color space is often performed on the fly by graphics hardware.

Combiner: In digital picture manipulators, a device that controls the way in which two or more channels work together. Under software control, it determines the priority of the channels (which picture appears in front and which in back) and the types of transitions that can take place between them.

Component (video): The normal interpretation of a component video signal is one in which the luminance and chrominance remain as separate components, such as analog components in MII and Betacam VTRs, digital components Y, B-Y, R-Y(Y, Cr, Cb) in ITU-R 601. RGB is also a component signal. Component video signals retain maximum luminance and chrominance bandwidth.

Component digital: A digital representation of a component analog signal set, most often Y, B-Y, R-Y. The encoding parameters are specified by ITU-R BT.601-2 (CCIR 601). The parallel interface is specified by ITU-R BT.656 (CCIR 656) and SMPTE 125M.

Component digital post production: A method of post production that records and processes video completely in the component digital domain. Analog sources are converted only once to the component digital format and then remain in that format throughout the post production process.

Composite (video): Luminance and chrominance are combined along with the timing reference "sync" information using one of the coding standards--NTSC, PAL or SECAM--to make composite video. The process, which is an analog form of video compression, restricts the bandwidths (image detail) of components. In the composite result color is literally added to the monochrome (luminance) information using a visually acceptable technique. As our eyes have far more luminance resolving power than for color, the color sharpness (bandwidth) of the coded single is reduced to far below that of the luminance. This provides a good solution for transmission but it becomes difficult, if not impossible, to accurately reverse the process (decode) into pure luminance and chrominance which limits its use in post production.

Composite digital: A digitally encoded video signal, such as NTSC or PAL video, that includes horizontal and vertical synchronizing information.

Compress: A digital picture manipulator effect where the picture is squeezed (made proportionally smaller).

Compressed serial digital interface (CSDI): A way of compressing digital video for use on SDI-based equipment proposed by Panasonic. Now incorporated into Serial digital transport interface.

See: **Serial digital transport interface.**

Compression: Reduction of the size of digital data files by removing redundant information (lossless) or removing non-critical data (lossy).

Pictures are analyzed looking for redundancy and repetition and so discard unnecessary data. The techniques were primarily developed for digital transmission but have been adopted as a means of handling digital video in computers and reducing the storage demands for digital VTRs. Compression can be at either a set rate or a variable rate. Also known as Bit Rate Reduction (BRR)

Compression artifacts: Compacting of a digital signal, particularly when a high compression ratio is used, may result in small errors when the signal is decompressed. These errors are known as "artifacts," or unwanted defects. The artifacts may resemble noise (or edge "busyness") or may cause parts of the picture, particularly fast moving portions, to be displayed with the movement distorted or missing.

Compressionist: One who controls the compression process to produce results better than would be normally expected from an automated system.

Compression ratio: The ratio of the data in the non-compressed digital video signal to the compressed version. Modern compression techniques start with the ITU-R 601 component digital television signal so the amount of data of the non-compressed video is well defined--76 Gbytes/hour for the 525/60 standard and 75 Gbytes/hour for 625/50.
The compression ratio should not be used as the only method to assess the quality of a compressed signal. For a given technique greater compression can be expected to result in worse quality but different techniques give widely differing quality of results for the same compression ratio. The only sure method of judgment is to make a very close inspection of the resulting pictures.

Concatenation: Linking together (of systems). Although the effect on quality resulting from a signal passing through many systems has always been a concern, the use of a series of compressed digital video systems is, as yet, not well known. The matter is complicated by virtually all digital compression systems differing in some way from each other--hence the need to be aware of concatenation. For broadcast, the current NTSC and PAL analog compression systems will, more and more, operate alongside digital **MPEG** compression systems used for transmission and, possibly, in the studio.

Even the same brand and model of encoder may encode the same signal in a different manner.

See also: **Mole technology.**

Conditional access: Digital television signals can be scrambled in such a way that they cannot be understood by a conventional decoder. Only when unscrambled by a special system can the original pictures be seen by the viewer. By controlling the operation of the de-scrambling system through the use of a pre-paid access card, or by a transmitted code, the broadcaster can control access to a particular channel or service. Conditional access can be used to control many things from pay-per-view subscription through to target viewing areas. The ATSC specification, at press time, was not complete.

Contouring: Digital video picture defect caused quantizing at too coarse a level.

Contribution quality: The level of quality of a television signal from the network to its affiliates. For digital television this is approximately 45 Mbps.

Core: In fiber optic cable, the core is the light-transmitting material at the center of the fiber.

Co-siting: Relates to SMPTE 125M component digital video, in which the luminance component (Y) is sampled four times for every two samples of the two chrominance components (Cb and Cr). Co-siting refers to delaying transmission of the Cr component to occur at the same time as the second sample of luminance data. This produces a sampling order as follows: Cb1/Y1/Cr1, /Y2/, Cb2/Y3/Cr2, /Y4/, 4:2:2 with co-siting on the first, third, and fifth. Co-siting reduces required bus width from 30 bits to 20 bits.

Coverage area: Coverage area is the area within an NTSC station's Grade B contour without regard to interference from other television stations which may be present. For an ATV station, coverage area is the area contained within the station's noise-limited contour without regard to interference which may be present.

CRC: Cyclic redundant check. Used in data transfer to check if the data has been corrupted. It is a check value calculated for a data stream by feeding it through a shifter with feedback terms "EXORed" back in. It performs the same function as a checksum but is considerably harder to fool.

A CRC can detect errors but not repair them, unlike an ECC--which is attached to almost any burst of data that might possibly be corrupted. They are used on disks, ITU-R 601 data, Ethernet packets, etc.

CSDI: See: Compressed serial digital interface.

D1: A format for component digital video tape recording working to the ITU-R 601, 4:2:2 standard using 8-bit sampling. The tape is 19 mm wide and allows up to 94 minutes to be recorded on a cassette. Being a component recording system it is ideal for studio or post production work with its high chrominance bandwidth allowing excellent chroma keying. Also multiple generations are possible with very little degradation and D1 equipment can integrate without transcoding to most digital effects systems, telecines, graphics devices, disk recorders, etc. Being component there are no color framing requirements. Despite the advantages, D1 equipment is not extensively used in general areas of TV production, at least partly due to its high cost. (Often used incorrectly to indicate component digital video.)

D2: The VTR standard for digital composite (coded) NTSC or PAL signals that uses data conforming to SMPTE **244M.** It uses 19 mm tape and records up to 208 minutes on a single cassette. Neither cassettes nor recording formats are compatible with D1. D2 has often been used as a direct replacement for 1-inch analog VTRs. Although offering good stunt modes and multiple generations with low losses, being a coded system means coded characteristics are present. The user must be aware of cross-color, transcoding footprints, low chrominance bandwidths and color framing sequences. Employing an 8-bit format to sample the whole coded signal results in reduced amplitude resolution making D2 more susceptible to contouring artifacts. (Often used incorrectly to indicate composite digital video.)

D3: A composite digital video recording format that uses data conforming to SMPTE 244M. Uses 1/2-inch tape cassettes for recording digitized composite (coded) PAL or NTSC signals sampled at 8 bits. Cassettes are available for 50 to 245 minutes. Since this uses a composite signal the characteristics are generally as for D2 except that the 1/2-inch cassette size has allowed a full family of VTR equipment to be realized in one format, including a camcorder.

D4: A format designation never utilized due to the fact that the number four is considered unlucky (being synonymous with death in some Asian languages).

D5: A VTR format using the same cassette as D3 but recording component signals conforming to the ITU-R BT.601-2 (CCIR 601) recommendations at 10-bit resolution. With internal decoding D5 VTRs can play back D3 tapes and provide component outputs. Being a non-compressed component digital video recorder means D5 enjoys all the performance benefits of D1, making it suitable for high-end post production as well as more general studio use. Besides servicing the current 625 and 525 line TV standards the format also has provision for HDTV recording by use of about 4:1 compression (HD D5).

See also: **HD D5.**

D6: A digital tape format which uses a 19mm helical-scan cassette tape to record uncompressed high definition television material at 1.88 GBps (1.2 Gbps). D6 is currently the only high definition recording format defined by a recognized standard. D6 accepts both the European 1250/50 interlaced format and the Japanese 260M version of the 1125/60 interlaced format which uses 1035 active lines. It does not accept the ITU format of 1080 active lines. ANSI/SMPTE 277M and 278M are D6 standards.

D7: DVCPRO. Panasonic's development of native DV component format which records a 18 micron (18x10-6m, eighteen thousandths of a millimeter) track on 6.35 mm (0.25-inch) metal particle tape. DVCPRO uses native DCT-based DV compression at 5:1 from a 4:1:1 8-bit sampled source. It uses 10 tracks per frame for 525/60 sources and 12 tracks per frame for 625/50 sources, both use 4:1:1 sampling. Tape speed is 33.813m/s. It includes two 16-bit digital audio channels sampled at 48 kHz and an analog cue track. Both Linear (LTC) and Vertical Interval Time Code (VITC) are supported. There is a 4:2:2 (DVCPRO50) and progressive scan 4:2:0 (DVCPRO P) version of the format, as well as a high definition version (DVCPROHD).

See also: **DVCPRO50, DVCPROHD, DVCPRO P.**

D8: There is no D8. The Television Recording and Reproduction Technology Committee of SMPTE decided to skip D8 because of the possibility of confusion with similarly named digital audio or data recorders (DA-88).

D9 (Formerly Digital-S): A 1/2-inch digital tape format developed by JVC which uses a high-density metal particle tape running at 57.8mm/s to record a video data rate of 50 Mbps. The tape can be shuttled and search up to 32x speed. Video sampled at 4:2:2 is compressed at 3.3:1 using DCT-based intra-frame compression (DV). Two or four audio channels are recorded at 16-bit, 48 kHz sampling; each is individually editable. The format also includes two cue tracks. Some machines can play back analog S-VHS. D9 HD is the high definition version recording at 100 Mbps.

D9 HD: A high definition digital component format based on D9. Records on 1/2-inch tape with 100 Mbps video.

D16: A recording format for digital film images making use of standard D1 recorders. The scheme was developed specifically to handle Quantel's Domino (Digital Opticals for Movies) pictures and record them over the space that sixteen 625 line digital pictures would occupy. This way three film frames can be recorded or played every two seconds. Playing the recorder allows the film images to be viewed on a standard monitor; running at 16x speed shows full motion direct from the tape.

DA-88: A Tascam-brand eight track digital audio tape machine using the 8 mm video format of Sony. It has become the de facto standard for audio post production though there are numerous other formats, ranging from swappable hard drives to analog tape formats and everything in between.

DAC (D-A, D/A, D-to-A): Digital-to-analog converter.

See also: **ADC.**

Data compression: A technique that provides for the transmission or storage, without noticeable information loss, of fewer data bits than were originally used when the data was created.

Data recorders: Machines designed to record and replay data. They usually include a high degree of error correction to ensure that the output data is absolutely correct and, due to their recording format, the data is not easily editable. This compares with video recorders which will conceal missing or incorrect data by repeating adjacent areas of picture and which are designed to allow direct access to every frame for editing. Where data recorders are used for recording video there has to be an attendant "workstation" to see the pictures or hear the sound, whereas VTRs produce the signals directly. Although many data recorders are based on VTRs' original designs, and vice versa, VTRs are more efficient for pictures and sound while data recorders are most appropriate for data.

dB (decibel): A measure of voltage, current, or power gain equal to 1/10 of a bel. Given by the equations 20 log Vout/Vin, 20 log Iout/Iin, or 10 log Pout/Pin. See also: Bel.

DBS: Digital broadcast system. An alternative to cable and analog satellite reception initially utilizing a fixed 18-inch dish focused on one or more geostationary satellites. DBS units are able to receive multiple channels of multiplexed video and audio signals as well as programming information, Email, and related data. DBS typically uses MPEG-2 encoding and COFDM transmission. Also known as digital satellite system.

D-Cinema (also E-Cinema): Digital cinema. Typically the process of using video at 1080/24p instead of film for production, post production and presentation.

DCT: 1. Discrete cosine transform. A widely used method of data compression of digital video pictures basically by resolving blocks of the picture (usually 8 x 8 pixels) into frequencies, amplitudes, and colors. JPEG and DV depend on DCT. 2. Also an Ampex data videotape format using discrete cosine transform.

DD2: Using D2 tape, data recorders have been developed offering (by computer standards) vast storage of data (which may be images). A choice of data transfer rates is available to suit computer interfaces. Like other computer storage media, images are not directly viewable, and editing is difficult.

DDR: Digital disk recorder. See: Disk recorder.

DDS: Digital data service.

Demultiplexing: Separating elementary streams or individual channels of data from a single muti-channel stream. For example, video and audio streams must be demultiplexed before they are decoded. This is true for multiplexed digital television transmissions.

See also: **Multiplex.**

DEMUX: Demultiplexer. See: Demultiplexing.

Deserializer: A device that converts serial digital information to parallel digital.

Desktop video: Video editing and production done using standard desktop computing platforms running add-on video hardware and software.

DM: Drop and insert. A point in the transmission where portions of the digital signal can be dropped out and/or inserted.

Diagnostics: Tests to check the correct operation of hardware and software. As digital systems continue to become more complex, built-in automated testing becomes an essential part of the equipment. Some extra hardware and software has to be added to make the tests operate. Digital systems with such provisions can often be quickly assessed by a trained service engineer, so speeding repair.

Digital: Circuitry in which data carrying signals are restricted to either of two voltage levels, corresponding to logic 1 or 0. A circuit that has two stable states: high or low, on or off.

Digital Betacam: A development of the original analog Betacam VTR which records digitally on a Betacam-style cassette. It uses mild intra-field compression to reduce the ITU-R **601** sampled video data by about 2:1. Some models can replay both digital and analog Betacam cassettes.

Digital chromakeying: Digital chromakeying differs from its analog equivalent in that it can key uniquely from any one of the 16 million colors represented in the component digital domain. It is then possible to key from relatively subdued colors, rather than relying on highly saturated colors that can cause color spill problems on the foreground.

A high-quality digital chromakeyer examines each of the three components of the picture and generates a linear key for each. These are then combined into a composite linear key for the final keying operation. The use of three keys allows much greater subtlety of selection than does a chrominance-only key

Digital components: Component video signals that have been digitized.

Digital disk recorder (DDR): A video recording device that uses a hard disk drive or optical disk drive mechanism. Disk recorders offer nearly instantaneous access to recorded material.

Digital effects: Special effects created using a digital video effects (DVE) unit.
Digital parallel distribution amplifier: A distribution amplifier designed to amplify and fan-out parallel digital signals.

Digital-S: See: **D9.**

Digital word: The number of bits treated as a single entity by the system.

Digitizing time: Time taken to record footage into a disk-based editing system, usually from a tape-based analog system, but also from newer digital tape formats without direct digital connections.

Distribution quality: The level of quality of a television signal from the station to its viewers. For digital television this is approximately 19.39 Mbps.

Dither: A form of smart conversion from a higher bit depth to a lower bit depth, used in the conversion of audio and graphic files. In the conversion from 24-bit color to 8-bit color (millions of colors reduced to 256), the process attempts to improve on the quality of on-screen graphics with reduced color palettes by adding patterns of different colored pixels to simulate the original color. The technique is also known as "error diffusion," and is applied to audio bit rate reduction and graphic resolution.

DNG: Digital news gathering. Electronic news gathering **(ENG)** using digital equipment and/or transmission.

Dolby Digital (formerly Dolby AC-3): The approved 5.1 channel (surround-sound) audio standard for ATSC digital television, using approximately 13:1 compression

Six discrete audio channels are used: Left, Center, Right, Left Rear (or side) Surround, Right Rear (or side) Surround, and a subwoofer (considered the ".1" as it is limited in bandwidth). The bit rate can range from 56 kbps to 640 kbps, typically 64 kbps mono, 192 kbps two-channel, 320 kbps 35mm Cinema 5.1, 384 kbps Laserdisc/DVD 5.1 and ATSC, 448 kbps 5.1.

When moving from analog recording to a digital recording medium, the digital audio coding used yields an amount of data often too immense to store or transmit economically, especially when multiple channels are required. As a result, new forms of digital audio coding--often known as "perceptual coding"--have been developed to allow the use of lower data rates with a minimum of perceived degradation of sound quality.

Dolby's third generation audio coding algorithm (originally called AC-3) is such a coder.

This coder has been designed to take maximum advantage of human auditory masking in that it divides the audio spectrum of each channel into narrow frequency bands of different sizes, optimized with respect to the frequency selectivity of human hearing. This makes it possible to sharply filter coding noise so that it is forced to stay very close in frequency to the frequency components of the audio signal being coded. By reducing or eliminating coding noise wherever there are no audio signals to mask it, the sound quality of the original signal can be subjectively preserved. In this key respect, a coding system like Dolby Digital is essentially a form of very selective and powerful noise reduction.

Dolby E: A new coding system designed specifically for use with video available from Dolby Laboratories. The audio framing is matched to the video framing, which allows synchronous and seamless switching or editing of audio and video without the introduction of gaps or AN sync slips. All of the common video frame rates, including 30/29.97, 25, and 24/23.976, can be supported with matched Dolby E audio frame sizes. The Dolby E coding technology is intended to provide approximately 4:1 reduction in bit rate. The reduction ratio is intentionally limited so that the quality of the audio may be kept very high even after a number of encode-decode generations. The fact that operations such as editing and switching can be performed seamlessly in the coded domain allows many coding generations to be avoided, further increasing quality.

A primary carrier for the Dolby E data will be the AES/EBU signal. The Dolby E coding will allow the two **PCM** audio channels to be replaced with eight encoded audio channels. A VTR PCM track pair will become capable of carrying eight independent audio channels, plus the accompanying metadata. The system is also intended to be applied on servers and satellite links. A time delay when encoding or decoding Dolby E is unavoidable. In order to facilitate the provision of a compensating video delay, the audio encoding and decoding delay have been fixed at exactly one frame. When applied with video recording formats which incorporate frame based video encoding, it can be relatively easy to provide for equal video and audio coding delays. When applied with uncoded video, it may be necessary to provide a compensating one frame video delay.

Dolby Surround (Dolby Stereo, & Dolby 4:2:4): Matrix Analog coding of four audio channels--Left, Center, Right, Surround (LCRS), into two channels referred to as Right-total and Left-total (Rt, Lt). On playback, a Dolby Surround Pro Logic decoder converts the two channels to LCRS and, optionally, a subwoofer channel. The Pro Logic circuits are used to steer the audio and increase channel separation. The Dolby Surround system, originally developed for the cinema, is a method of getting more audio channels but suffers from poor channel separation, a mono limited bandwidth surround channel and other limitations. A Dolby Surround track can be carried by analog audio or linear PCM, Dolby Digital and MPEG compression systems.

Down converting: The process which changes the number of pixels and/or frame rate and/or scanning format used to represent an image by removing pixels. Down converting is done from high definition to standard definition.

See also: **Side converting, up converting.**

DQPSK: Differential quadrature phase shift keying. DQPSK is a digital modulation technique commonly used with cellular systems. Motorola's CyberSurfr cable modem uses DQPSK to carry data upstream from the subscriber's computer to the Internet on a narrower frequency band than standard QPSK. Narrower bands allow more upstream channels, so the CyberSurfr has additional noise-free channels to choose from when it's installed.

DRAM: Dynamic RAM (Random Access Memory). High density, cost-effective memory chips (integrated circuits). Their importance is such that the Japanese call them the "rice of electronics." **DRAMs** are used extensively in computers and generally in digital circuit design, but also for building framestores and animation stores. Being solid state, there are no moving parts and they offer the densest available method for accessing or storing data. Each bit is stored on a single transistor, and the chip must be powered and clocked to retain data.

DSO: Digital signal level zero, 64 kbps.

DS1: A telephone company format for transmitting information digitally. DS1 has a capacity of 24 voice circuits at a transmission speed of 1.544 megabits per second.

See also: **T1.**

DS3: A terrestrial and satellite format for transmitting information digitally. DS3 has a capacity of 672 voice circuits at a transmission speed of 44.736 Mbps (commonly referred to as 45 Mbps). DS3 is used for digital television distribution using mezzanine level compression--typically MPEG-2 in nature, decompressed at the local station to full bandwidth signals (such as HDTV) and then re-compressed to the ATSC's 19.39 Mbps transmission standard.

DSL: Digital subscriber line. The ability to use a standard telephone line to transport data. xDSL is the generic term for each of two varieties: ADSL (asynchronous), where the upstream and downstream data rates are different, and SDSL (synchronous), where the upstream and downstream data rates are the same.

DSS: Digital satellite system.Due to trademark issues, the abbreviation is no longer used. See DBS.

DTT: Digital terrestrial television. The term used in Europe to describe the broadcast of digital television services using terrestrial frequencies.

DTV Team, The: Originally Compaq, Microsoft and Intel, later joined by Lucent Technologies. The DTV Team promotes the computer industry's views on digital television--namely, that DTV should not have interlace scanning formats but progressive scanning formats only. (Intel, however, now supports all the ATSC Table 3 formats, including those that are interlace, such as 1080i.) Internet: http://wwi.dtv. orgi.

DV: This digital VCR format is a cooperation between Hitachi, JVC, Sony, Matsushita, Mitsubishi, Philips, Sanyo, Sharp, Thomson and Toshiba. It uses 6.35 mm (0.25-inch) wide tape in a range of products to record 525/60 or 625/50 video for the consumer (DV) and professional markets (Panasonic's DVCPRO, Sony's DVCAM and Digital-8). All models use digital intra-field DCT-based "DV" compression (about 5:1) to record 8-bit component digital video based on 13.5 MHz luminance sampling. The consumer versions, DVCAM, and Digital-8 sample video at 4:1:1 (525/60) or 4:2:0 (625/50) video (DVCPRO is 4:1:1 in both 525/60 and 625/25) and provide two

16-bit/48 or 44.1 kHz, or four 12-bit/32 kHz audio channels onto a 4 hour 30 minutes standard cassette or smaller 1 hour "mini" cassette. The video recording rate is 25 Mbps.

DVB: Digital video broadcasting. The group, with over 200 members in 25 countries, which developed the preferred scheme for digital broadcasting in Europe. The DVB Group has put together a satellite system--DVB-S--that can be used with any transponder, current or planned, a matching cable system--DVB-C, and a digital terrestrial system--DVB-T. Internet: httpliwww.dvb.orgi.

See also: **DVB-T.**

DVB-T: The DVB-T is a transmission scheme for terrestrial digital television. Its specification was approved by ETSI in February 1997 and DVB-T services began in 1998. As with the other DVB standards, MPEG-2 sound and picture coding form the basis of DVB-T. It uses a transmission scheme based on Coded Orthogonal Frequency Division Multiplexing (COFDM), which spreads the signals over a large number of carriers to enable it to operate effectively in very strong multipath environments. The multipath immunity of this approach means that DVB-T can operate an overlapping network of transmitting stations with a single frequency. In the areas of overlap, the weaker of the two received signals is rejected.

See also: **COFDM, DVB.**

DVCAM: Sony's development of native DV which records a 15 micron (15x10-6m, fifteen thousandths of a millimeter) track on a metal evaporated (ME) tape. DVCAM uses DV compression of a 4:1:1 signal for $52^{5}/_{6}0$ (NTSC) sources and 4:2:0 for 625/50 (PAL). Audio is recorded in one of two forms--four 12-bit channels sampled at 32 kHz, or two 16-bit channels sampled at 48 kHz.

DVCPRO: See: **D7.**

DVCPRO50: This variant of DV uses a video data rate of 50 Mbps--double that of other DV systems--and is aimed at the higher quality end of the market. Sampling is 4:2:2 to give enhanced chroma resolution, useful in post production processes (such as chromakeying). Four 16-bit audio tracks are provided. The format is similar to Digital-S (D9).

DVCPRO HD: This variant of DV uses a video data rate of 100 Mbps--four times that of other DV systems--and is aimed at the high definition EFP end of the market. Eight audio channels are supported. The format is similar to D9 HD.

DVCPRO P: This variant of DV uses a video data rate of 50 Mbps--double that of other DV systems--to produce a 480 progressive picture. Sampling is 4:2:0.

DVD: Digital versatile disk: A high density development of the compact disk. It is the same size as a CD but stores from 4.38 GB (seven times CD capacity) on a single sided, single layer disk. DVDs can also be double sided or dual layer-storing even more data. The capacities commonly available at present:

DVD-5: 4.7 GB (1 side, 1 layer)

DVD-9: 8.5 GB (1 side, 2 layers)

DVD-10: 9.4 GB (2 sides, 1 layer each)

DVD-18: 17.0 GB (2 sides, 2 layers)

DVD-R: 4.7 GB (1 side, 1 layer) (write once)

DVD-RAM: 2.6 GB (per side, 1 layer) (rewritable)

***DVD-RAM:** 4.7 GB (per side, 1 layer) (rewritable)
*Expected in 2000.

DVE: Digital video effects. A registered trademark of Nippon Electric Company. Refers to video equipment that performs digital effects such as compression and transformation.

DVTR: Digital videotape recorder.

Dynamic Rounding: The intelligent truncation of digital signals. Some image processing requires that two signals are multiplied, for example in digital mixing, producing a 16-bit result from two original 8-bit numbers (see: Byte). This has to be truncated, or rounded, back to 8-bits. Simply dropping the lower bits can result in visible contouring artifacts especially when handling pure computer generated pictures.

Dynamic Rounding is a mathematical technique for truncating the word length of pixels--usually to their normal 8-bits. This effectively removes the visible artifacts and is non-cumulative on any number of passes. Other attempts at a solution have involved increasing the number of bits, usually to 10, making the LSBs (least significant bit) smaller but only masking the problem for a few generations.

Dynamic Rounding is a licensable technique, available from Quantel and is used in a growing number of digital products both from Quantel and other manufacturers.

EAV: End of active video in component digital systems.

EBU: European Broadcasting Union. An organization of European broadcasters that, among other activities, produces technical statements and recommendations for the 625/50 line television system. CP 67, CH-1218 Grand-Saconnex GE, Switzerland. Tel: 011-41-22-717-2221. Fax: 011-41-22-717-2481. Email: ebunebu.cri. Internet: http://www.ebu.chl.

ECC: Error Check and Correct. A block of check data, usually appended to a data packet in a communications channel or to a data block on a disk, which allows the receiving or reading system both to detect small errors in the data stream (caused by line noise or disk defects) and, provided they are not too long, to correct them.

E-Cinema (also D-Cinema): Electronic cinema. Typically the process of using video at 1080/24p instead of film for production, post production and presentation.

EDH: Error detection and handling for recognizing inaccuracies in the serial digital signal. It may be incorporated into serial digital equipment and employ a simple LED error indicator.

Electronic Programming Guide (EPG): An application that provides an on-screen listing of all programming arid content that an interactive television service subscriber or digital television viewer has available to them.

See also: **PSIP.**

Embedded audio: Digital audio that is multiplexed and carried within an SDI connection--so simplifying cabling and routing. The standard (ANSI/SMPTE 272M-1994) allows up to four groups each of four mono audio channels. Generally VTRs only support Group 1 but other equipment may use more, for example Quanters Clipbox server connection to an edit seat uses groups 1-3 (12 channels). 48 kHz synchronous audio sampling is pretty well universal in TV but the standard also includes 44.1 and 32 kHz synchronous and asynchronous sampling. Synchronous means that the audio sampling clock is genlocked to the associated video (8,008 samples per five frames in 525/60, 1,920 samples per frame in 625/50). Up to 24-bit samples are allowed but mostly only up to 20 are currently used. 48 kHz sampling means an average of just over three samples per line, so three samples per channel are sent on most lines and four occasionally--the pattern is not specified in the standard. Four channels are packed into an Ancillary Data Packet and sent once per line (hence a total of 4 x 3 = 12 or 4 x 4 = 16 audio samples per packet per line).

Enhancements: Producers add these to interactive and digital television, as well as other digital content to enhance program material. Examples are supplementary text and graphics that add more depth and richness, or links to reach a Web site, as is done using TV Crossover Links. In analog, the vertical blanking interval (VBI) is used to broadcast enhancements, while in digital, the enhancements are part of the ATSC MPEG-2 stream. Enhancements can be created using industry-standard tools and technologies, like HTML and the ECMA Internet Scripting.

Encryption: The process of coding data so that a specific code or key is required to restore the original data. In broadcast, this is used to make transmissions secure from unauthorized reception as is often found on satellite or cable systems.

Error concealment: In digital video recording systems, a technique used when error correction fails. Erroneous data is replaced by data synthesized from surrounding pixels.

Error correction: In digital video recording systems, a scheme that adds overhead to the data to permit a certain level of errors to be detected and corrected.

Error detection: Checking for errors in data transmission. A calculation is made on the data being sent and the results are sent along with it. The receiver then performs the same calculation and compares its results with those sent. If an error is detected the affected data can be deleted and retransmitted, the error can be corrected or concealed, or it can simply be reported.

Error detection and handling: See: **EDH.**

Essence: The actual program (audio, video and/or data) without metadata.

See also: **Metadata.**

Ethernet (IEEE 802.3): A type of high-speed network for interconnecting computing devices. Ethernet can be either 10 or 100 Mbps (Fast Ethernet). Ethernet is a trademark of Xerox Corporation, Inc.

Extended Studio PAL: A 625-line video standard that allows processing of component video quality digital signals by composite PAL equipment. The signal can be distributed and recorded in a composite digital form using D2 or D3 VTRs.

FDDI: Fiber Distributed Data Interface. Standards for a 100 Mbps local area network, based upon fiber optic or wired media configured as dual counter rotating token rings. This configuration provides a high level of fault tolerance by creating multiple connection paths between nodes--connections can be established even if a ring is broken.

Fiber bundle: A group of parallel optical fibers contained within a common jacket. A bundle may contain from just a few to several hundred fibers.

Fiber Channel: See: **Fibre Channel.**

Fiber optics: Thin glass filaments within a jacket that optically transmits images or signals in the form of light around corners and over distances with extremely low losses.

Fibre Channel (also Fiber Channel): A high speed data link planned to run up to 2 Gbps on a fiber optic cable. A number of manufacturers are developing products to utilize the Fiber Channel--Arbitrated Loop (FC-AL) serial storage interface at 1 Gbps so that storage devices such as hard disks can be connected. Supports signaling rates from 132.8 Mbps to 1,062.5 Mbps, over a mixture of physical media including optical fiber, video coax, miniature coax, and shielded twisted pair wiring. The standard supports data transmission and framing protocols for the most popular channel and network standards including SCSI, HIPPI, Ethernet, Internet Protocol, and ATM.

Field: In an interlaced-scanning format, a frame consists of a field of even scan lines or a field of odd scan lines captured or displayed at different times. In a progressive-scanning format, a field is the same as a frame.

See also: Frame

FireWire: Apple Computer's trademark for IEEE 1394.

See: **IEEE 1394.**

Fixed data rate compression: Techniques designed to produce a data stream with a constant data rate. Such techniques may vary the quality of quantization to match the allocated bandwidth.

Format conversion: The process of both encoding/decoding and resampling digital rates to change a digital signal from one format to another.

Fractual compression: A technique for compressing images that uses fractals. It can produce high quality and high compression ratios. The drawback to fractal compression is that it is computationally expensive, so therefore takes a long time.

Fragmentation: The scattering of data over a disk caused by successive recording and deletion operations. Generally this will eventually result in slow data recall--a situation that is not acceptable for video recording or replay. The slowing is caused by the increased time needed to randomly access data. With such stores, defragmentation routines arrange the data (by copying from one part of the disk to another) so that it is accessible in the required order for replay. Clearly any change in replay, be it a transmission running order or the revision of an edit, could require further de-fragmentation. True random access disk stores, able to play frames in any order at video rate, never need de-fragmentation.

Frame: A frame is one complete image in a sequence of images. In video, the frame captures and displays all pixels and lines of an image. In a progressive-scanning format, there is no decomposition into fields. In an interlaced-scanning format, the frame consists of odd and even line fields, captured or displayed at different times, which in combination contain all pixels and lines of an image. The frame rate of a progressive scan format is twice that of an interlace scan format.

Frame buffer: Memory used to store a complete frame of video.

Frame synchronizer: A digital buffer that, by storage, comparison of sync information to a reference, and timed release of video signals, can continuously adjust the signal for any timing errors.

Freeze: In digital picture manipulators, the ability to stop or hold a frame of video so that the picture is frozen like a snapshot.

Freeze frame: The storing of a single frame of video.

Generation (loss): The signal degradation caused by successive recordings. Freshly recorded material is first generation, one re-recording, or copy, makes the second, etc. This is of major concern in analog linear editing but much less so using a digital suite. Non-compressed component DVTRs should provide at least twenty generations before any artifacts become noticeable, but the very best multi-generation results are possible with disk-based systems. Generations are effectively limitless. Besides the limitations of recording, the action of processors such as decoders and coders will make a significant contribution to generation loss. The decode/recode cycle of NTSC and **PAL** is well known for its limitations but equal caution is needed for digital video compression systems, especially those using **MPEG,** and the color space conversions that typically occur between computers handling RGB and video equipment using Y, Cr, Cb.

See also: **Color space, concatenation, error concealment, error correction, error detection.**

GIF (pronounced jif): Graphics interchange format. A computer graphics file format developed by CompuServe for use in compressing graphic images, now commonly used on the Internet. GIF compression is lossless, supports transperancy, but allows a maximum of only 256 colors. Images that will gain the most from GIF compression are those which have large areas (especially horizontal area) with no changes in color.

GoP: See: **Group of pictures.**

Grand Alliance: The United States grouping, formed in May 1993, to produce "the best of the best" initially proposed HDTV systems. The participants are: AT&T, General Instrument Corporation, Massachusetts Institute of Technology, Philips Consumer Electronics, David Sarnoff Research Center, Thomson Consumer Electronics and Zenith Electronics Corporation.

The format proposed is known as the ATSC format.

See also: **ATSC.**

Group of pictures: In an MPEG signal the GoP is a group of frames between successive I frames, the others being P and/or B frames. In the widest used application, television transmission, the GoP is typically 12 frames but this can vary--a new sequence starting with an I frame may be generated if there is a big change at the input, such as a cut. If desired, SMPTE time code data can be added to this layer for the first picture in a GoP.

H.263: A standard for variable low bit rate coding of video. 11.263 is better than MPEG-1/MPEG-2 for low resolutions and low bit rates. H.263 is less flexible than MPEG, but therefore requires much less overhead.

HD-0: A set of formats based partially on the ATSC Table 3, suggested by The DTV Team as the initial stage of the digital television rollout. Pixel values represent full aperture for ITU-R 601.

The DTV Team's HDO Compression Format Constraints

HD-1: A set of formats partially based on the ATSC Table 3, suggested by The DTV Team as the second stage of the digital television rollout, expected to be formalized in the year 2000. Pixel values represent full aperture for ITU-R 601. (Items in bold have been added to HD-0.)

The DTV Team's HD1 Compression Format Constraints

HD-2: A set of formats partially based on the ATSC Table 3, suggested by The DTV Team as the third stage of the digital television rollout contingent on some extreme advances in video compression over the next five years. Pixel values represent full aperture for ITU-R 601. (Items in bold have been added to HD-1.)

The DTV Team's HD2 Compression Format Constraints

HD D5: A compressed recording system developed by Panasonic which uses compression at about 4:1 to record HD material on standard D5 cassettes. HD D5 supports the 1080 and the 1035 interlaced line standards at both 60 Hz and 59.94 Hz field rates, all 720 progressive line standards and the 1080 progressive line standard at 24, 25 and 30 frame rates. Four uncompressed audio channels sampled at 40 kHz, 20 bits per sample, are also supported.

HDCAM: Sometimes called HD Betacam--is a means of recording compressed high-definition video on a tape format (1/2-inch) which uses the same cassette shell as Digital Betacam, although with a different tape formulation. The technology is aimed specifically at the USA and Japanese 1125/60 markets and supports both 1080 and 1035 active line standards. Quantization from 10 bits to 8 bits and DCT intra-frame compression are used to reduce the data rate. Four uncompressed audio channels sampled at 48 kHz, 20 bits per sample, are also supported.

HDTV: High definition television. The 1,125-, 1,080- and 1,035-line interlace and 720 and 1,080-line progressive formats in a 16:9 aspect ratio. Officially a format is high definition if it has at least twice the horizontal and vertical resolution of the standard signal being used. There is a debate as to whether 480-line progressive is also high definition. It is the opinion of the editors that 480-line progressive is not an HDTV format, but does provide better resolution than 480-line interlace, making it an enhanced definition format.

HFC: Hybrid fiber coax. A type of network that contains both fiber-optic cables and copper coaxial cables. The fiber-optic cables carry TV signals from the head-end office to the neighborhood; the signals are then converted to electrical signals and then go to coaxial cables.

HIPPI: High performance parallel interface. A parallel data channel used in mainframe computers that supports data transfer rates of 100 Mbps.

Huffman coding: This compresses data by assigning short codes to frequently-occurring sequences and longer ones to those less frequent. Assignments are held in a Huffman Table. The more likely a sequence is to occur the shorter will be the code that replaces it. It is widely used in video compression systems where it often contributes a 2:1 reduction in data.

I frames: One of the three types of frames that are used in MPEG-2 coded signals. These contain data to construct a whole picture as they are composed of information from only one frame (intraframe). The original information is compressed using DCT.

See also: **B frames, P frames, MPEG.**

Icon: In desktop computing and editing, a graphic symbol that represents a file, a tool, or a function.

IEEE 1394 (FireWire): A low-cost digital interface originated by Apple Computer as a desktop LAN and developed by the IEEE 1394 working group. Can transport data at 100, 200, or 400 Mbps. One of the solutions to connect digital television devices together at 200 Mbps.

Serial Bus Management provides overall configuration control of the serial bus in the form of optimizing arbitration timing, guarantee of adequate electrical power for all devices on the bus, assignment of which IEEE 1394 device is the cycle master, assignment of isochronous channel ID, and notification of errors.

There are two types of IEEE 1394 data transfer: asynchronous and isochronous. Asynchronous transport is the traditional computer memory-mapped, load and store interface. Data requests are sent to a specific address and an acknowledgment is returned.

In addition to an architecture that scales with silicon technology, IEEE 1394 features a unique isochronous data channel interface. Isochronous data channels provide guaranteed data transport at a pre-determined rate. This is especially important for time-critical multimedia data where just-in-time delivery eliminates the need for costly buffering.

i.LINK: Sony's trademark for IEEE 1394.

See: **IEEE 1394.**

Illegal colors: Colors that force a color system to go outside its normal bounds. Usually these are the result of electronically painted images rather than direct camera outputs. For example, removing the luminance from a high intensity blue or adding luminance to a strong yellow in a paint system may well send a subsequent NTSC or PAL coded signal too high or low--producing at least inferior results and maybe causing technical problems. Out of gamut detectors can be used to warn of possible problems.

Interactive television: A combination of television with interactive content and enhancements. Interactive television provides better, richer entertainment and information, blending traditional TV-watching with the interactivity of a personal computer. Programming can include richer graphics, one-click access to Web sites through TV Crossover Links, electronic mail and chats, and online commerce through a back channel.

See also: **Back channel.**

Interframe coding: Data reduction based on coding the differences between a prediction of the data and the actual data. Motion compensated prediction is typically used, based on reference frames in the past and the future.

Interlaced: Short for interlaced scanning. Also called line interlace. A system of video scanning whereby the odd- and even-numbered lines of a picture are transmitted consecutively as two separate interleaved fields. Interlace is a form of compression.

Interpolation (spatial): When re-positioning or re-sizing a digital image inevitably more, less or different pixels are required from those in the original image. Simply replicating or removing pixels causes unwanted artifacts. For far better results the new pixels have to be interpolated--calculated by making suitably weighted averages of adjacent pixels--to produce a more transparent result. The quality of the results will depend on the techniques used and the number of pixels (points--hence 16-point interpolation), or area of original picture, used to calculate the result.

Interpolation (temporal): Interpolation between the same point in space on successive frames. It can be used to provide motion smoothing and is extensively used in standards converters to reduce the judder caused by the 50/60 Hz field rate difference. The technique can also be adapted to create frame averaging for special effects.

Intraframe Coding: Video coding within a frame of a video signal.

See also: **I frames.**

I/O: Input/output. Typically refers to sending information or data signals to and from devices.

IP: See: **TCP/IP.**

ISDB: Integrated services digital broadcasting. Japan's transmission specification for digital broadcasting. ISDB uses a new transmission scheme called BST-OFDM that ensures the flexible use of transmission capacity and service expandability in addition to the benefits of OFDM. Since OFDM uses a large number of carriers that are digitally modulated. It provides sufficient transmission quality under multipath interference. The basic approach of BST-OFDM is that a transmitting signal consists of the required number of narrow band OFDM blocks called BST-segments, each with a bandwidth of 100 kHz.

ISDN: Integrated services digital network. Allows data to be transmitted at high speed over the public telephone network. ISDN operates from the Basic Rate of 64 kbits/sec to the Primary Rate of 2 Mbps (usually called ISDN-30 as it comprises 30 Basic Rate channels). Most of the Western world currently has the capability to install ISDN-2 with 128 kbps and very rapid growth is predicted for ISDN generally. In the television and film industries, audio facilities are already using it. The cost of a call is usually similar to using a normal telephone.

Nominally ISDN operates internationally, but there are variations in standards, service and ISDN adapter technologies. Some operators in the USA use a similar system, Switch 56 (56 kbits/sec and upwards), although the availability of ISDN is becoming wider.

ITU: International Telecommunications Union. An international broadcast standards committee that replaced the CCIR. Place des Nations, CH-1211 Geneva 20, Switzerland. Tel: 011-41-22-730-5111. Fax: 011-41-22-733-7256. Email: ittimailAitu.int. Internet: http://www.itu.inti.

ITU-R 601: See: **ITU-R BT.601-2.**

ITU-R BT.601-2: Formerly known as CCIR 601. This international standard defines the encoding parameters of digital television for studios. It is the international standard for digitizing component television video in both 525 and 625 line systems and is derived from the SMPTE RP125. ITU-R 601 deals with both color difference (Y, R-Y, B-Y) and RGB video, and defines sampling systems, RGB/Y, R-Y, B-Y matrix values and filter characteristics. It does not actually define the electro-mechanical interface--see ITU-R BT.656. ITU-R 601 is normally taken to refer to color difference component digital video (rather than RGB), for which it defines 4:2:2 sampling at 13.5 MHz with 720 luminance samples per active line and 8 or 10-bit digitizing. Some headroom is allowed with black at level 16 (not 0) and white at level 235 (not 255)--to minimize clipping of noise and overshoots. Using 8-bit digitizing approximately 16 million unique colors are possible: 28 each for Y (luminance), Cr and Cb (the digitized color difference signals) = 224 = 16,777,216 possible combinations. The sampling frequency of 13.5 MHz was chosen to provide a politically acceptable common sampling standard between 525/60 and 625/50 systems, being a multiple of 2.25 MHz, the lowest common frequency to provide a static sampling pattern for both.

ITU-R BT.656: Formerly known as CCIR 656. The physical parallel and serial interconnect scheme for ITU-R BT.601-2 (CCIR 601). ITU-R BT.656 defines the parallel connector pinouts as well as the blanking, sync, and multiplexing schemes used in both parallel and serial interfaces. Reflects definitions in EBU Tech 3267 (for 625-line signals) and in SMPTE 125M (parallel 525) and SMPTE 259M (serial 525).

ITU-R BT.709-3: Ratified by the International Telecommunications Union (ITU) in June 1999, the 1920x1080 digital sampling structure is a world format. All supporting technical parameters relating to scanning, colorimetry, transfer characteristics, etc. are universal. The CIF can be used with a variety of picture capture rates: 60p, 50p, 30p, 25p, 24p, as well as 60i and 50i.

See also: **CIF.**

ITU-R BS.775 An international recommendation for multichannel stereophonic sound systems with and without accompanying picture. This recommendation gives speaker placements for various types of sound systems.

Java: A general purpose programming language developed by Sun Microsystems and best known for its widespread use on the World Wide Web. Unlike other software, programs written in Java can run on any platform type (including set-top boxes), as long as they contain a Java Virtual Machine. Internet: java.sun.com.

See also: **Windows CE.**

Jitter: An undesirable random signal variation with respect to time.

JPEG: Joint Photographic Experts Group. ISO/ITU-T. JPEG is a standard for the data compression of still pictures (intrafield). In particular its work has been involved with pictures coded to the ITU-R 601 standard. JPEG uses DCT and offers data compression of between two and 100 times and three levels of processing are defined: the baseline, extended and "lossless" encoding. See also: Motion-JPEG.

Keyframe: A set of parameters defining a point in a transition, such as a DVE effect. For example, a keyframe may define a picture size, position and rotation. Any digital effect must have a minimum of two keyframes, start and finish, although more complex moves will use more--maybe as many as 100. Increasingly, more parameters are becoming "keyframeable," meaning they can be programmed to transition between two, or more, states. Examples are color correction to made a steady change of color, and keyer settings, perhaps to made an object slowly appear or disappear.

Latency: The factor of data access time due to disk rotation. The faster a disk spins the quicker it will be at the position where the required data can start to be read. As disk diameters have decreased so rotational speeds have tended to increase but there is still much variation. Modern 31/2-inch drives typically have spindle speeds of between 3,600 and 7,200 revolutions per minute, so one revolution is completed in 16 or 8 milliseconds (ms) respectively. This is represented in the disk specification as average latency of 8 or 4 ms.

Layered embedded encoding: The process of compressing data in layers such that successive layers provide more information and thus higher quality reconstruction of the original. That is, a single stream of data can supply a range of compression and thus, in the case of video, a scalable range of video resolution and picture quality. This is particularly useful for a muticast where a single stream is sent out and people are connecting over varying bandwidths. The low bandwidth connection can take just the lower layers while the high-bandwidth connection can take all of the layers for the highest quality.

Letterbox: Image of a widescreen picture on a standard 4:3 aspect ratio television screen, typically with black bars above and below. Used to maintain the original aspect ratio of the source material.

See also: **Side panels and pillarbox.**

Live-streaming: Streaming media that is broadcast to many people at a set time.

See also: **On-demand streaming.p> Lossless compression:** Reducing the bandwidth required for transmission of a given data rate without loss of any data.

Lossy compression: Reducing the total data rate by discarding data that is not critical. Both the video and audio for **DTV** transmission will use lossy compression.

See also: **Algorithm.**

LSB: Least significant bit. The bit that has the least value in a binary number or data byte. In written form, this would be the bit on the right.

For example: Binary 1101 = Decimal 13

In this example the right-most binary digit, 1, is the least significant bit--here representing 1. If the LSB in this example were corrupt, the decimal would not be 13 but 12. See also: **MSB.**

Luminance: The component of a video signal that includes information about its brightness.

See also: **Chrominance.**

Macroblock: In the typical 4:2:0 picture representation used by MPEG-2, a macroblock consists of four eight by eight blocks of luminance data (arranged in a 16 by 16 sample array) and two eight by eight blocks of color difference data which correspond to the area covered by the 16 by 16 section luminance component of the picture. The macroblock is the basic unit used for motion compensated prediction.

See also: **Block, Slice.**

MAMA: The Media Asset Management Association. MAMA serves as a advanced user-group and independent international industry consortium, created by and for media producers, content publishers, technology providers, and value-chain partners to develop open content and metadata exchange protocols for digital media creation and asset management. Internet: http.:11www .marne rp 0

Mbone: Multicast backbone. A virtual network consisting of portions of the Internet in which multicasting has been enabled. The Mbone originated from 1EFT in which live audio and video were transmitted around the world. The Mbone is a network of hosts connected to the Internet communicating through IP multicast protocols, multicast-enabled routers, and the point-to-point tunnels that interconnect them.

Megabyte (Mbyte): One million bytes (actually 1,048,576); one thousand kilobytes.

Metadata (side information): Informational data about the data itself. Typically information about the audio and video data included in the signal's data stream.

See also: **Essence.**

Mezzanine compression: Contribution level quality encoded high definition television signals. Typically split into two levels: High Level at approximately 140 Mbps and Low Level at approximately 39 Mbps (for high definition within the studio, 270Mbps is being considered). These levels of compression are necessary for signal routing and are easily re-encoded without additional compression artifacts (concatenation) to allow for picture manipulation after decoding. DS3 at 44.736 will be used in both terrestrial and satellite program distribution.

Modem: Modulator/demodulator. A device that transforms a typical two-level computer signal into a form suitable for transmission over a telephone line. Also does the reverse--transforms an encoded signal on a telephone line into a two-level computer signal.

Mole Technology: A seamless MPEG-2 concatenation technology developed by the ATLANTIC project (BBC [U.K.], Centro Studi e Laboratori telecomunicazione [Italy], Ecole Nationale Superieure des Telecommunications [France], Ecole Polytechnique FdUile de Lausanne [Switzerland], Electrocraft [U.K.], Fraunhofer-Institut fOr Integrierte Schaltungen [Germany], Instituto de Engenharia de Sistemas e Computadores [Portugal], Snell & Wilcox [U.K.]) in which an MPEG-2 bit stream enters a Mole-equipped decoder, and the decoder not only decodes the video, but the information on how that video was first encoded (motion vectors and coding mode decisions). This "side information" or "metadata" in an information bus is synchronized to the video and sent to the Mole-equipped encoder. The encoder looks at the metadata and knows exactly how to encode the video. The video is encoded in exactly the same way (so theoretically it has only been encoded once) and maintains quality.

If an opaque bug is inserted in the picture, the encoder only has to decide how the bug should be encoded (and then both the bug and the video have been theoretically encoded only once).

Problems arise with transparent or translucent bugs, because the video underneath the bug must be encoded, and therefore that video will have to be encoded twice, while the surrounding video and the bug itself have only been encoded once theoretically.

What Mole can not do is make the encoding any better. Therefore the highest quality of initial encoding is suggested.

Montreux International Television Symposium & Technical Exhibition (TV Montreux): A bi-annual international conference for the television broadcast industry. Internet: www.m o ntre ch isyrn posi arRil orn e himi.

Moore's Law: A prediction for the rate of development of modern electronics. This has been expressed in a number of ways but in general states that the density of information storable in silicon roughly doubles every year. Or, the performance of silicon will double every eighteen months, with proportional decreases in cost. For more than two decades this prediction has held true. Moore's law initially talked about silicon but it could be applied to disk drives: the capacity of disk drives doubles every two years. That has been true since 1980, and will continue well beyond 2000. Named after Gordon E. Moore, physicist, co-founder and chairman emeritus of Intel Corporation.

Motion compensation: The use of motion vectors to improve the efficiency of the prediction of pixel values. The prediction uses motion vectors to provide offsets into past and/or future reference frames containing previously decoded pixels that are used to form the prediction and the error difference signal.

Motion estimation: An image compression technique that achieves compression by describing only the motion differences between adjacent frames, thus eliminating the need to convey redundant static picture information from frame to frame. Used in the MPEG standards.

Motion-JPEG: Using JPEG compressed images as individual frames for motion. For example, 30 Motion-JPEG frames viewed in one second will approximate 30-frame per second video.

MOV: The file extension used by MooV format video files on Windows. These MOV files are generated with Apple Computer's QuickTime and played on Windows systems via QuickTime for Windows.

MPEG: Compression standards for moving images conceived by the Motion Pictures Expert Group, an international group of industry experts set up to standardize compressed moving pictures and audio. MPEG-2 is the basis for ATSC digital television transmission.

Its work follows on from that of JPEG to add interfield compression, the extra compression potentially available through similarities between successive frames of moving pictures. Four MPEG standards were originally planned, but the accommodation of HDTV within MPEG-2 has meant that MPEG-3 is now redundant. MPEG-4 is intended for unrelated applications, however, can be used to display ATSC formats on a PC. The main interest for the television industry is in MPEG-1 and MPEG-2. A group of picture blocks, usually four, which are analyzed during MPEG coding to give an estimate of the movement between frames. This generates the motion vectors that are then used to place the macroblocks in decoded pictures.

See also: **B frames, GoP, I frames, P frames.**

MPEG-1: A group of picture blocks, usually four, which are analyzed during MPEG coding to give an estimate of the movement between frames. This generates the motion vectors that are then used to place the macroblocks in decoded pictures. This was designed to work at 1.2 Mbps, the data rate of CD-ROM, so that video could be played from CDs. However the quality is not sufficient for TV broadcast.

MPEG-2: This has been designed to cover a wide range of requirements from "VHS quality" all the way to HDTV through a series of algorithm "profiles" and image resolution "levels." With data rates of between 1.2 and 15 Mbps, there is intense interest in the use of MPEG-2 for the digital transmission of television--including HDTV--applications for which the system was conceived. Coding the video is very complex, especially as it is required to keep the decoding at the reception end as simple and inexpensive as possible. MPEG-2 is the compression used by the ATSC and DVB standards.

MPEG can offer better quality pictures at high compression ratios than pure JPEG compression, but with the complexity of decoding and especially coding and the 12-long group of pictures (GoP), it is not an ideal compression system for editing. If any P or B frames are used then even a cut will require the re-use of complex, and not perfect, MPEG coding. However, MPEG Splicers are beginning to appear to alleviate this difficulty.

Of the six profiles and four levels creating a grid of 24 possible combinations, 12 have already been implemented. The variations these define are so wide that it would not be practical to build a universal coder or decoder. Interest is now focused on the Main profile, Main level, sometimes written as MP@ML, which covers broadcast television formats up to 720 pixels x 576 lines at 30 frames per second. These figures are quoted as maximums so 720 x 486 at 30 frames are included, as are 720 x 576 at 25 frames. As the coding is intended for transmission the economy of 4:2:0 sampling is used.

A recent addition to MPEG-2 is the studio profile. Designed for studio work its sampling is 4:2:2. The studio profile is written as 422P@ML. To improve the picture quality, higher bit rates are used. The first applications for this appear to be in electronic news gathering (ENG), and with some video servers.

See also: **B frames, Compression, GoP, I frames, JPEG, P frames.**

MPEG-4: The third standard developed by MPEG. Started in July 1993 MPEG-4 has benefited from the huge R&D investments made by participating companies and provides a harmonised range of responses to the diverse needs of the digital audio-visual industry, including compatibility with other major standards such as H.263 and VRML.

MPEG 4:2:2: Also referred to as Studio MPEG, Professional MPEG and 442P©ML. Sony's Betacam SX is based on MPEG 4:2:2. See: MPEG-2.

MPEG-7: A standardized description of various types of multimedia information. This description will be associated with the content itself, to allow fast and efficient searching for material that is of interest to the user. MPEG-7 is formally called "Multimedia Content Description Interface." The standard does not comprise the (automatic) extraction of descriptions/features. Nor does it specify the search engine (or any other program) that can make use of the description. It is not a new compression standard, but an attempt to manage motion imaging and multimedia technology.

MPEG-21: The Motion Picture Experts Group's attempt to get a handle on the overall topic of content delivery. By defining a Multimedia Framework from the viewpoint of the consumer, they hope to understand how various components relate to each other and where gaps in the infrastructure might benefit from new standards. A technical report on the MPEG-21 framework is scheduled for mid-2000.

MPEG IMX: Sony's trademark for a family of devices, such as DVTRs, that are I frame-only 50 Mbps **MPEG-2** streams using Betacam style cassettes. Plays Digital Betacam, Betacam SX, Betacam SP, Betacam, and, MPEG IMX, outputting 50 Mbps MPEG I-frame on SDTI-CP regardless of the tape being played. It can also handle other (lower) input and output data rates, but the recordings are 50 Mbps I-frame in any case.

See **also:SDTI-CP.**

MPEG splicing: The ability to cut into an MPEG bit stream for switching and editing, regardless of type of frames (I, B, P).

MSB: Most significant bit. The bit that has the most value in a binary number or data byte. In written form, this would be the bit on the left.

For example: **Binary 1110 = Decimal 14**

In this example, the left-most binary digit, 1, is the most significant bit--here representing 8. If the MSB in this example were corrupt, the decimal would not be 14 but 6.

See also: **LSB.**

Multicast: 1. Data flow from single source to mutiple destinations; a multicast may be distinguished from a broadcast in that number of destinations may be limited. 2. Aterm often used incorrectly to describe digital television program multiplexing.

Multimedia content description interface: See: **MPEG-7.**

Multipath interference: The signal variation caused when two RF signals take multiple paths from transmitter to receiver. In analog television, this creates ghosting. In digital television, this can cause the receiver not to output a signal as it can not differentiate between signals.

Multipoint: A term used by network designers to describe network links that have many possible endpoints.

Multiplex: 1. To transmit two or more signals at the same time or on the same carrier frequency. 2. To combine two or more electrical signals into a single, composite signal, such as ATSC multicasting.

Multiplexer: Device for combining two or more electrical signals into a single, composite signal.

Mux: See: **Multiplex.**

Netshow: Microsoft NetShow is a service that runs on Windows NT servers, delivering the high-quality streaming multimedia to users on corporate intranets and the Internet. It consists of server and tools components for delivering audio, video, illustrated audio, and other multimedia types over the network. NetShow provides the foundation for building rich, interactive mutimedia applications for commerce, distance learning, news and entertainment delivery, and corporate communications.

Nonlinear: A term used for editing and the storage of audio, video and data. Information (footage) is available anywhere on the media (computer disk or laser disc) almost immediately without having to locate the desired information in a time linear format.

Nonlinear editing: Nonlinear distinguishes editing operation from the "linear" methods used with tape. Nonlinear refers to not having to edit material in the sequence of the final program and does not involve copying to make edits. It allows any part of the edit to be accessed and modified without having to re-edit or re-copy the material that is already edited and follows that point. Nonlinear editing is also non-destructive--the video is not changed but the list of how that video is played back is modified during editing.

NTSC: National television system committee. The organization that developed the analog television standard currently in use in the U.S., Canada, and Japan. Now generally used to refer to that standard. The NTSC standard combines blue, red, and green signals modulated as an AM signal with an FM signal for audio.

See also: **PAL and SECAM.**

NVOD: Near video on demand. Rapid access to program material on demand achieved by providing the same program on a number of channels with staggered start times. Many of the hundreds of TV channels soon to be on offer will be made up of NVOD services. These are delivered by a disk-based transmission server.

Nyquist frequency (Nyquist rate): The lowest sampling frequency that can be used for analog-to-digital conversion of a signal without resulting in significant aliasing. Normally, this frequency is twice the rate of the highest frequency contained in the signal being sampled.

Off-line (editing): A decision-making process using low-cost equipment usually to produce an EDL or a rough cut which can then be conformed or referred to in a high quality on-line suite--so reducing decision-making time in the more expensive on-line environment. While most off-line suites enable shot selection and the defining of transitions such as cuts and dissolves, very few allow settings for the DVEs, color correctors, keyers and layering that are increasingly a part of the on-line editing process.

On-demand streaming: Streaming media content that is transmitted to the client upon request.

See also: **Live streaming.**

On-line (editing): Production of the complete, final edit performed at full program quality--the buck stops here! Being higher quality than off-line, time costs more but the difference is reducing. Preparation in an off-line suite will help save time and money in the on-line. To produce the finished edit on-line has to include a wide range of tools, offer flexibility to try ideas and accommodate late changes, and to work fast to maintain the creative flow and to handle pressured situations.

0C3: Optical Carrier Level 3. A 155 Mbps ATM SONET signal stream that can carry three DS3 signals.

Open Cable: A project aimed at obtaining a new generation of set-top boxes that are interoperable. These new devices will enable a new range of interactive services to be provided to cable customers.

Operating system: The base program that manages a computer and gives control of the functions designed for general purpose usage--not for specific applications. Common examples are MS-DOS and Windows for PCs, Mac 0S8 for Apple Macintosh, and UNIX (and its variations IRIX and Linux). For actual use, for example, as a word processor, specific applications software is run on top of the operating system.

Optical disks: Disks using optical techniques for recording and replay of material. These offer large storage capacities on a small area, the most common being the 5-1/4-inch compact disk, being removable and having rather slower data rates than fixed magnetic disks--but faster than floppies. Write Once, Read Many or "WORM" optical disks first appeared with 2 GB capacity on each side of a 12-inch platter--useful for archiving images. In 1989 the read/write magneto-optical (MO) disk was introduced which can be re-written around a million times. With its modest size, just 5-1/4-inches in diameter, the ISO standard cartridge can store 325 MB per side--offering low priced removable storage for over 700 TV pictures per disk. A variant on the technology is the phase change disk but this is not compatible with the ISO standard.

An uprated MO disk system introduced in 1994 has a capacity of 650 MB per side, 1.3 GB per disk. In 1996 a second doubling of capacity was introduced offering 2.6 GB on a removable disk. Besides the obvious advantages for storing TV pictures this is particularly useful where large format images are used, in print and in film for example.

The NEC DiskCam system uses optical disks for storage.

Oversampling: Sampling data at a higher rate than normal to obtain more accurate results or to make it easier to sample.

P frames: One of the three types of frames used in the coded MPEG-2 signal. These contain only predictive information (not a whole picture) generated by looking at the difference between the present frame and the previous one. They contain much less data than the **I** frames and so help towards the low data rates that can be achieved with the MPEG signal. To see the original picture corresponding to a P frame a whole MPEG-2 GoP has to be decoded.

See also: **B frames, I frames and MPEG.**

PAL: Phase alternate line. The television broadcast standard throughout Europe (except in France and Eastern Europe, where SECAM is the standard). This standard broadcasts 625 lines of resolution, nearly 20 percent more than the U.S. standard, NTSC, of 525.

See also: **NTSC and SECAM.**

Palette: In 8-bit images or displays, only 256 different can be displayed at any one time. This collection of 256 colors is called the palette. In 8-bit environments, all screen elements must be painted with the colors contained in the palette. The 256-color combination is not fixed--palettes can and do change frequently. But at any one time, only 256 colors can be used to describe all the objects on the screen or image.

Pan and Scan: The technique used to crop a widescreen picture to conventional 4:3 television ratio, while panning the original image to follow the on-screen action.

Pan and Scanner: One who pans and scans, typically during a live event originating in a widescreen format (16:9) but simulcast in 4:3.

Parallel: One transmission path for each bit.

Parallel cable: A multi-conductor cable carrying simultaneous transmission of digital data bits. Analogous to the rows of a marching band passing a review point.

Parallel data: Transmission of data bits in groups along a collection of wires (called a bus). Analogous to the rows of a marching band passing a review point. A typical parallel bus may accommodate transmission of one 8-, 16-, or 32-bit byte at a time.

Parallel digital: A digital video interface which uses twisted pair wiring and 25-pin D connectors to convey the bits of a digital video signal in parallel. There are various component and composite parallel digital video formats.

Parity: A method of verifying the accuracy of transmitted or recorded data. An extra bit appended to an array of data as an accuracy check during transmission. Parity may be even or odd. For odd parity, if the number of 1's in the array is even, a 1 is added in the parity bit to make the total odd. For even parity, if the number of 1's in the array is odd, a 1 is added in the parity bit to make the total even. The receiving computer checks the parity bit and indicates a data error if the number of is does not add up to the proper even or odd total.

PCM: Pulse code modulation. A method by which sound is digitally recorded and reproduced. Sounds are reproduced by modulating (changing) the playback rate and amplitude of the sampled (stored) digital pulses (waves). This enables the PCM sound to be reproduced with a varying pitch and amplitude.

Picture: A source image or reconstructed data for a single frame or two interlaced fields. A picture consists of three rectangular matrices of eight-bit numbers representing the luminance and two color difference signals.

PID: Packet identifier. The identifier for transport packets in MPEG-2 Transport Streams.

Pillarbox: Describes a frame that the image fails to fill horizontally (a 4:3 image on a 16:9 screen), in the same way that a letterbox describes a frame that the image fails to fill vertically (a 16:9 image on a 4:3 screen)

See also: **Letterbox and side panels.**

Pixel: A shortened version of "Picture cell" or "Picture element." The name given to one sample of picture information. Pixel can refer to an individual sample of R, G, B luminance or chrominance, or sometimes to a collection of such samples if they are co-sited and together produce one picture element.

Plant native format: A physical plant's highest video resolution.

Point-to-multipoint: An arrangement, either permanent or temporary, in which the same data flows or is transferred from a single origin to multiple destinations; the arrival of the data at all the destinations is expected to occur at the same time or nominally the same time.

Pre-read: See: Read before write.

Progressive: Short for progressive scanning. A system of video scanning whereby lines of a picture are transmitted consecutively, such as in the computer world.

Protocol: Set of syntax rules defining exchange of data including items such as timing, format, sequencing, error checking, etc.

PSIP: Program and system information protocol. A part of the ATSC digital television specification that enables a DTV receiver to identify program information from the station and use it to create easy-to-recognize electronic program guides for the viewer at home. The PSIP generator insert data related to channel selection and electronic program guides into the ATSC MPEG transport stream.

See also: **Electronic Program Guide.**

QAM: Quadrature amplitude modulation. A downstream digital modulation technique that conforms to the International Telecommunications Union (ITU) standard **ITU-T** J. 83 Annex B which calls for 64 and 256 quadrature amplitude modulation (QAM) with concatenated trellis coded modulation, plus enhancements such as variable interleaving depth for low latency in delay sensitive applications such as data and voice. Using 64 QAM, a cable channel that today carries one analog video channel could carry 27 Mbps of information, or enough for multiple video programs. Using 256 QAM, the standard 6 MHz cable channel would carry 40 Mbps.

QPSK: Quadrature phase shift keying. QPSK is a digital frequency modulation technique used for sending data over coaxial cable networks. Since it's both easy to implement and fairly resistant to noise, QPSK is used primarily for sending data from the cable subscriber upstream to the Internet.

Quantization: The process of sampling an analog waveform to convert its voltage levels into digital data.

Quantizing: The process of converting the voltage level of a signal into digital data before or after the signal has been sampled.

Quantizing error: Inaccuracies in the digital representation of an analog signal. These errors occur because of limitations in the resolution of the digitizing process.

Quantizing noise: The noise (deviation of a signal from its original or correct value) which results from the quantization process. In serial digital video, a granular type of noise that occurs only in the presence of a signal.

QuickTime: Apple Computer's system-level software architecture supporting time-based media, giving a seamless integration of video, sound, and animation. For Macintosh and Windows computers.

RAID: Redundant array of independent disks. A grouping of standard disk drives together with a RAID controller to create storage that acts as one disk to provide performance beyond that available from individual drives. Primarily designed for operation with computers RAIDs can offer very high capacities, fast data transfer rates and much-increased security of data. The latter is achieved through disk redundancy so that disk errors or failures can be detected and corrected.

A series of RAID configurations is defined by levels and, being designed by computer people, they start counting from zero. Different levels are suited to different applications.

Level 0: No redundancy--benefits only of speed and capacity--generated by combining a number of disks. Also known as "striping."

Level 1 Complete mirror system--two sets of disks both reading and writing the same data. This has the benefits of level 0 plus the security of full redundancy--but at twice the cost. Some performance advantage can be gained in read because only one copy need be read, so two reads can occur simultaneously.

Level 2: An array of nine disks. Each byte is recorded with one bit on each of eight disks and a parity bit recorded to the ninth. This level is rarely, if ever, used.

Level 3: An array of n+1 disks recording 512 byte sectors on each of the n disks to create n x 512 "super sectors" + 1 x 512 parity sector on the additional disk which is used to check the data.

The minimum unit of transfer is a whole superblock. This is most suitable for systems in which large amounts of sequential data are transferred--such as for audio and video. For these it is the most efficient RAID level since it is never necessary to read/modify/write the parity block. It is less suitable for database types of access in which small amounts of data need to be transferred at random.

Level 4: The same as Level 3 but individual blocks can be transferred. When data is written it is necessary to read the old data and parity blocks before writing the new data as well as the updated parity block, which reduces performance.

Level 5: The same as Level 4, but the role of parity the disk is rotated for each block. In level 4 the parity disk receives excessive load for writes and no load for reads. In Level 5 the load is balanced across the disks.

Soft RAID: A RAID system implemented by low level software in the host system instead of a dedicated RAID controller. While saving on hardware, operation consumes some of the host's power.

RAM: Random access memory. A temporary, volatile memory into which data can be written or from which data can be read by specifying an address.

Rate conversion: 1. The process of converting from one digital sample rate to another. The digital sample rate for the component digital video format is 13.5 MHz. For the composite digital video format, it is either 14.3 MHz for NTSC or 17.7 MHz for PAL. 2. Often used incorrectly to indicate both resampling of digital rates and encoding/decoding.

Read before write: A feature of some videotape recorders that plays back the video or audio signal off of tape before it reaches the record heads, sends the signal to an external device for modification, and then applies the modified signal to the record heads so that it can be re-recorded onto the tape in its original position.

RealAudio: Popular software for streaming audio and video over the Internet. made by RealNetworks of Seattle, Washington.

Realtime: Computation or processing done in the present to control physical events occurring in the present. For example, when a digital effects system operator moves a joystick and the video images on the monitor appear to move simultaneously, the computations required to make the images move are said to have occurred in realtime.

See also: **Rendering.**

RealVideo: Popular software for streaming audio and video over the Internet. made by RealNetworks of Seattle, Washington.

Rec. 601: See: ITU-R BT.601-2.

Reclocking: The process of clocking digital data with a regenerated clock.

Rendering: The process of non-realtime drawing of a picture relying on computer processing speed for graphics and compositing.

Resolution: 1. Detail. In digital video and audio, the number of bits (four, eight, 10, 12, etc.) determines the resolution of the digital signal. Four bits yields a resolution of one in 16. Eight bits yields a resolution of one in 256. Ten bits yields a resolution of one in 1,024. Eight bits is the minimum acceptable for broadcast television. 2. A measure of the finest detail that can be seen, or resolved, in a reproduced image. While influenced by the number of pixels in an image (for high definition approximately 2,000 x 1,000, broadcast NTSC TV 720 x 487, broadcast PAL TV 720 x 576), note that the pixel numbers do not define ultimate resolution but merely the resolution of that part of the equipment. The quality of lenses, display tubes, film process and film scanners, etc., used to produce the image on the screen must all be taken into account. This is why a live broadcast of the Super Bowl looks better than a broadcast recorded and played off of VHS, while all are NTSC or PAL.

Resolution independent: Term used to describe the notion of equipment that can operate at more than one resolution. Dedicated TV equipment is designed to operate at a single resolution although some modern equipment, especially that using the ITU-R 601 standard, can switch between the specific formats and aspect ratios of 525/60 and 625/50.

By their nature, computers can handle files of any size, so when applied to imaging, they are termed resolution independent. As the images get bigger so the amount of processing, storage and data transfer demanded increases--in proportion to the resulting file size. So, for a given platform, the speed of operation slows. Other considerations when changing image resolution may be reformatting disks, checking if the **RAM** is sufficient to handle the required size of file, allowing extra time for RAM/disk caching and how to show the picture on an appropriate display.

Return loss: A measure of the ratio of signal power transmitted into a system to the power reflected or returned. It can be thought of as an echo that is reflected back by impedance changes in the system. Any variation in impedance from the source results in some returned signal. Real-life cabling systems do not have perfect impedance structure and matching, and therefore have a measurable return loss. Twisted pairs are not completely uniform in impedance. Changes in twist, distance between conductors, cabling handling, cable structure, length of link, patch cord variation, varying copper diameter, dielectric composition and thickness variations, and other factors all contribute to slight variations in cable impedance. In addition, not all connecting hardware components in a link may have equal impedance. At every connection point there is the potential for a change in impedance. Each change in the impedance of the link causes part of the signal to be reflected back to the source. Return loss is a measure of all the reflected energy caused by variations in impedance of a link relative to a source impedance of 100 ohms. Each impedance change contributes to signal loss (attenuation) and directly causes return loss.

RGB: The abbreviation for the red, green and blue signals, the primary colors of light (and television). Cameras and telecines have red, blue and green receptors, the TV screen has red, green and blue phosphors illuminated by red, green and blue guns. Much of the picture monitoring in a production center is in RGB. RGB is digitized with 4:4:4 sampling which occupies 50 percent more data than 4:2:2.

Ringing: An oscillatory transient on a signal occurring as a result of bandwidth restrictions and/or phase distortions. A type of ringing causes ghosting in the video picture.

RLE: Run length encoding. A compression scheme. A run of pixels or bytes of the same color or value are coded as a single value recording the color or byte value and the number duplications in the run.

ROM: Read only memory. A memory device that is programmed only once with a permanent program or data that cannot be erased.

RP-125: A SMPTE parallel component digital video recommended practice. Now SMPTE 125M.

See: **SMPTE 125M.**

RS-232: A standard, single-ended (unbalanced) interconnection scheme for serial data communications.

RS-422: A medium range (typically up to 300 m/1000 ft or more) balanced serial data transmission standard. Data is sent using an ECL signal on two twisted pairs for bi-directional operation. Full specification includes 9-way D-type connectors and optional additional signal lines.

RS-422 is widely used for control links around production and post areas for a range of equipment.

Run-length coding: A system for compressing data. The principle is to store a pixel value along with a message detailing the number of adjacent pixels with that same value. This gives a very efficient way of storing large areas of flat color and text but is not so efficient with pictures from a camera, where the random nature of the information, including noise, may actually mean that more data is produced than was needed for the original picture.

Sampling: Process by which an analog signal is measured, often millions of times per second for video, in order to convert the analog signal to digital. The official sampling standard for standard definition television is ITU-R 601.

For TV pictures eight or 10 bits are normally used; for sound, 16 or 20-bits are common, and 24-bits are being introduced. The ITU-R 601 standard defines the sampling of video components based on 13.5 MHz, and AES/EBU defines sampling of 44.1 and 48 kHz for audio.

Sampling frequency: The number of discrete sample measurements made in a given period of time. Often expressed in megahertz for video.

SAV: Start of active video. A synchronizing signal used in component digital video.

Scalable coding: The ability to encode a visual sequence so as to enable the decoding of the digital data stream at various spatial and/or temporal resolutions. Scalable compression techniques typically filter the image into separate bands of spatial and/or temporal data. Appropriate data reduction techniques are then applied to each band to match the response characteristics of human vision.

Scalable video: Refers to video compression that can handle a range of bandwidths, scaling smoothly over them.

Scrambling: 1. To transpose or invert digital data according to a prearranged scheme in order to break up the low-frequency patterns associated with serial digital signals. 2. The digital signal is shuffled to produce a better spectral distribution.

See also: **Encryption.**

SCSI: Small computer systems interface. A very widely used high data rate general purpose parallel interface. A maximum of eight devices can be connected to one bus, for example a controller, and up to seven disks or devices of different sorts--Winchester disks, optical disks, tape drives, etc.--and may be shared between several computers.

SCSI specifies a cabling standard (50-way), a protocol for sending and receiving commands and their format. It is intended as a device-independent interface so the host computer needs no details about the peripherals it controls. But with two versions (single ended and balanced), two types of connectors and numerous variations in the level of implementation of the interface, SCSI devices cannot "plug and play" on a computer with which they have not been tested. Also, with total bus cabling for the popular single ended configuration limited to 18 feet (6 meters), all devices must be close.

SCSI is popular and has continued development over a number of years resulting in the following range of maximum transfer rates:

Standard SCSI: 5 Mbps (max.)

Fast SCSI: 10 Mbps (max.)

Ultra SCSI: 20 Mbps (max.)

For each of these there is the 8-bit normal "narrow" bus (1 byte per transfer) or the 16-bit Wide bus (2 bytes per transfer), so Wide Ultra SCSI could transfer data at a maximum rate of 40 Mbps. Note that these are peak rates. Continuous rates will be considerably less. Also, achieving this will depend on the performance of the connected device.

Differential SCSI: An electrical signal configuration where information is sent simultaneously through sets of wires in a cable. Information is interpreted by the difference in voltage between the wires. Differential interfaces permit cable lengths up to 75 feet (25 meters).

Single-Ended SCSI: An electrical signal configuration where information is sent through one wire in a cable. Information is interpreted by the change in the voltage of the signal. Single-ended interfaces permit cable lengths up to 18 feet (6 meters).

SDDI: See: **Serial digital data interface.**

SDI: See: Serial digital interface.

SDTI: See: **Serial digital transport interface.**

SDTI-CP: Serial digital transport interface-content package. Sony's way of formatting MPEG IMX (50 Mbps, I frame MPEG-2 streams) for transport on a serial digital transport interface.

See also: **Serial digital transport interface.**

SECAM: Sequential couleur avec =mire. The television broadcast standard in France, the Middle East, and most of Eastern Europe, SECAM provides for sequential color transmission and storage in the receiver. The signals used to transmit the color are not transmitted simultaneously but sequentially line for line. SECAM processes 625 lines, a maximum of 833 pixels per line *and* 50 Hz picture frequency. SECAM is used as a transmission standard and not a production standard (PAL is typically used).

Sequence:A coded video sequence that commences with a sequence header and is followed by one or more groups of pictures and is ended by a sequence end code.

Serial: One bit at a time, along a single transmission path.

Serial digital: Digital information that is transmitted in serial form. Often used informally to refer to serial digital television signals.

Serial digital data interface (SDDI): A way of compressing digital video for use on SDI-based equipment proposed by Sony. Now incorporated into Serial digital transport interface.

See: **Serial digital transport interface.**

Serial digital interface (SDI): The standard based on a 270 Mbps transfer rate. This is a 10-bit, scrambled, polarity independent interface, with common scrambling for both component ITU-R 601 and composite digital video and four channels of (embedded) digital audio. Most new broadcast digital equipment includes SDI which greatly simplifies its installation and signal distribution. It uses the standard 75 ohm BNC connector and coax cable as is commonly used for analog video, and can transmit the signal over 600 feet (200 meters) depending on cable type.

Serial digital transport interface (SDTI): SMPTE 305M. Allows faster-than-realtime transfers between various servers and between acquisition tapes, disk-based editing systems and servers, with both 270 Mb and 360 Mb are supported. With typical realtime compressed video transfer rates in the 18 Mbps to 25 Mbps to 50 Mbps range, SDTI's 200+ Mbps payload can accommodate transfers up to four times normal speed.

The SMPTE 305M standard describes the assembly and disassembly of a stream of 10-bit data words that conform to SDI rules. Payload data words can be up to 9 bits. The 10th bit is a complement of the 9th to prevent illegal SDI values from occurring. The basic payload is inserted between SAV and EAV although an appendix permits additional data in the SDI ancillary data space as well. A header immediately after **EAV** provides a series of flags and data IDs to indicate what's coming as well as line counts and CRCs to check data continuity.

Serial interface: A digital communications interface in which data is transmitted and received sequentially along a single wire or pair of wires. Common serial interface standards are RS-232 and RS-422.

Serializer: A device that converts parallel digital information to serial.

Serial storage architecture (SSA): A high speed data interface developed by **IBM** and used to connect numbers of storage devices (disks) with systems. Three technology generations are planned: 20 Mbps and 40 Mbps are now available, and 100 Mbps is expected to follow.

Serial video processing: A video mixing architecture where a series of video multipliers, each combining two video signals, is cascaded or arranged in a serial fashion. The output of one multiplier feeds the input of the next, and so on, permitting effects to be built up, one on top of the other.

Server (file): A storage system that provides data files to all connected users of a local network. Typically the file server is a computer with large disk storage which is able to record or send files as requested by the other connected (client) computers--the file server often appearing as another disk on their systems.

The data files are typically around a few kilobytes in size and are expected to be delivered within moments of request

Server (video): A storage system that provides audio and video storage for a network of clients. While there are some analog systems based on optical disks, most used in professional and broadcast applications are based on digital disk storage.

Aside from those used for video on demand (VOD), video servers are applied in three areas of television operation: transmission, post production and news. Compared to general purpose file servers, video severs must handle far more data, files are larger and must be continuously delivered.

There is no general specification for video servers and so the performance between models varies greatly according to storage capacity, number of channels, compression ratio and degree of access to store material--the latter having a profound influence.

Store sizes are very large, typically up to 500 Gigabytes or more. Operation depends entirely on connected devices, edit suites, automation systems, secondary servers, etc., so the effectiveness of the necessary remote control and video networking is vital to success.

Set-top box (STB): These receivers (named because they typically sit on top of a television set) convert and display broadcasts from one frequency or type--analog cable, digital cable, or digital television) to a standard frequency (typically channel 3 or 4) for display on a standard analog television set.

Side converting: The process which changes the number of pixels and/or frame rate and/or scanning format used to represent an image by interpolating existing pixels to create new ones at closer spacing or by removing pixels. Side converting is done from standard resolution to standard resolution and high definition to high definition.

See also: **Down converting, up converting.**

Side panels: Image of a standard 4:3 picture on a widescreen 16:9 aspect ratio television screen, typically with black bars on the side. Used to maintain the original aspect ratio of the source material.

See also: **Letterbox, pillarbox.**

SIGGRAPH: The Association of Computing Machinery (ACM)'s Special Interest Group on Computer Graphics (SIGGRAPH). Internet: http:themwsitrgraph.orgi.

Signaling rate: The bandwidth of a digital transmission system expressed in terms of the maximum number of bits that can be transported over a given period of time. The signaling rate is typically much higher than the average data transfer rate for the system due to software overhead for network control, packet overhead, etc.

Simple profile: MPEG image streams using only I and P frames is less efficient than coding with **B** frames. This profile, however, requires less buffer memory for decoding.

Simulcast: To broadcast the same program over two different transmission systems. Currently, some AM and FM stations simulcast the same program for part of the day, and some radio stations simulcast the audio from televised music events.

Although not initially required by the FCC, it is believed that most television stations will simulcast their DTV and NTSC signal. Simulcasting will be required towards the end of the DTV transition period to protect the public interest.

Slice: A series of macroblocks. A slice is the basic synchronizing unit for reconstruction of the image data and typically consists of all the blocks in one horizontal picture interval--typically 16 lines of the picture.

SMPTE: 1. Society of Motion Picture and Television Engineers. A professional organization that sets standards for American television. 595 W. Hartsdale Ave., White Plains, NY, 10607-1824. Te1:914-761-1100.Fax:914-761-3115. Email: smptegsmpte.org Internet: hi.tvilwww.smpte.orgi. 2. An informal name for a color difference video format that uses a variation of the Y, R-Y, and B-Y signal set.

SMPTE 125M (formerly RP-125): The SMPTE standard for a bit parallel digital interface for 55-line interlace component video signals. SMPTE 125M defines the parameters required to generate and distribute component video signals on a parallel interface.

SMPTE 244M: The SMPTE standard for a bit parallel digital interface for composite video signals. **SMPTE 244M** defines the parameters required to generate and distribute composite video signals on a parallel interface.

SMPTE 259M: The SMPTE standard for standard definition serial digital component and composite interfaces.

SMPTE 272M: The SMPTE standard for formatting AES/EBU audio and auxiliary data into digital video ancillary data space.

SMPTE 292M: The SMPTE standard for bit-serial digital interface for high-definition television systems.

SMPTE 293M: The SMPTE standard defining the data representation of the 720x483 progressive signal at 59.94 Hz.

SMPTE 294M: The SMPTE standard defining the serial interfaces for both 4:2:2P (progressive) on two-SMPTE 259M links and 4:2:0P (progressive) on a single SMPTE 259M link (at 360Mbps).

SMPTE 299M: The SMPTE standard for 24-bit digital audio format for HDTV bit-serial interface. Allows eight embedded AES/EBU audio channel pairs.

SMPTE 305M: The SMPTE standard for Serial Digital Transport Interface (SDTI).

SMPTE 310M: The SMPTE standard for synchronous serial interface (SSI) for MPEG-2 digital transport streams; used as the "standard" for the output from the ATSC systems multiplexer and the input to DTV transmitters.

Soft RAID: A RAID system implemented by low level software in the host system instead of a dedicated RAID controller. While saving on hardware, operation consumes some of the host's power.

See also: **RAID.**

Sonet: Synchronous optical network. A set of standards for the digital transmission of information over fiber optics. Based on increments of 51 Mbps. It was developed to cost effectively support broadband services and multi-vendor internetworking.

Spatial resolution: The number of pixels horizontally and vertically in a digital image.

Sprites: In MPEG-4, static background scenes. Sprites can have dimensions much larger than what will be seen in any single frame. A coordinate system is provided to position objects in relation to each other and the sprites. MPEG- 4's scene description capabilities are built on concepts used previously by the Internet community's Virtual Reality Modeling Language (VRML).

SRAM: Static RAM. This type of memory chip in general behaves like dynamic RAM (DRAM) except that static RAMs retain data in a six-transistor cell needing only power to operate (DRAMs require clocks as well). Because of this, current available capacity is 4 Mbits--lower than DRAM--and costs are higher, but speed is also greater.

SSA: See: **Serial Storage Architecture.**

Statistical multiplexing: Increases the overall efficiency of a multi-channel digital television transmission multiplex by varying the bit-rate of each of its channels to take only that share of the total multiplex bit-rate it needs at any one time. The share apportioned to each channel is predicted statistically with reference to its current and recent-past demands.

See also: **Multiplex.**

Storage capacity: Using the ITU-R 601 4:2:2 digital coding standard, each picture occupies a large amount of storage space--especially when related to computer storage devices such as DRAM and disks. So much so that the numbers can become confusing unless a few benchmark statistics are remembered. Fortunately, the units of mega, giga, tera and penta make it easy to express the very large numbers involved. The capacities can all be worked out directly from the 601 standard. Bearing in mind that sync words and blanking can be regenerated and added at the output, only the active picture area need be stored.

For the 525 line TV standard the line data is: 720(Y) + 360(Cr) + 360(Cb) = 1,440 pixels/line
487 active lines/picture there are 1,440 x 487 = 701,280 pixels/picture
(sampling at 8-bits, a picture takes 701.3 kbytes)
1 sec takes 701.3 x 30 = 21,039 kbytes, or 21 Mbytes

For the 625 line TV standard the active picture is: 720(Y) + 360(Cr) + 360(Cb) = 1,440 pixels/line
With 576 active lines/picture there are 1,440 x 576 = 829,440 pixels/picture
(sampling at 8-bits, a picture takes 830 kbytes)
1 second takes 830 x 25 = 20,750 kbytes, or 21 Mbytes

So both 525 and 625 line systems require approximately the same amount of storage for a given time:
1 minute takes 21 x 60 = 1,260 Mbytes, or 1.26 Gbytes
1 hour takes 1.26 x 60 = 76 Gbytes
Useful numbers (referred to non-compressed video):
1 Gbyte will hold 47 seconds.
1 hour takes 76 Gbytes.

Stream: 1. To transmit multimedia files that begin playing upon arrival of the first packets, without needing to wait for all the data to arrive. 2. To send data in such a way as to simulate real-time delivery of multimedia.

Streaming media: Multimedia content--such as video, audio, text, or animation--that is displayed by a client a client as it is received from the Internet, broadcast network, or local storage.

Sub-pixel: A spatial resolution smaller than that of pixels. Although digital images are composed of pixels it can be very useful to resolve image detail to smaller than pixel size, i.e., sub-pixel. For example, the data for generating a smooth curve on television needs to be created to a finer accuracy than the pixel grid itself, otherwise the curve will look jagged. Again, when tracking an object in a scene or executing a DVE move, the size and position of the manipulated picture must be calculated, and the picture resolved, to a far finer accuracy than the pixels, otherwise the move will appear jerky.

See also: **Pixel.**

Sweetening: Electronically improving the quality of an audio or video signal, such as by adding sound effects, laugh tracks, and captions.

Synchronous: A transmission procedure by which the bit and character stream are slaved to accurately synchronized clocks, both at the receiving and sending end.

T1: In telecommunications, the paired cable used to transport DS1 service.

Table 3 Compression Format Constraints: See: **ATSC.**

TCP/IP: Transmission control protocol/internet protocol. An Internet protocol suite developed by the U.S. Department of Defense in the 1970s. TCP governs the exchange of sequential data. IP routes outgoing and recognizes incoming messages.

TDM: Time division multiplex. The management of multiple signals on one channel by alternately sending portions of each signal and assigning each portion to particular blocks of time.

Tearing: A lateral displacement of the video lines due to sync instability. Visually it appears as though parts of the images have been torn away.

Temporal abasing: A defect in a video picture that occurs when the image being sampled moves too fast for the sampling rate. A common example occurs when the rapidly rotating spokes of a wagon's wheels appear to rotate backwards because of video scanning that moves more slowly than the spokes.

Temporal resolution: The ability of the display to reproduce adequate detail to allow the visual system to distinguish the separate parts or components of an object that is moving through the display.

Time code: 1. Vertical interval time code (VITC). This is SMPTE time code that is recorded as video signals in the vertical interval of the active picture. It has the advantage of being readable by a VTR in still or jog. Multiple lines of VITC can be added to the signal allowing the encoding of more information than can be stored in normal LTC. 2. Linear time code (LTC). Time code recorded on a linear analog track (typically an audio channel) on a videotape. Also called longitudinal time code. Time code can be drop frame (59.94 Hz) that matches actual elapsed time by dropping occasional frames or non-drop frame (60 Hz) that runs continuously although it does not exactly match actual elapsed time.

Timeline: In nonlinear editing, the area in which audio and video clips are applied, typically giving duration in frames and seconds. Also seen in animation and composition software.

TOV: Threshold of visibility. The impairment level (or D/U in dB) beyond which a source of impairment or interference may introduce visible deficiencies in more sensitive program material. For all tests, TOV was determined by expert observers.

Transcode: The process of converting a file or program from one formator resolution to another.

Truncation: Removal of the lower significant bits on a digital word--as could be necessary when sending a 16-bit word on an 8-bit bus. If not carefully handled it can lead to unpleasant artifacts on video signals.

See also: **Dynamic Rounding.**

TV Crossover Links: A type of enhancement which notifies users that there is enhanced or Web content associated with a program or an advertisement. A TV Crossover Link appears as a small icon in the corner of the TV screen at a point in time determined by content producers. Clicking the link displays a panel, giving the viewer an option to go to the content enhancement (Web site) or continue watching TV. If the viewer chooses to go to the Web site, the receiver connects to the site, while the current program or advertisement remains on-screen. Pressing the View button on the remote control or keyboard returns to TV viewing. The term is a trademark of the Microsoft Corporation.

Up converting (up-rezing): The process which increases the number of pixels and/or frame rate and/or scanning format used to represent an image by interpolating existing pixels to create new ones at closer spacing. Despite its name the process does not increase the resolution of the image. Up converting is done from standard definition to high definition.

See also: **Down converting, side converting.**

Vaporware: Software or hardware that is promised or talked about but is not yet completed--and may never be released.

Variable bit rate reduction: See: **Compression.**

Video coder overload (also buffer overload): Video coder overload is tested using rapid scene cuts, at most only a few frames apart, to stress digital compression systems by presenting them with a video signal that contains little or no temporal redundancy (frame-to-frame correlation).

Video for Windows: Microsoft's system-level Windows software architecture that is similar to Apple Computer's QuickTime.

Video-on-demand (VOD): When video can be requested at any time and is available at the discretion of the end-user, it is then video-on-demand.

VRML: Virtual reality modeling language. An ISO standard for 3-D multimedia and shared virtual worlds on the Internet.

VSB: Vestigial side band. VSB is a digital frequency modulation technique used to send data over a coaxial cable network. Used by Hybrid Networks for upstream digital transmissions, VSB is faster than the more commonly used QPSK, but it's also more susceptible to noise.

VSWR: Voltage standing wave ratio. The ratio of the maximum value of a standing wave to its minimum value and is related to the return loss by the equation: RL = 20log [(VSWR + 1)/(VSWR-1)] Thus a VSWR of 1.5:1 corresponds to a return loss of 20log(5) = 13.97dB.

WAV (pronounced wave): The Windows-compatible audio file format. The WAV file can be recorded at 11 kHz, 22 kHz, and 44 kHz, and in 8- or 16-bit mono and stereo.

See also: **AIF, AU.**

Wavelet-based compression: An asymmetrical image compression technique that is scalable and can provide high quality. The drawback is that it becomes more computationally expensive as the picture resolution and frame rates go up. The encode and decode are asymmetrical in that one side is a lot more expensive computationally than the other. The ImMix Cube and TurboCube used wavelet-based compression.

WebTV: WebTV Networks, Inc. is a leading manufacturer of set-top boxes used for viewing interactive television and regular television. These receivers let users access the Internet, including use of electronic mail and online chats. WebTV set-top boxes like the WebTV Plus Receiver connect to a standard television and a phone line. The WebTV Plus Receiver supports

TV Crossover Links and WebPIP. WebPIP lets users simultaneously view Web pages and TV programming on the same screen, without a special picture-in-picture TV. WebTV is a trademark and service of the Microsoft Corporation.

Widescreen: Term given to picture displays that have a wider aspect ratio than normal. For example, TV's normal aspect ratio is 4:3 and widescreen is 16:9. Although this is the aspect ratio used by HDTV, widescreen is also used with normal definition systems.

Window: 1. Video containing information or allowing information entry, keyed into the video monitor output for viewing on the monitor CRT. A window dub is a copy of a videotape with time code numbers keyed into the picture. 2. A video test signal consisting of a pulse and bar. When viewed on a monitor, the window signal produces a large white square in the center of the picture. 3. A graphical user interface that presents icons and tools for manipulating a software application. Most applications have multiple windows that serve different purposes.

Window shades: See also: **Pillar box, side panels.**

Windows CE: Microsoft Windows CE is a 32-bit real-time embedded operating system (RTOS) designed from the ground up to empower the development of a new range of emerging computing appliances, including set-top boxes, digital versatile disc (DVD) drives, entertainment consoles, smart phones, highly portable and personal computing devices like handheld computers, and home appliances. Windows CE is modular, allowing use of a minimum set of software components needed to support receiver requirements. This uses less memory and improves operating system performance. Windows CE provides a subset of the Win32 application program interface (API) set, which provides an effective amount of application source-code level portability and compatibility and user interface consistency with other Microsoft Windows operating systems and Windows applications.

See also: **Java.**

Windows Media Player: Delivers the most popular streaming and local audio and video formats, including ASF, WAV, AVI, MPEG, Quick-Time, and more. Windows Media Player can play anything from low-bandwidth audio to full-screen video.

WORM: Write Once/Read Many--describes storage devices on which data, once written, cannot be erased or re-written. Being optical, WORMs offer very high recording densities and are removable, making them very useful for archiving.

WYSIWYG: What you see is what you get--usually, but not always. Referring to the accuracy of a screen display to show how the final result will look. For example a word processor screen showing the final layout and typeface that will appear from the printer.

YUV: A color model used chiefly for video signals in which colors are specified according to their luminance--the Y component--and their hue saturation--the U and V components.

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