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Product development model: Case study of high-definition television

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PRODUCT DEVELOPMENT MODEL: CASE STUDY OF HIGH DEFINITION TELEVISION

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ABSTRACT

This study addresses the necessary relationships (competition and cooperation) between and among (1) the manufacturers, (2) the customers, (3) the research organizations, and (4) the government agencies, who are involved in the development of a high technology product as the product traverses successfully through its product development life-cycle (PDLC). The PDLC is composed of three phases (invention, development, and integration) and each of these phases consists of three stages (idea generation and assessment, development and testing, and standardization and launch).

The literature review identified the problem - delay in HDTV development; the case study analyzed the history of television to produce a product development model (PDM) which considers the phases, stages, entities and their relationships; and the field survey validated the PDM using convergence analysis. Monochrome television (MTV) represented the invention phase, color television (CTV) the development phase, and high definition television (HDTV) the integration phase.

The PDM illustrates the following -- The relationship for the between entities' category changes from competition to cooperation as the product traverses through the stages, while it remains the same for the among entities' category; and the relationship for the among entities' category changes from competition to cooperation as the product traverses through the phases, while it remains the same for the between entities' category.

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LIST OF ACRONYMS

ABC	AMERICAN BROADCASTING CORPORATION
ABU	ASIA PACIFIC BROADCASTING CORPORATION
ACATS	ADVISORY COMMITTEE ON ATS
ACTV	ADVANCED COMPATIBLE TELEVISION
AD-HDTV	ADVANCED DIGITAL HTDV
ADR	AUDIO DATA RATE
ADS	ADVANCED DESIGN SYSTEMS
ADTV	ADVANCED DIGITAL TELEVISION
AEA	AMERICAN ELECTRONICS ASSOCIATION
AM	AMPLITUDE MODULATION
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
AT&T	AMERICAN TELEPHONE AND TELEGRAPH
ATRC	ADVANCED TELEVISION RESEARCH CONSORTIUM
ATS	ADVANCED TELEVISION SYSTEM
ATSC	ADVANCED TELEVISION SYSTEMS COMMITTEE
ATTC	ADVANCED TELEVISION TEST CENTER
ATV	ADVANCED TELEVISION
ATVA	ADVANCED TELEVISION ALLIANCE
B	BLUE
BAA	BROADCAST AGENCY ANNOUNCEMENT
BBC	BRITISH BROADCASTING CORPORATION
BDT	TELECOMMUNICATIONS DEVELOPMENT BUREAU
BSI	BRITISH STANDARDS INSTITUTE
BTA	BROADCAST TECHNOLOGY ASSOCIATION
BTS	BROADCAST TELEVISION SYSTEMS
C	CUSTOMER
C	CHROMA
CAGR	COMPOUNDED ANNUAL GROWTH RATE
CATV	CABLE TELEVISION
CATV	COMMON ANTENNA TELEVISION
CBS	COLUMBIA BROADCASTING SERVICE
CBU	CARIBBEAN BROADCASTING UNION
CCDC-HDTV	CHANNEL COMPATIBLE DIGICIPHER HDTV
CCIR	INTERNATIONAL RADIO CONSULTATIVE COMMITTEE
CCITT	INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE
CD	COMPACT DISC
CIS	COMMUNICATION AND INFORMATION SCIENCES
COMPACT	COMMITTEE TO PROTECT AMERICAN COLOR TELEVISION
CRT	CATHODE RAY TUBE
CTI	COLOR TELEVISION INCORPORATED
CTV	COLOR TELEVISION
CVC	COMPATIBLE VIDEO CONSORTIUM
DARPA	DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
DBS	DIRECT BROADCAST SATELLITE
DMD	DIGITAL MICROMETER DEVICES
DOC	DEPARTMENT OF COMMERCE
DOD	DEPARTMENT OF DEFENSE
DPCM	DIGITAL PULSE CODE MODULATION
DRAM	DYNAMIC RANDOM ACCESS MEMORY
DSC-HDTV	DIGITAL SPECTRUM COMPATIBLE HDTV
DSP	DIGITAL SIGNAL PROCESSORS
DSS	DOT SEQUENTIAL SYSTEM
DVP	DIGITAL VIDEO PROCESSOR
EBU	EUROPEAN BROADCASTING UNION
EDTV	ENHANCED DEFINITION TELEVISION
EEC	EUROPEAN ECONOMIC COUNCIL
EIA	ELECTRONICS INDUSTRIES ASSOCIATION
EIAJ	ECONOMIC INDUSTRY ASSOCIATION OF JAPAN

EIJ	ELECTRONICS INDUSTRIES OF JAPAN
EL	ELECTROLUMINESCENCE
EMI	ELECTRICAL AND MUSICAL INDUSTRIES
FCC	FEDERAL COMMUNICATIONS COMMISSION
FM	FREQUENCY MODULATION
FSS	FIELD SEQUENTIAL SYSTEM
G	GREEN
GA	GOVERNMENT AGENCY
GA	GRAND ALLIANCE
GATT	GENERAL AGREEMENT ON TRADE AND TARIFF
GC	GRAPHIC CONTROLLERS
GE	GENERAL ELECTRIC CORPORATION
GI	GENERAL INSTRUMENTS CORPORATION
GNP	GROSS NATIONAL PRODUCT
Ha	ALTERNATE HYPOTHESIS
HBO	HOME BOX OFFICE
HD-NTSC	HIGH DEFINITION NTSC
HDS	HIGH DEFINITION SYSTEM
HDS-NA	HIGH DEFINITION SYSTEM NORTH AMERICA
HDTV	HIGH DEFINITION TELEVISION
Ho	ORIGINAL HYPOTHESIS
HRD	HIGH RESOLUTION DISPLAY
HRS	HIGH RESOLUTION SYSTEMS
IABA	INTER AMERICAN BROADCASTING ASSOCIATION
IBC	INTERNATIONAL BROADCASTING CONVENTION
IBM	INTERNATIONAL BUSINESS MACHINES
IC	INTEGRATED CIRCUITS
ICC	IMAGE COMPRESSION CHIP
IDT	INTEGRATED DEVICE TECHNOLOGY
IDTV	IMPROVED DEFINITION TELEVISION
IEEE	INSTITUTE OF ELECTRONICS AND ELECTRICAL ENGINEERS
IFRB	INTERNATIONAL FREQUENCY REGISTRATION BOARD
IPSATO	IBERIAN PENINSULA SOUTH AMERICAN TELEVISION ASSOCIATION
ISO	INTERNATIONAL STANDARDS ORGANIZATION
ITS	INTERNATIONAL TELEVISION SYMPOSIUM
ITU	INTERNATIONAL TELECOMMUNICATIONS UNION
JCIC	JOINT COMMITTEE ON INTER-SOCIETY COORDINATION
LCD	LIQUID CRYSTAL DOIDES
LMCC	LAND MOBILE COMMUNICATION COUNCIL
LSI	LARGE SCALE INTEGRATION
LSS	LINE SEQUENTIAL SYSTEM
M	MANUFACTURER
MAC	MULTIPLEX ANALOG COMPONENT
MATV	MASTER ANTENNA TELEVISION
MCTC	MICROELECTRONICS AND COMPUTER TECHNOLOGY CORPORATION
MIT	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MPEG	MOTION PICTURE ENHANCEMENT GROUP
MPEG	MOTION PICTURE EXPERTS GROUP
MPT	MINISTRY OF POST AND TELEGRAPH
MRPIS	MULTI-REGIONAL POLICY IMPACT SIMULATION
MTV	MONOCHROME TELEVISION
MUSE	MULTIPLE SUB-NYQUIST SAMPLING ENCODING
MUSICAM	MASKING PATTERN-ADAPTED UNIVERSAL SUBBAND INTEGRATED CODING AND MULTIPLEXING
NAB	NATIONAL ASSOCIATION OF BROADCASTERS
NBC	NATIONAL BROADCASTING CORPORATION
NCTA	NATIONAL CABLE TELEVISION ASSOCIATION
NEC	NIPPON ELECTRIC CORPORATION
NEP	NEW ECONOMIC POLICY
NHK	NIPPON HYOSO KYOKAI
NOI	NOTICE OF INQUIRY

NSDA	NATIONAL SPACE DEVELOPMENT AGENCY
NTIA	NATIONAL TELECOMMUNICATION AND INFORMATION ADMINISTRATION
NTSC	NATIONAL TELEVISION SYSTEMS COMMITTEE
NYIT	NEW YORK INSTITUTE OF TECHNOLOGY
OIRT	ORGANIZATION OF INTERNATIONAL RADIO AND TELEVISION
OTA	OFFICE OF TECHNOLOGY ASSESSMENT
P	PHASE
PAL	PHASE ALTERNATE LINE
PALAF	PHASE ALTERNATE LINE ALTERNATE FRAME
PBS	PUBLIC BROADCASTING CORPORATION
PCM	PULSE CODE MODULATION
PDLC	PRODUCT DEVELOPMENT LIFE CYCLE
PDT	PRIORITIZED DATA PROTOCOL
PLC	PRODUCT LIFE CYCLE
QAM	QUADRATURE AMPLITUDE MODULATION
R	RED
RCA	RADIO CORPORATION OF AMERICA
RO	RESEARCH ORGANIZATION
RRH	REFUTED RESEARCH HYPOTHESIS
RRNA	R.R. NATHAN ASSOCIATES
S	STAGE
S-NTSC	SUPER NTSC
SAC	SHIPBOARD COMMAND AND CONTROL SYSTEM
SBCA	SATELLITE BROADCASTING AND COMMUNICATION ASSOCIATION
SC-HDTV	SPECTRUM COMPATIBLE HDTV
SECAM	SEQUENTIAL CORE AU'MEMOIRE
SIA	SEMICONDUCTOR INDUSTRY ASSOCIATION
SMPTE	SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS
SRC	SEMICONDUCTOR RESEARCH CORPORATION
SS-QAM	SPECTRALLY SHAPED QAM
SS/WP	SYSTEMS SUB-COMMITTEE/WORKING PARTY
STC	SATELLITE TELECOMMUNICATIONS CORPORATION
SWRI	SOCIAL WELFARE RESEARCH INSTITUTE
TI	TEXAS INSTRUMENTS
TV	TELEVISION
TVRO	TELEVISION RECEIVE ONLY EARTH STATIONS
UHM	UNIVERSITY OF HAWAII AT MANOA
USITC	UNITED STATES INDUSTRIAL TRADE COMMISSION
VCR	VIDEO CASSETTE RECORDER
VDP	VIDEO DISPLAYS
VDR	VIDEO DATA RATE
VISTA	VISUAL SYSTEM TRANSMISSION ALGORITHM
VLSI	VERY LARGE SCALE INTEGRATION
VRAM	VIDEO RANDOM ACCESS MEMORY
VSB	VESTIGIAL SIDE BAND
VTR	VIDEO TAPE RECORDER
WARC	WORLD ADMINISTRATIVE RADIO CONFERENCE
WP	WORKING PAPER
Y	LUMINANCE

CHAPTER ONE
INTRODUCTION

1.1 Background

Radical changes in the world economy have brought new challenges and opportunities to industries and organizations in the United States and elsewhere. Persistent failures of traditional organizations in both home and abroad, have triggered chain of thoughts to emerge among scholars and professionals in the reevaluation of the basic tenet upon which these industries and organizations have been built. It is the purpose of this dissertation to explore the nature of these challenges and opportunities, and offer insight into the successful and prosperous thriving of these entities (Manufacturers, Research Organizations, Customers, and Government Agencies) through these impediments (inefficiencies). (Note: See Section 6.2).

1.1.1 Entities Involved

The entities involved in an economy can divided into four broad categories -- 1. Manufacturers, 2. Research Organization, 3. Customers, and 4. Government Agencies. (Note: See Section 6.2).

1.1.1.1 Manufacturers

These are people, groups, organizations, etc. (individual or collection) who are involved in activities such as producing, fabricating, building, constructing, casting, setting up, tooling, etc. (Note: Examples of Manufacturers for television are RCA, Zenith, Magnavox, etc.). (Note: See Section 6.2.1).

1.1.1.2 Research Organizations

These are people, groups, organizations, etc. (individual or collection) who are involved in the investigation undertaken in order to discover new facts and ideas, get additional information or ideas for the social good, equity and access through the mode of professionalism and expertise. (Note: Examples of Research Organizations are MIT, David Sarnoff Research Center, Bell Labs, etc.). (Note: See Section 6.2.2).

1.1.1.3 Customers

These are people, groups, organizations, etc. (individual or collection) who are involved in buying the products and using it. (Note: Examples of Customers for television are ordinary television broadcast viewers, production houses such as ABC, CBS, NBC, etc.). (Note: See Section 6.2.3).

1.1.1.4 Government Agencies

These are people, groups, organizations, etc. (individual or collection) whose interest is in power, efficiency and equity for the public interest. (Note: Examples of Government Agencies are FCC, NTIA, DARPA, DOD, etc.). (Note: See Section 6.2.4).

1.2 Competition and Cooperation

1.2.1 Competition

Competition and its different aspects have always maintained the central place in economics theory and practice for well over two centuries now. Competition has been considered an essential component to the innovation process on which capitalism places heavy reliance. Competition has been the prime mover of technological innovation and high technology product development, just as innovation has been the prime mover of economic progress.

Note: A high technology product is characterized by (Rogers, E.M., & Larsen, J.K., 1984):
1. The need of highly skilled employees, many of whom are scientists and engineers;
2. A fast rate of growth;
3. A high ratio of R&D expenditure to sale; and,
4. A ripe market for it.

Economists have always recognized the core importance of technological innovation to economic growth, stability and welfare, and have regarded it to be the very essence of the present capitalistic economic society. Adam Smith's "Wealth of Nation" drowns itself completely when it carries on the discussion of "improvements in machinery." Adam Smith (1723-1790), a Scottish Philosopher, in the first page of "The Wealth of Nations," emphasized the importance of the development of machinery and the emergence of a category of workers whose job is "not to do anything, but to observe everything" (McNulty, P.J., 1984). This theme of his came out of an interest in the "process of production" and its organization. The other theme of his was dominated by the concept of "market process," in other words the "invisible hand." Karl Marx's capitalist economy model ascribes a central role to technological innovation in capital goods. Paul

Samuelson, in his principle text, has acknowledged the importance of technological change (Treece, D.J., 1992).

"Competition" is the rivalry between individuals (or groups), and it arises whenever two or more parties strive for something that all cannot obtain (The New Palgrave: A Dictionary of Economics, 1987). The Webster's Third New International Dictionary (1966) defines competition as "a common struggle for the same object." Its history can be traced to the beginning of civilization and sociological order.

In economic theory, competition refers to market conditions in terms of how much control sellers can exercise over the market. The varieties of competition range from "perfect competition," in which numerous firms produce or sell identical goods or services and have no control over the market, to "oligopoly," in which few large sellers with substantial influence vie with one another for available business and have some control over the market, to "monopoly," in which one seller has all the influence and has full control over the market.

The conditions necessary for perfect competition are --

A. The commodity products must be homogeneous so that the buyer has no preference for the product of any particular seller;
B. There must be a large number of both buyers and sellers;
C. All buyers and sellers must be in easy and immediate contact with each other, so that they have full information of the markets; and D. There must be no preferential treatment -- by tariffs, bounties, taxes and other means (Pass, C., Lowes, B., Pendleton, A., & Chadwick, L., 1991).

When scanning economic literature competition has been stressed more in the "the process of market," which covers many of the external activities of a firm, than in the "process of production," which covers many of the internal activities of a firm.

1.2.2 Cooperation

Like competition, cooperation is also an important ingredient to social progress and economic efficiency. The Webster's Third New International Dictionary (1976) defines cooperation as "the collective action for common well being or progress." It is the state of being associated. Competition and cooperation constitute antithetical approaches to human interaction (Jorge, A., 1978). The importance of cooperation in today's high velocity economic and technological environment cannot be undermined and understated. The challenge facing the entities (the manufacturers, the research organizations, the customers, and the government agencies) in today's economy is largely to find which mode of relationship -- cooperation and competition, to implement, espouse and adopt -- when, where and how.

During the early nineteenth century the ideal of cooperation was put forward as an alternative to competition (Hanson, J.L., 1986). The earliest attempt of cooperation in production to achieve a measure of success was that of Robert Owen (1771-1858) at New Lanark. In general, cooperation was implemented by organization or individuals who pooled their resources to buy or sell more efficiently and profitably than they could separately, and thus formed cooperatives. Cooperative societies engaged in the manufacture and the distribution of goods and ran democratically for the mutual benefit of individual members. The long history of this movement caught significant momentum in 1844, when a group of unemployed workers belonging to various trades formed a Society in Rochdale "for pecuniary benefit and improvement of social and domestic conditions of their members" (Gilpin, A., 1973). With the passage of time the total number of membership of this cooperative has increased from mere 20 in 1844 to over 13 million in 1970 and accounted for about 9 percent of all retail trade in Great Britain.

Cooperatives were formed to save money by buying or selling direct, eliminating middlemen or the charges of financial institutions. Among the many different types of cooperatives possible, some are -- producers' cooperatives, housing cooperatives, farm-marketing cooperatives, farm-purchasing cooperatives, and consumers' cooperatives (Bahr, L.S., & Johnston, B., 1991). A brief description of them is provided below.

Producers' cooperatives -- In this cooperative form, workers pool their funds and operate the enterprise in which they work. This type has its greatest strength in France, where a relatively large portion of industry has been small-scale. As for United States, they have had little success.

Credit cooperatives -- Through the pooling of savings in credit cooperatives, or credit union, members are able to borrow small sums, ordinarily to finance consumption needs, at lower rates than elsewhere.

Housing cooperatives -- Capital for cooperative housing is supplied through the purchase of shares by members.

Agricultural Marketing cooperatives -- These are voluntary business organizations for the collective marketing of members' produce.

Agricultural Purchase cooperatives -- These cooperatives buy goods necessary in farming operations, such as fertilizers, seed, feed, etc. Orders of the members are pooled, and the cooperative by buying large scale is able to save considerably.

Consumers' cooperatives -- These cooperatives pooled members to bypass the middle men.

Besides this, it is a misfortune to discover that the subject of cooperation has not been treated in depth except in discussion of successful enterprise such as INTELSAT, INMARSAT, etc., and economic textbooks, literature and journals do not provide its readers with extensive information about cooperation and almost always assume that the price mechanism, which is the sharpest and the strongest competitive weapon, can effect whatever coordination the economic system requires for economic efficiency and social progress. The ideal tenet of the published economic literature orthodoxy is that competition drives resource allocation towards efficient outcomes and social progress. Since the time of Adam Smith, economists have strongly supported the idea of market mechanism and competition as the necessary and only ingredient to social progress. Analysts have tended to stress the values of pluralism and rivalry as being the best and the only mechanism to promote and enhance innovation. While these are important for competition which enhances progress, cooperation is equally important. The overextended belief of certain economists in competition being the best mechanism of efficient allocation of resources in a world characterized by ubiquitous uncertainty due to future actions, preferences and technological state, speaks of their ignorance of the real world system (Koopmans, T., 1957). A reconceptualization of competition and a reassessment of cooperation is a necessity in today's high velocity economic and technological environment where there is no arena in which uncertainty is higher than ever before in the past and its magnitude and intensity continues to grow with every passage of time. In today's global economic system the correct choice between competition and cooperation by the entities is vital and imperative if any industry, organization, or country (particularly the United States) is to remain an economic leader.

There is no doubt that market mechanism process provides incentives for entrepreneurs and firms to innovate in an attempt to generate sufficient revenues and profits, but there are several reasons for going beyond the markets (Fransman, M, 1990).

The first is that, while many of the pressures, incentives and information flow that constitute the motive force for technical change originate in the market mechanism process, they do not fully determine the ensuing process of technical change, its form, characteristics and evolutionary directions. Technical change does not directly follow the market. Organizational structures, institutional practices, and social norms shape the process.

Secondly, under certain circumstances the market does not provide adequate guidance for resource allocation. In Fransman's word "they do not provide necessary guidance for new technologies of (not for tomorrow) but the day after tomorrow."

Thirdly, the firms are limited by the bounded visions of for-profit corporations. And finally, market mechanism processes do not tend to generate an appropriate amount of research cooperation.

The economic models of innovation process and development have generally tended to be non-robust in nature, showing that competition could lead to provide too little or too much research and development investment because of the fragmented market structure (Baldwin, W., & Scott, J.T., 1987). In today's environment, market structure failures can arise from -- 1. The classic problem of free rider, in which firms are unable to exclude others from using their technologies; and 2.

Incentives to invent first and accumulate monopoly rent first gets firms to apply too much resource earlier on and thus misallocate resources. It is true that a monopolized industry would avoid both these problems. (It was this very reason why Bell Labs flourished under monopoly and developed the best R&D in the world). But it is hard to say whether there would be more or less research and development investment undertaken in monopolized case than in competitive case (Nelson, R., and Winter, S. 1982). Therefore, the theoretical literature identifies a wide range of possible outcomes, and thus provides little guide to policy. Moreover, the economic debate seems to be out of touch with the real world for practical purposes. Neither perfect competition nor complete monopoly is observable in any industry today. Even the telecommunications services industries, which were once considered to be natural monopolies, are in a process of deregulation worldwide. Companies that once competed against each other are beginning to cooperate among themselves by forming alliances. (Note: See Chapter 8).

The global intensification of competitiveness in high technological firms has placed insurmountable burden on firms and players within an industry to coordinate their competition and cooperation to develop profitably commercial new technologies. This has caused academics, business people, and policy makers, professionals, as well as independent agencies, to rethink fundamental ideas about competition and cooperation. This is especially true in the United States because it is losing its capacity to compete and remain an economic superpower in the world economy (Scott, B., & Lodge, G.C., 1984), which is leading, at least in some circles, to the reevaluation of the American institutions, policies, and ideologies. It may be necessary to review and change some of the economics principles and tenets upon which the capitalistic society has placed heavy reliance.

The semiconductor industry has provided a very good example of this phenomenon. The high velocity environment to which the electronics industry has been subjected has made the reevaluation acutely important.

The intense global competition of the 1980s and 1990s has forced many companies in the semiconductor industries to cooperate not only in R&D, but in a wide spectrum of activities. However, it has been accomplished only in a piecemeal manner and the primary reason for this has been the existing regulations and practices that prohibit such activities. Good examples of this new trend are the Microelectronics and Computer Technology Corporation (MCTC) (formed in 1983), the Semiconductor Research Corporation (SRC) (formed in late 1982), and the Bell Research Laboratory (1984) (Stein, A.J., & Das, S., 1988). But these ventures have had minimal support from the U.S. government, in contrast to overseas ventures of other nations. Nevertheless, the recent formation of SEMATECH by the Semiconductor Industry Association (SIA) to develop world-class semiconductor manufacturing technologies with financial support from the U.S. government is an indication of retaliatory measures taken up by the U.S. to recuperate its competitiveness through cooperation.

1.3 Product Development Life Cycle (PDLC)

Traditional economics generally tends to provide treatments and discussions only after a product has been launched in the market and has been very successful at it. However, treatments before the product have been launched into the market is largely neglected and ignored.

The locus of the Product Life Cycle (PLC) has been the main trajectory along which traditional economics has directed its focus. The economics of the product before its introduction into the market has largely been neglected and ignored in traditional textbooks. Pre-product economics is important in today's high velocity economical and technological environment. Numerous expenditure, in terms of capital, labor and time, is incurred during this period. This period referred to as the product development period and the cycle called Product Development Lifecycle (PDLC) can be personified as "the period of a child when it is in the mother's womb." (Note: See Section 6.5).

It has been evident according to numerous economic literature that ideal of competition has been very successfully applied to the PLC. However, the theories of economics have generally refrained themselves from dealing with PDLC. Therefore, it is the tenet of this dissertation to determine when and where the ideals of competition and/or cooperation among and between entities may be applied while a product traverses along the Product Development Lifecycle (PDLC) phase and is subject to treatments at the various stages. Even though PDLC has been largely ignored, disregarded and neglected in the past, it cannot continue at the present and the future since it constitutes an important part of the economic life cycle of a product.

The most important product that is knocking at the door today is High Definition Television (HDTV). Its history has not been very pleasant but has been very thought provoking and informative. This is the very reason why it is an important case from which we can learn and prepare ourselves in the development of a high technology product for the future. The history of television dates well back to over a century now. It has gone through numerous transitions in the past and is ever changing at the present, starting from monochrome television to color television and to high definition television. It is the premise of this dissertation to look at the various historical and economic aspects of television and draw important conclusion out of it so that its concepts can be applied at successfully developing other high technology products in the future.

The delay and inefficiency in the implementation of HDTV have largely been a consequence of inadequacy. The ideal of competition, which has been suitable and successful after the product has been launched, has been applied with unsuccessful results to HDTV, a product that has yet to be launched. Therefore, it is evident that a new treatment is urgently needed that would help not only the successful introduction of HDTV, but other new high technology products that are being developed and ones that are yet to come in the future.

This dissertation attempts to answer questions such as -- to which ideal "competition and/or cooperation" should the various entities (manufacturers, research organizations, customers, and government agencies) adhere to -- when, why and how? and elaborate and discuss issues that are important in the development of a high technology product.

1.4 Overview of Chapters

Chapter 2 discusses the "Research Design and Methodologies" that have been used in this study. Chapters 3, 4, and 5 discusses the "Invention Phase" (History of Monochrome Television), "Development Phase" (History of Color Television), and "Integration Phase" (History of HDTV) in detail respectively. In Chapter 6, "Historical Analysis" is performed that integrates Chapters 3, 4, and 5. Chapter 7 discusses the "Field Survey" that has been used to validate the theoretical model developed through "Historical Analysis." Finally in Chapter 8 "Conclusion," the outcome of the study is presented and future implication of the research is discussed.

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CHAPTER TWO
RESEARCH DESIGN AND METHODOLOGY

2.1 Introduction

In this study the primary focus of the research has been directed towards the detection and exploration of the relationship that are important in the development of a high technology product and understanding the particular dominance of these factors in the interactions among the involved entities during the course of development.

2.2 Chapter Content

In this chapter a detailed discussion of the research design and methodology is presented. It starts with a discussion of Research Design in Section 2.3. Three types of designs (Experimental Design, Quasi-Experimental Design, and Case Study Design) have been discussed. In Section 2.3.4 the three designs are evaluated and analyzed for the appropriateness in this study.

Three types of Research Methods (Interviewing, Survey, and Historical Analysis) that have been used in this study are discussed in Section 2.4. Sections 2.4.1.1-2 elaborates on the Type I and Type II questionnaires that have been used in this research. Convergence Analysis, Survey, and Content analysis are discussed in Sections 2.4.1.1.1-2-3 respectively. Section 2.4.1.3 discusses questionnaire development.

The research plan is explained in Section 2.5. Sections 2.5.1-2-3 discusses Step 1 (Literature Review and Problem Analysis), Step II

(Historical Analysis), and Step III (Field Survey) respectively. Section 2.5.1.4 discusses Event IV of Step III "Final Model Development."

2.3 Research Design

Bouchard, T.J. (1976) has suggested in his research guidelines that the researchers should --

> 1. Choose the design that is most likely to serve the purpose rather than the easiest method; and
> 2. use more than one method.

It is thus imperative to consider the various different research designs. Three different designs -- Experimental Design, Quasi-experimental Design, and Case Study Design have been considered.

2.3.1 Experimental Design

To use this design, the study must meet four requirements. (Note - These are listed in Kin, R.K., 1993).

> 1. Have a unit of analysis with a sufficient number of "subjects" to produce multiple data points for any given variable.
> 2. Have a limited number of variables of interest -- usually much smaller than the number of data points available.
> 3. Have experimenters' ability to control and manipulate the variables of interest; and
> 4. Have random assignment of subjects to the treatment and control conditions.

2.3.2 Quasi-Experimental Design

If requirements 3 & 4 are not met another type -- quasi-experimental design becomes relevant. (Note: Campbell, D.T., & Stanley, J.C., 1963, has a very good description of this design). Quasi-experimental designs are used when the researcher cannot control or manipulate variables and cannot assure that the subjects are assigned to particular treatments because of real-life settings, in contrast to experimental laboratory settings.

2.3.3 Case Study Designs

There are situations where the number of subjects or data points is so small that it cannot outnumber the variables of interest (requirements 1 & 2), and the variables cannot be controlled or manipulated (requirements 3 & 4). Thus for the purpose of this study Experimental Design and Quasi-experimental Design cannot be used since it does not meet the requirements. In such a case, the Case Study Design remains the only choice.

Table 2-1 describes the technique of making choice of designs.

TABLE 2-1 SUMMARY OF SITUATIONS REQUIRING POSSIBLY DIFFERENT DESIGNS*

		TYPE OF DESIGN	
SITUATION	**EXPERIMENTAL**	**QUASI-EXPERIMENTAL**	**CASE STUDY**
Sufficient number of "subjects" producing multiple data points	XXXXXXX	XXXXXXX	
Limited number of variables of interest (fewer than the data points)	XXXXXXX	XXXXXXX	
Experimenter's ability to control and manipulate the variables of interest	XXXXXXX		

*Source: Yin, R.K., 1993.

2.3.4 Analysis of Design for This Study

In this dissertation the primary concern of the research is to determine the relationship between the various entities involved in the development of a high technology product. Being a real-life setting, the variables cannot be controlled and the samples cannot be subject to treatments; thus, Requirements 3 & 4 cannot be met. Further, since this study focusses on a single product, Requirements 1 & 2 are also not met.

The only choice, therefore remains -- CASE STUDY DESIGN.

2.4 Research Methods

In this study multiple research methods have been used. Case study using historical analysis and field studies (interviewing, and questionnaire administering) was used at various steps. Multiple methods have been used and the most appropriate one has been chosen for a particular inquiry.

2.4.1 Interviewing

Interviewing is a systematic data collection technique that is widely used in organizational settings. In this study, not much distinction has been made between interviewing and questionnaire administering since there is a strong relation between interviews and questionnaires, and it carries down to their popularity also (Bouchard, T.J., 1976). (Note: The primary reason for this is -- in interviews the question is asked and received verbally, while in questionnaire the same question could be administered but would be sent and received on a hard copy. However, in questionnaire administering, the effects due to non-verbal clues and cues are eliminated). (Note: See Section 7.2).

A matrix could be created by placing the type of questions along the 'x' axis and type of response along 'y' axis, as shown in Table 2-2.

TABLE 2-2 TYPES ACCORDING TO QUESTIONS AND RESPONSES*

		QUESTIONS	
		Specified	Unspecified
RESPONSE	Specified	I	III
	Unspecified	II	IV

*In this research Type I and Type II were used.

2.4.1.1 Type I

These are totally structured with closed ended questions and closed ended response (specified questions and specified response). This was used in the factor isolation confirmation survey, pilot survey, and final survey. The results are analyzed by using statistical techniques using the mean test and/or the median test. (Note: See Sections 7.3).

2.4.1.1.1 Convergence Analysis

Convergence analysis is a method of comparing the results of two methods. It could be a quantitative technique, as well as a qualitative technique. In the quantitative technique, percentage of match (correlation analysis) is generally used, while in the qualitative technique, judgments are made about the results. (Note: See Sections 7.2.5 and 7.3.4).

In this study qualitative analysis was performed for convergence analysis at the "Factor Isolation" comparison stage, in which the results obtained from historical analysis and results obtained from field survey are compared to see if both converge. Qualitative analysis could be performed since there are not many data points to be compared. During data comparison (between response and theoretical value) in the Pilot Survey and Final Survey, quantitative analysis using statistical correlation analysis has been used. (Note: See Section 7.2.5).

2.4.1.1.2 Survey

For this study the following definition for "survey" (as provided by Marsh, C., 1982) has been used.

Survey refers to an investigation where --
1. systematic measurements are made,
2. the variables in the response matrix are analyzed, and
3. the subject matter is social.

2.4.1.2 Type II

These are semi-structured with open ended response (specified questions and unspecified response). This instrument has been used during the first activity of the field research process. The results have been analyzed by using content analysis. (Note: See Section 7.2).

2.4.1.2.1 Content analysis

"Content analysis" is a type of analysis used to analyze verbal material. Content analysis is a technique for making inferences by objectively and systematically identifying specified characteristics of messages (Lindzey, G., & Arinson, E., 1968). In recent years content analysis has undergone extensive growth and is getting more and more popular among researchers (Holsti, O.R., 1968, & Carney, T.F., 1972). In this analysis it is necessary to identify, within text, instances of words and phrases that belong to a category specified by the investigator and counting their occurrences (Stone, P.J., Dunphy, D.C, Smith, M.S, & Ogilvie, D.M., 1966-67). (Note: See Section 7.2.3).

In this study the simplest form of content analysis technique has been used which has been based on classically oriented content analysis.

(Note: In this type, the recording unit "word" is used). Content analysis produces data in answer to a question by focusing the subject. The question determines the amount of work that would be spent in analysis. It is thus necessary for the question to be rich and is possible only through brilliant intuition. A content analysis can be conducted only when much is known about the subject matter and background of the inquiry (Carney, T.F., 1972). The validity is assessed by gathering data through different techniques, and seeing if those converge. (Note: See Section 7.2.5).

Categories have been formed through historical analysis. A question is formulated that focuses the response. Dictionaries and thesauruses have been used to create a list of words that fall in the particular categories. The total number of occurrences of those words is recorded. A standard (percentage) is set that springs from related materials (Carney, T.F., 1972). (Note: The standard is based on intuitive judgment). The results are analyzed and compared with that of other techniques (for this study, historical analysis and other theories).

2.4.1.3 Questionnaire development

In the development of the questionnaires the following rules (Erdos, P.L., 1970, & Payne, S.L., 1951) have been observed --

1. Is the question necessary? *If not eliminate them.*
2. Is the questionnaire repetitious? *If so, remove it.*
3. Does the question contain more than one idea? *If so break them.*
4. Can the respondent answer the question? *If not, don't ask.*
5. Could it be made more specific? *If so, do it.*

6. Is the question clear? *If not, make it.*
7. Is the response format adequate? *If not, simplify it.*
8. Can the item be arranged so that particular answers preclude the need to answer others? *If so, correct it.*

The answers to these questions are generally obtained after a Pilot Study has been carried out. "Pilot Study" is compulsory when using complex questionnaires. A completely clean questionnaire is obtained after the above questions have been taken care of. (Note: See Section 7.4).

2.4.2 Pilot Surveys

In order to make necessary decisions concerning the appropriateness of the questionnaire it is necessary for the researcher to anticipate the distribution of the response (Alreck, P.L., & Settle, R.B., 1985). One way to overcome the problem (of anticipating the distribution of responses) is to conduct a Pilot Survey. The questions are pretested during this phase. In this study, a pilot survey has been conducted to get a feel for the distribution, as well as to answer the questions in Section 2.4.1.3. The size of the sample was determined by using the process of sequential sampling. (Note: See Sections 8.4 and 8.5).

2.4.2.1 Sampling

Alreck, P.L., & Settle, R.B., in their book "The Survey Research Handbook, 1985" have mentioned

> The researchers should be advised that there are statistical formulas for the computation of a specific

> sample size to yield a given level of confidence interval. Unfortunately, they are of little value, even to the experienced, practicing researchers .... because the computations require fairly accurate estimate of population variance which is seldom known, ...the estimation of sample size remains largely an art.

The use of sequential sampling method is helpful in determining the sample size. (Note: See section below).

2.4.2.2 Sequential Sampling

To overcome the doubt of an appropriate sample size, the technique of sequential sampling was used (Alreck, P.L., & Settle, R.B., 1985, Law, A.M., & Kelton, W.D., 1991). In this technique the researcher proceeds with prior knowledge of the anticipated distribution from the Pilot survey and other methods, and analyzes the changes in the distribution with the addition of samples. When responses are steady, the researcher may be able to predict quite accurately the points of interest. The only disadvantage of this method is that it requires repetitious calculations. (Note: With the use of computers, this disadvantage seems to be trivial). (Note: See Section 7.5.2).

2.4.3 Historical Analysis

The case study is the method of studying a problem by the detailed examination of the characteristics of single objects or events (Cherns, A.B., & Davis, L.E., 1975) and when it concerns development it is a case history, life history or historical analysis. As a research procedure, this method has been used by many investigators to obtain detailed descriptions. It simplifies the range of data one is asked to consider, focuses attention and illuminates the meaning, provides "thick description" and experimental perspective, and is holistic and life-like (Guba, E.G., 1979).

The essence of a historical analysis (case study), the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result (Schramm, `W., 1971). To enhance the effectivity of "case study," comprehensive, extensive, and historical information must be incorporated (Haytin, D.L., 1988). (Note: See Chapter 6).

2.4.3.1 Problems With Case Study

Yin, R.K., 1984, has identified the following problems of Case Study --

1. The lack of rigor;
2. Limitation on generalization; and,
3. Takes too long and results in a massive, unreadable document.

2.4.3.1.1 Solution to the Problems

The problem of "lack of rigor" has been taken care of by considering a group of material as shown in Section 2.4.3.2.

The problem of "generalization" has been taken care of in the study by incorporating other methods (such as field survey) into the whole research. The model developed through case study was validated by field survey using convergence analysis. (Note: See Chapters 6 and 7).

The problem of "takes too long and results in a massive, unreadable document" could not be taken care of in this research. Problem I and Problem III act against each other. Therefore, to overcome Problem I, which the author feels more important, Problem III was of no concern.

2.4.3.2 Materials Used for Case Study

The study of HDTV is very new and is at an infant stage. (Note: It may not be wrong to say it is a mature baby). Hence, most of the research has had to heavily rely on a limited number of sources.

2.4.3.2.1 Primary Sources

The primary sources for this dissertation were --

1. Documents published by AEA (American Electronics Association),
2. Documents published by ATSC (Advanced Television Systems Committee),
3. Documents published by EIA (Electronics Industries Association),
4. Documents published by FCC (Federal Communications Commission),
5. Documents on Government (Senate and Congress) hearings on HDTV,
6. Documents published by ITU (CCIR) (International Telecommunications Union),
7. Documents published by the various proponents of HDTV,

8. Documents published by NAB (National Association of Broadcasters), and
9. Documents published by NTIA (National Telecommunications and Information Administration),

2.4.3.2.2 Secondary Sources

The secondary sources were --

1. Broadcasting Magazine,
2. Business Week,
3. Cablevision,
4. Electronic Business,
5. Electronic Market Databook,
6. Electronic News,
7. Fortune Magazine,
8. Government Documents,
9. IEEE Transactions on Broadcasting,
10. IEEE Transactions on Communications,
11. IEEE Spectrum,
12. SMPTE Journal,
13. Television Factbook,
14. The Wall Street Journal, and
15. The Washington Post.

The primary sources provided an in depth description development, status, and discourse on HDTV. The newspapers and magazines provided basic day to day information on the developments of HDTV. Other magazines and journals provided summarizes of major events, opinions of various experts, development, and description of systems details. In addition to these, many other books have also been consulted.

2.5 Research Plan

In this dissertation the research plan has been divided in three steps: Step I -- Literature review and Problem analysis, Step II -- Historical analysis;and Step III -- Field survey. (Note: See Figure 2-1). Steps are further divided into a couple of events. The events are divided into three operations -- activity, analysis, and result.

2.5.1 Step 1 Literature Review and Problem Analysis

This step consists of only one event. The event consists three stages -- 1. Literature Review, 2. Qualitative analysis, and 3. Problem Identification. A number of popular literature in HDTV has been used. (Note: See Section 2.4.3.2). While performing qualitative analysis, the premise was to determine some problem areas and narrow it down to one that required further study. (Note: See Chapters 3, 4, and 5).

2.5.2 Step II Historical Analysis

This step consists of three events -- 1. Invention Phase (Monochrome Television) analysis, 2. Development Phase (Color Television) analysis, and 3. Integration Phase (High Definition Television) analysis.

2.5.2.1 Event 1 -- Invention Phase (Monochrome Television) Analysis

In this event, monochrome television was analyzed in detail. Chapter 3 discusses in detail the history of monochrome television and begins right from the very beginning to the very last. Rigorous qualitative analysis was performed (with the problem area identified in Step I in mind) and various factors were isolated. (Note: See Chapter 6). The trends were also observed. These trends were compared with that of Event 2 -- Development Phase (Color Television) analysis and Event 3 -- Integration Phase (High Definition Television) analysis.

2.5.2.2 Event 2 -- Development Phase (Color Television) Analysis

This event is similar to Event 1, except that it is for color television. Chapter 4 describes in detail the history of color television from its very inception. Rigorous qualitative analysis was performed (with the problem area identified in Step I in mind) and various factors were isolated. (Note: See Chapter 6). As with Event 1, the trends were also observed and compared.

2.5.2.3 Event 3 -- Integration Phase (High Definition Television) Analysis

Similar to Event 1 and Event 2, in this event high definition television was analyzed in detail. Chapter 5 describes in detail the history of high definition television from its very inception. Rigorous qualitative analysis was performed (with the problem area identified in Step I in mind) and various factors were isolated. (Note: See Chapter

6). Similar to Event 1 and Event 2, the trends were compared with that of Event 1 and Event 2.

2.5.3 Step III-Field Survey

This event consists of four events -- 1. Open ended interview survey to isolate factors, 2. Closed ended questionnaire survey to confirm factors, 3. Closed ended questionnaire survey to confirm model and hypotheses (Pilot Survey), and 4. Closed ended questionnaire survey to confirm model and hypotheses (Final Survey). (Note: See Chapter 7).

2.5.3.1 Event 1 -- Open Ended Interview

In this event, open ended questions, that were suggested by literature review (Step I) and historical analysis (Step II), were asked to various subjects. (Note: The question asked is listed in Appendix M). A sample of subjects was chosen from the Communication and Information Sciences (CIS) Department Ph.D. students at the University of Hawaii at Manoa (UHM), randomly. CIS Ph.D. students were selected because of their interdisciplinary backgrounds and diverse interests due to the nature of the CIS program. Further, all of the students have been associated closely with high technology products, and therefore are familiar with the topic of study. (Note: The list of subjects is in Appendix L). Content analysis was used to isolate the important factors. (Note: See Section 7.2.3). To avoid the passing of non-verbal clues and cues, telephone and recorder were used. Even though the researcher felt that the response would be satisfactory Event 2 was used to confirm the results of this Event. (Note: See the following Section 2.5.3.2).

2.5.3.2 Event 2 -- Closed Ended Questionnaire Survey to Confirm Factors

After Event 1, a closed ended questionnaire survey was formulated and administered to top level executives of companies involved in the development of high technology products in Hawaii. "The Hawaii High Technology Business Directory, 1991" compiled by "High Technology Development Corporation" was used to isolate the top level executives and companies. The questionnaire was administered by fax. (Note: The questionnaire is listed in Appendix P). (Note: The list of subjects chosen is listed in Appendix O). Percentage analysis was used to evaluate the result. (Note: See Section 7.3)

After the factors were isolated, convergence analysis was performed with that of the results of Step II "Historical analysis" to determine the quality of result. (Note: See Section 7.3.4).

2.5.3.3 Event 3 -- Pilot Survey

After the factors were isolated, a questionnaire was developed that would be used to determine the relationship of the concerned entities during the various stages and phases of the product development. The questionnaire was developed by drawing in from existing models and incorporating observances from Step II. (Note: See Section 7.4.1 for questionnaire development, and Appendix R for the questionnaire and Appendix Q for the list of subjects).

The Pilot Survey was conducted to satisfy the requirements of Sections 2.4.1.3, 2.4.2, and 2.4.2.1-2. (Note: See Section 7.4).

2.5.3.4 Event 4 -- Final Survey

After the Pilot Survey, a final questionnaire was developed that took into consideration Sections 2.4.1.3, 2.4.2, and 2.4.2.1-2. (Note: See Section 7.5.1 for questionnaire development and see Appendix U for a sample of the final questionnaire). The questionnaire was distributed to experts who have been involved in the development of high technology products throughout the USA, especially the Silicon Valley (Santa Clara and Santa Rosa) area, because it is where many such products are being developed (Rogers, E.M., & Larsen, J.K., 1984). (Note: See Section 7.5 for the description of the Pilot Survey and Appendix T for a list of subjects participating in it).

2.5.4 Event 3/Step III -- Final Model

The data obtained from Section 2.5.3.4 were subject to heavy statistical analysis. Convergence analysis and hypotheses testing were performed to check the results with that obtained from Sections 2.5.2, and 2.5.2.1-2-3. Both quantitative analysis and qualitative analysis were performed to obtain a final model. (Note: See Section 7.6).

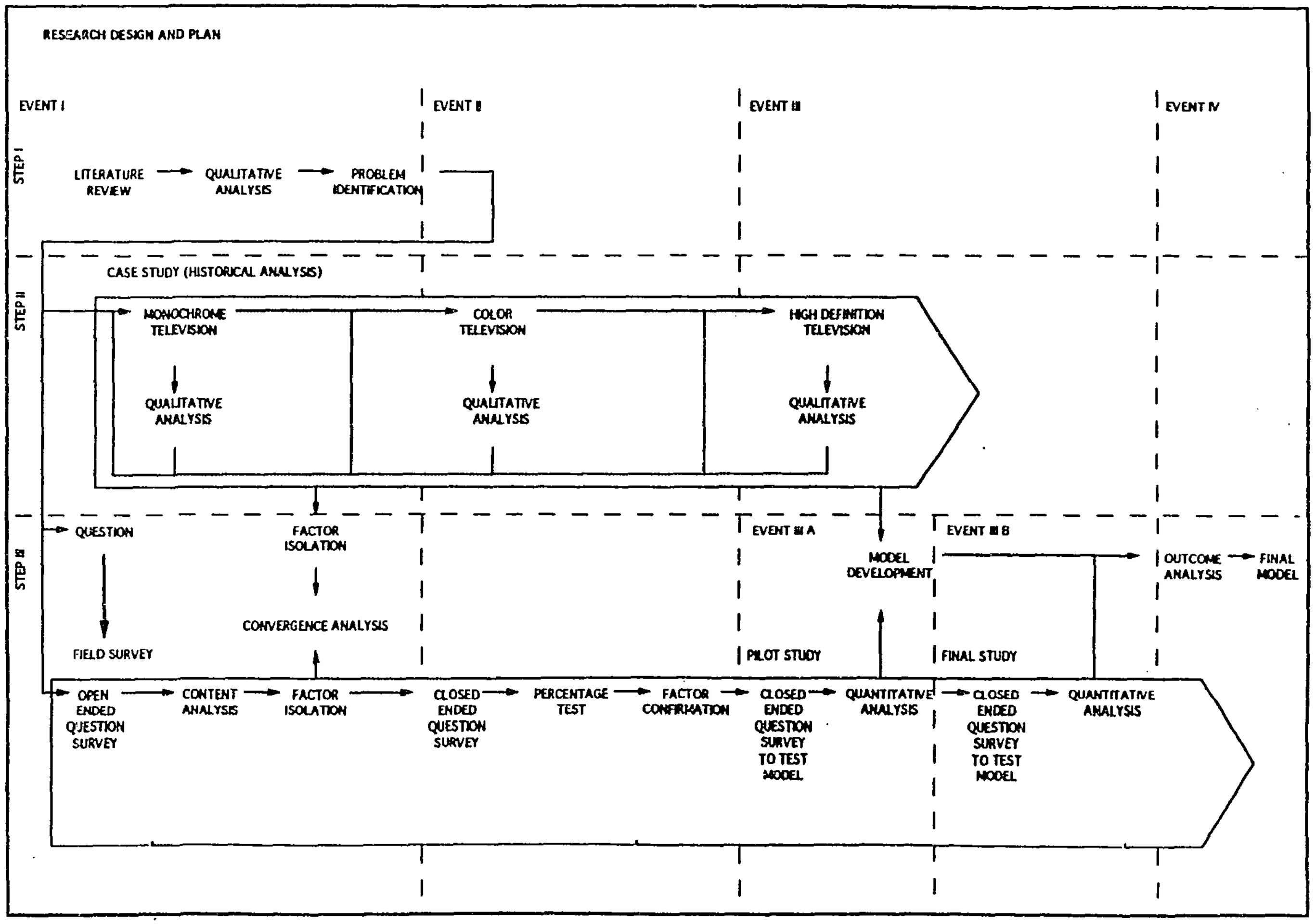

FIGURE 2-1 RESEARCH DESIGN AND PLAN

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CHAPTER THREE
INVENTION PHASE -- HISTORY OF MONOCHROME TELEVISION

3.1 Background

When man realized that he could send meaningful dots and dashes through space, his quest to send voice grew. Due to this irresistible chagrin he accomplished something, something that would change the course of history and alter the image of the world; and that something was being able to send voice through space. If it was possible to send voice through space, there seemed to be no question (or reason) for not being able to send vision simultaneously through space with voice. This attracted many enthusiastic inventors, but the journey would be long and difficult. Some would be destined to succeed and prevail, while others would be doomed to failure and face extinction.

In spite of all odds, the thirst would be quenched and sending vision, as well as voice simultaneously, would be possible. It would be possible to see and hear through barriers, and it would be possible to bring home live scenes thousands of miles across the horizon, and even from other planets.

It is very difficult to state exactly when and where the history of television began. Some historians have gone to such an extent as to state Biblical times (Stanley, K., 1965). However, in my opinion, as well as many others in the literature, the discovery of photosensitivity of selenium marks the correct starting date of the history of television.

The history of television can be divided into three distinct Phases (Note: See Section 6.6). They are:

1. The Invention Phase (monochrome television),
2. The Development Phase (color television), and
3. The Integration Phase (high definition television).

In this chapter, we will discuss the Invention Phase (i.e., history of monochrome television).

The Invention Phase can be further divided into three stages (Note: See Section 6.5). They are:

1. the Idea Generation and Assessment Stage,
2. the Development and Testing Stage, and,
3. the Standardization and Launch Stage.

3.2 Idea Generation and Assessment Stage

The discovery of the photosensitivity property of the element selenium in 1873 prompted unsurmounted impetus and momentum to the search of ways of transmitting and receiving pictures through space, in other words being able to see through distance. During that period selenium was being used as high resistances for continuity checks of the Atlantic cable by Willioughby Smith, who was the chief electrician of Telegraph Construction Company in Valentia, Ireland (Smith, W., 1873, 1891). However, selenium proved to be unsuitable for this purpose due to its large and unsuspected variations in resistance. Smith investigated this variability and sent a report to the Society of Telegraph Engineers giving details of the test and results (Smith, W., 1873). This letter later appeared in the American Journal of Science and Arts (Smith, W., 1873). In the letter Smith reported: "When the bars were fixed in a box with sliding cover, so as to exclude all light, their resistance was the highest, and remained very constant...., but immediately when the cover of the box was removed, the conductivity increased from 15% to 100%, according to the intensity of the light falling on the bar." In official circles Smith is credited and given full honor for the discovery of photosensitivity property of selenium, however, it was Joseph May, a subordinate of Smith, who conducted all the experiments at Smith's request (Shiers, G., 1977).

The idea of the photosensitive property of selenium did not give any thought to transmitting pictures, messages, or images over a wire during the initial stages of its discovery. The fascinating idea that selenium could serve as a visual pickup device (the counterpart of a microphone) and the astounding disclosure of a working telephone by Alexander G. Bell in 1876 provided the initial impetus for early enthusiastic inventors. However, other factors, particularly telegraphic practices and devices and scientific discoveries in the field of optics entered into the early schemes and provided the momentum for research (Sheers, G., 1977, Bell, A.G., 1880).

In 1843, Alexander Bain, a Scottish clockmaker had patented the first copying telegraph (Bain, A., 1843). Many other methods for sending graphic materials along a telegraph wire had been demonstrated by many individuals by the turn of that decade. However, Bain's method embodied certain very vital principles that would be the guiding force in the development of television -- automatic synchronous control, sequential scanning line by line, and transmission by a single wire with a ground return. A more compact machine for the reproduction of handwriting was invented by Fredick Collier Bakewell of London in 1848 (Bakewell, F.C., 1848) and Giovanni Caselli of France devised an electromechanical system in 1850 (Caselli, G., 1861).

Among the very notable discoveries made during that time was Michael Faraday's discovery of rotation of plane polarized light, called Faraday's effect in 1845 and John Kerr's discovery of a similar effect whereby the plane of polarized light is rotated by reflection from the polished poleface of an electromagnet in 1876 (Sheers, G., 1977). These discoveries would prove very important in the later stages.

The proponents of transmitting information during that era were quite well equipped with resources and had a rich storage of tools available at their disposal. The psychophysical phenomenon of the eye, such as the persistence of vision was well founded. The function of the retina and the laws of optics were well advanced. The principles of photography, synchronism, scanning, electric circuits, wire connections were all available. With the well-founded results of telegraphy, it would not be surprising if its theory would be further refined and proposed by many early proponents.

During that time, there were two primary ways to accomplish the transmission of images -- the serial transmission and the parallel transmission. The most straightforward solution was to reject serial transmission outright and try to transmit with a massively parallel system utilizing a large array of sensors, each focused on a very small portion of the image to be transmitted (Sweeney, D., 1987). Naturally, the more the amount of sensors, the better the resolution. This became quite unfeasible because of the incomprehensible amount of sensors required for even a low resolution picture.

Later on proponents advocated another system, the scanning system that used the serial transmission and it really worked. In this scanning method, the image is registered a point or a line at a time by the scanner, and a multitude of light values corresponding to the particular point or line as scanned by the scanner, is transmitted one by one serially, and then assembled into a likeness of the original image by a reverse-scanning mechanism.

One of the earliest proponents of television was George Carey of Boston who used the parallel system of image transmission. In 1875, Carey proposed a system consisting of circular mosaic of selenium as the transmitter, connected by separate wires to the electric filaments at the receiver (Carey, G. R., 1895). By 1875, the practice of sending messages over telegraph wires and through submarine cables was well established and the desirability and commercial value of being able to transmit both spoken words and visual images were the theme of many proponents. The payoffs were high and the stakes were well worthwhile.

In 1878, an important discovery that would later have important bearing on the picture transmission concept was made. Sir William Crookes discovered the cathode ray which by the turn of the century was shown by Thompson to be a beam of high speed electrons (Thompson, J.J., 1897).

There were many other proponents who turned their thoughts toward the problems, possibilities and techniques of electric vision during this era. Adriano de Paiva, a Portuguese Professor of physics at the

Academia Polytechnica in Porto brought forward the idea of electric telescope in 1878 (Paiva, A., 1878). In his plan, selenium was scanned by metallic plate and had a moveable incandescent lamp at the receiver. This single circuit arrangement required synchronization, a problem that would elude and defeat many inventors for many years.

During this period the relationship between the structure of the ear and its telephone model and the comparable imitation of the eye in possible apparatus for electric vision began to emerge (Shiers, G., 1970).

Denis D. Redmond, of Belmont Lodge, Sanford, Dublin in 1879 came out with an idea of transmitting luminous image by electricity (Redmond, D.D., 1880). He used a number of circuits containing selenium and platinum arranged in mosaic pattern. During this period Redmond realized the inertia effect of selenium and its sluggish property in response to light.

The works and the developments that were taking place in Europe aroused the interest of Alexander Graham Bell. Working with his coworker Sumner Tainter with selenium cells, they came out with a visual telegraph, the photophone in 1880 (Bell, A.G., 1880).

During that same year, in April 1880, John Perry and William Edward Ayrnton of London advanced their ideas on seeing by electricity and suggested a multicircuit scheme (Perry, J., and Arynton, W.E., 1880). They proposed two schemes. For one, they suggested an apertured mosaic with magnetically operated shutters for controlling the light amount, and in their alternative, they suggested making use of the Kerr effect with polarized light reflected from poles of magnet cores viewed through an optical analyzer.

William Edward Sawyer, an electrical engineer of New York studied the plans of Carey critically, analyzed it and evaluated it. He suggested spiral scanning by means of a rotating light pipe between the image plane and a selenium coil, with a similarly rotating spark gap fed by induction coil at the receiver (Sawyer, W.E., 1880).

Constantin Senlecq, a lawyer of Adres, near Calais was also among the initial proponents. He proposed various systems, which he continued to change and refine with the course of time. In 1879 he discussed about the concerned apparatus intended for graphical recording. In 1881, he discussed synchronism and its effect in picture transmission (Selnecq, C., 1881). During this year Shelford Bidwell described to members of the Royal Institution and other British organizations a facsimile scanner that moved a selenium element system systematically over the target image area (O'Brien, R.S., & Monroe, R.B., 1976).

Late in the 80s, Maurice Leblanc of Paris came open with a wealth of ideas on problems of transmitting images by electricity (Leblanc, M., 1880). His most important contribution is the use of a single mirror vibrating on two axes at different rates for analyzing an object and recomposing the image, arranged to give a back and forth linear scan. He also proposed a method of color transmission by using seven selenium cells. However, the concrete suggestion of a receiver came from William Lucas of London in 1882 (Lucas, W., 1882). In his proposal, light was modulated by a crossed pair of Nicol prisms operated by incoming signals via an electromagnet. The modulated beam was then deflected by vertical and horizontal prisms to cast a moving spot of light that traced a horizontal scanning pattern on the screen. He came out with the concept of back and forth linear scanning and flyback. This was an optical equivalent plan of a cathode ray tube. The problem however was of scanning.

This classical answer to the scanning problem was solved by Paul Nipkow, a 23 year old physics student in Berlin, Germany in 1883. His answer was spinning a perforated disc in front of the image (Nipkow, P., 1883). Jean Lizare Weiller, also in Germany proposed another scanning mechanism in 1889 (Weiller, J.L., 1883). He proposed a revolving drum carrying a series of tilted mirrors as a scanning device. Another kind of scanner was proposed by Louis Marcel Brillouin in 1890, which consisted of lensed discs rotating at different speeds (Brillouin, L.M., 1890).

The introduction of a scanning process resulted in significant simplification of the image transmission system, but at the same time it had the associated limitations of a single-channel system, which subsequently led to delays in development of television (Gorokov, P.K., 1961).

In 1892, the first photoelectric cells were made by Elster and Geital for measurement purposes (Glover, A.M., 1941). This would change the orientation of many proponents. (In 1906, Rignoux and Fournier in France assembled an experimental system along the lines of Carey's idea; but with only 64 selenium photocells, the system could produce only simple patterns (O'Brien, R.S. & Monroe, S.C., 1976)).

Leon Le Pontois, in 1893, described an apparatus for transmitting pictures of moving or stationary objects at great distances (Pontois, L.L., 1893). His "telectroscope" employed Nipkow discs, pulsating current motors, and tuning forks. (The word "television" was coined in 1900 by a Frenchman named Perski (Wilson, J.C., 1937)). That same year (1893) George H. Morse put forward another idea (Morse G.H., 1893). He proposed using selenium surface at the end of a cable made up of many thousands of small wire that was enclosed in an evacuated glass cylinder with a mesh electrode placed in front of the selenium both for transmitter and receiver. The only difference between transmitter and receiver was the lens and eyepiece respectively. This was a parallel transmission scheme.

In 1894, Charles Francis Jenkins proposed his phantoscope (Jenkins, C.F., 1894). In his system he had a mosaic of selenium and a mosaic of filaments. A cable connected the mosaics.

In 1897, the most well known "telectroscope" was invented by Sczczepanik, a school master of Krosno, Poland (Szczepanik, J., & Kleinberg, L., 1898). His most remarkable claims were voice communication and reproduction of images in natural color. Sczczepanik was the first inventor of telectroscope to avail widespread publicity as well as a handsome financial support. Mark Twain called him the "Austrian Edison" (Twain, M., 1898). The apparatus was put in exhibition at the International Exposition in Paris in 1900. During this year, 1897, Professor Karl Ferdinand Braun created means of focusing and deflecting Crookes' cathode ray, creating the basis of modern cathode ray oscilloscope and picture tubes (Braun, F., 1897).

In 1898 an entirely different system called the "Teleoscope" was proposed by a Swiss physicist, Franz Dussaud, in France. His technique combined cameras with lanterns for large screen projection (Scientific American Supplement, 1898). Also during this year M. Vol'fke obtained a patent for his system that used Nipkow discs and included radio transmission and a gas discharge tube (Vol'fke, M., 1898).

3.3 Development and Testing Stage

The early years of the twentieth century (between 1901 and 1920) saw notable developments in television engineering. During this period, proponents added numerous devices to the inventories. The method of disclosure also changed as inventors realized the potential commercial value of their ideas (Shiers, G., 1981).

December 12, 1901, was the day when Gulglielmo Marconi and his associates succeeded in the historic first wireless transmission across the Atlantic. This was the first effort to apply the electromagnetic waves predicted by James Clerk Maxwell in 1873 and proven experimentally by Heinrich Hertz in late 1880s.

Otto von Brook also made a good start in 1901 with a proposal based on the recent invention of "Telegraphone" by Valdemar Poulsen. His proposal was radical and included intermediate magnetic signal storage, a rotary magnetic distributor and the conversion of simultaneous signals from the camera mosaic into sequential signals for single-line transmission (Shiers, G., 1977).

The missing element that impeded implementation of many proposed systems, both mechanical and electronic, was a mean of amplifying the very weak signals that were obtained from any scanning system. The "Edison effect" of 1883 had been put to use in the Fleming valve of 1904 for wireless signal detection. Amplification was shortly made possible by the invention of the 3-electrode Audion tube by Lee DeForest in 1906.

In 1904, Arthur Korn, a German Professor, successfully transmitted a recognizable photograph of the French President Fallieres from Berlin to Paris by wire (Sweeney, D, 1987). Korn's system was never really adaptable to television transmission, largely because of its reliance on selenium cells; but it was still a milostone in the development of television.

In 1906, Max Dieckmann and Gustav Glage applied a Braun tube for visually displaying graphic patterns. It was a system that was a half way step towards television. Later in 1907, Boris Rosing at the Technological Institute of St. Petersburg, combined an opto-mechanical transmitter with a display tube (Rosing, B., 1923). He introduced a new scanner with polyhedral mirror drums of phototubes instead of selenium cells. Rosing claims to have transmitted moving images on May 9, 1911. The images were not recognizable as representations of objects, but geometric forms.

In 1910, Alfred Ekstrom, of Sweden introduced spotlight scanning of transparencies by a rotary motor with a cam operated motion. In 1914, Samuel Hart employed a turret-type lens drum designed for interlaced line or group scan and a linear discharge tube with magnetic deflection.

In 1911, A. A. Campbell Swinton saw possibilities of television communication with a variation of Rosing's scheme with cathode ray tubes at both the transmitter and receiver (Swinton, A.A.C., 1912). He actually predicted television apparatus as is used today. Little progress was made with his suggestion.

A scheme that was all electronic except for an oscillating mirror was disclosed by Alexander McLean Nicolson in 1917. His specification, titled "television" was assigned to Western Electric, and included newly developed radio circuits and picture tubes.

World War I (1914 - 1918) broke in Europe. Numerous developments took place during that period. The electron tube technology was applied to radio transmission during that period and there was a rise in general interest in the progress made in science and the advantages it provided. Using advances in radio circuits and improved phototubes, the transmission of graphic messages and photographs in facsimile became commercially feasible. The rapid progress in transmission of still pictures and the unprecedented success of commercial radio broadcast stimulated vigorous interest in television.

In 1919, Denes Von Mihaly started experiments on phototelegraphy in Hungary and in 1923 he developed a "Telehor" system with a galvanometer scanner operated by a phonic wheel and tuning fork (Mihaly, D.V., 1923).

In 1920, in spite of the revolution, S.N. Kakourin of the Soviet Union, brought forward a two-channel system with Nipkow disks, phototube and electron tube circuits (Gorokov, P.K., 1961). In 1922, Boris Ritcheouloff came out with two systems, one with vacuum tubes containing vibrating photoelements, the other a magnetic recording system in which a moving iron strip, disk or drum served as storage medium. This described the recording and playback of visual signals and sound.

The first post-war regular broadcasting began in 1920, and by the end of 1922, there were well over 500 radio broadcasting stations on air in the United States (O'Brien, R.S., & Monroe, R.B., 1976). It was expected that television would take the same pattern but television was just a mere collection of ideas and proposals.

While Baird, Jenkins and Mihaly were getting ready with their mechanical systems, Vladimir K. Zworkin, working at Westinghouse filed for a patent on December 29, 1923, for an all electronic system employing an electronic scanned camera pickup tube and a cathode ray display tube (Sweeney, D., 1988). A laboratory demonstration of his system in 1924, produced crude, shadowy pictures of a simple crossed pattern. In 1929, he demonstrated his system to the Institute of Radio Engineers on a kinescope display tube. During that year he moved to RCA where he devoted much of his time perfecting his system.

In England, John Logie Baird was busy working with his system. In 1925, he demonstrated shadowgraphs in public and finally obtained real images with light and shade in his London laboratory. That same year, Charles Francis Jenkins sent moving outline images of model windmill and silhouette figures from motion pictures by radio over six miles in Washington D.C. (Jenkins, C.F., 1929).

During those momentous years, numerous patents were lodged. Mechanical systems such as disks, drums, and vibrating mirrors were generally preferred for scanning. Jenkins employed his prismatic disk and rings, a new optical scanner, then a lens drum, and a lens disk and mirrors. Baird adopted Nipkow's aperture disk. Selenium cells were being supplanted by new phototubes and light-valves were in more frequent use.

In 1921, John B. Johnson of the Bell System described a sealed, low-voltage tube with gas focusing. This opened the way for commercial instrumentation and also brought the small picture tube to reality (Shiers, G., 1977).

In 1925, Captain Richard Randger contributed to photoradio or picturegram (Dunlap, O.E., 1971). On May 7, 1925, he sent war game pictures and maps 5,136 miles in 20 minutes from New York to Honolulu.

However, it was only the demonstration done by Baird in 1926 that marked the end of the long and speculative search for ways to see by electricity and the beginning of a new era of telecommunications and the age of information science. Other systems were also proposed during that period but none of them caught any attention. The Baird system received massive public attention (Sidey, P., Longman, B., Glencross, D., and Pilgrim, T., 1981).

In 1927, having distance in mind, Baird sent pictures between London and Glasgow by wire, a distance of 692 kilometers. Another long distance transmission followed by sending images between London and Leeds, a distance of 274 kilometers (O'Brien, R.S., & Monroe, R.B., 1976, and Sweeney, D., 1988).

During this same year, 1927, at the Bell Telephone Laboratory, a team headed by Herbert E. Ives undertook similar developments. A public demonstration was held by transmitting pictures from Washington D.C. to New York, and also from New York City to New Jersey a 20 mile radio link. Color was demonstrated by Bell in 1929 (O'Brien, R.S., & Monroe, R.B., 1976).

3.4 Standardization and Launch

The experimental broadcasting demonstrated by Baird and Mihaly led to a surge in public interest. In 1927, the first license W3XK was given to Jenkins. In 1928, Ersnt Alexanderson at the General Electric began experimental transmission over W2XAD, Schenectady. During that same year, RCA started operating an experimental 250 watts television station, W2XBS, in New York City (O'Brien, R.S., & Monroe, R.B., 1976).

During 1928, interest in television rose steadily. More than 30 companies were engaged in television ventures and a dozen radio stations started experimental broadcasting in the United States. Numerous apparatuses were displayed at radio shows in United States, Britain and Germany.

In 1928, it became evident that television had finally arrived. It took only a few years for a corporate expansion of broadcast and manufacturing companies. However, the proliferation of different apparatus raised the question of engineering standards. Baird had earlier adopted 30 line images with 12.5 pictures (frames) per second, vertical scanning, and aspect ratio of about 3:2. The Germans adopted similar standards as Baird but preferred aspect ratio of 4:3 and horizontal scanning. Jenkins, in the United States adopted 48 lines image with 15 frames per second in October 1928, but in mid 1929, he adopted 60 lines image, 20 frames per second, and aspect ratio 5:6.

Rapid use of air waves also provided constraints to the Federal Radio Commission in the United States.

In 1929, arrangements were made between, BBC (British Broadcasting Corporation) and the Baird Television Company for regular experimental broadcast. The telecast lasted for ninety minutes, five days a week and had a definition of 30 lines and frame repetition of 12.5 per second (Sidey, P., Longman, B., Glenncross, D., and Pilgrim, T., 1981).

Baird continued to experiment with television transmission and broadcast. In 1928, he transmitted television signals between London and New York by short wave radio. In 1930, he demonstrated color television, three dimensional television, theater projection, infrared pickup, and had made television recordings on phonograph records.

In July 1930, NBC took over operation of RCA's W2XBS. A new one kilowatt transmitter, with a studio, was located in the New Amsterdam Theater building near Times Square in New York. In July 1931, CBS started operating from W2XAB, a 500 watts transmitter and studio located at 485 Madison Avenue, in New York City. It operated two bands in 1929. W2XBS in the band 2.0 to 2.1 MHz and W2XAB in the band 2.75 to 2.85 MHz, both with 60 lines per frame and frame repetition of 24 per second (Sweeney, D., 1988).

In England, the contest between the Baird system and the new system developed by EMI (Electrical and Musical Industries) was reaching its climax. Beginning November 2, 1936, and continuing for three months, BBC broadcasted programs using the Baird system and EMI system on alternate weeks. The Baird system had 240 lines resolution, and repetition rate was 25 frames per second. The EMI system had 405 lines resolution, 50 fields, and 25 frames per second repetition rate. The EMI system was designed under the leadership of Isaac Schoenberg. Britain shortly resorted to the EMI system (Sidey, P., Longman, B., Glenncross, D., & Pilgrim, T., 1981).

Similar to the standards controversies in Britain, standards controversies in the United States also were taking place. Each broadcast station had its own standard. In 1940, the FCC established the National Television Systems Committee (NTSC) to review and recommend a unified standard. The NTSC proposed 525 lines resolution and 30 frames per second standard to FCC in March 20, 1941. In May, FCC announced its approval and by July 1941, one unified standard was implemented (O'Brien, R.S., & Monroe, R.B., 1976).

Even though NBC initiated television broadcast by taking over RCA's W2XBS in July 1930 and CBS started operating W2XAB in July 1931, commercial broadcasting was only fully authorized by FCC after the establishment of technical standards for broadcasting and reception in 1941 (Garrison, C. & Willis, E., 1963). During that period there were only six commercial broadcasting stations in operation, which were all located in the metropolitan New York Area. (Only later did the activity center shift to Chicago). Most of the television receivers were semi-professional mostly made at home by individuals. World War II suddenly halted the ambitious onset of the television industry. It did not get much attention (or any) during the war, but the spillovers of technology due to the developments in warfare technology (radar and telecommunications technology) during that period provided the television industry with some remarkable rewards. Developments would be cutting edge in the television technologies. Hence after the World War II, the developments in television proceeded with astonishing vigor (Wooster, J.H., 1985).

Table 3-1 provides data on the number of monochrome television receivers in use and graphically it is presented in Graph 3-1. Table 3-2 provides data on market for monochrome television from 1947 to 1991. The growth in monochrome television production is illustrated in Graph 3-2. It can be seen from the graph, that the early years are characterized by explosive growth. In 1946, 6900 sets were produced and made available to U.S. consumers. The factory value of this initial production run was just over $1 million (Nathan, R.R., 1989). In 1947 there were less than 200,000 sets. By 1949, there was a 15 fold increase, and by 1959, there were over 50 million sets in use. Graph 3-3 illustrates the price of the sets. It can be seen that the price steadily declined. There were basically two reasons for this. One was economy of scale, and the other was efficiency in production.

TABLE 3-1
MONOCHROME TELEVISION RECEIVERS IN USE IN THE U.S.*

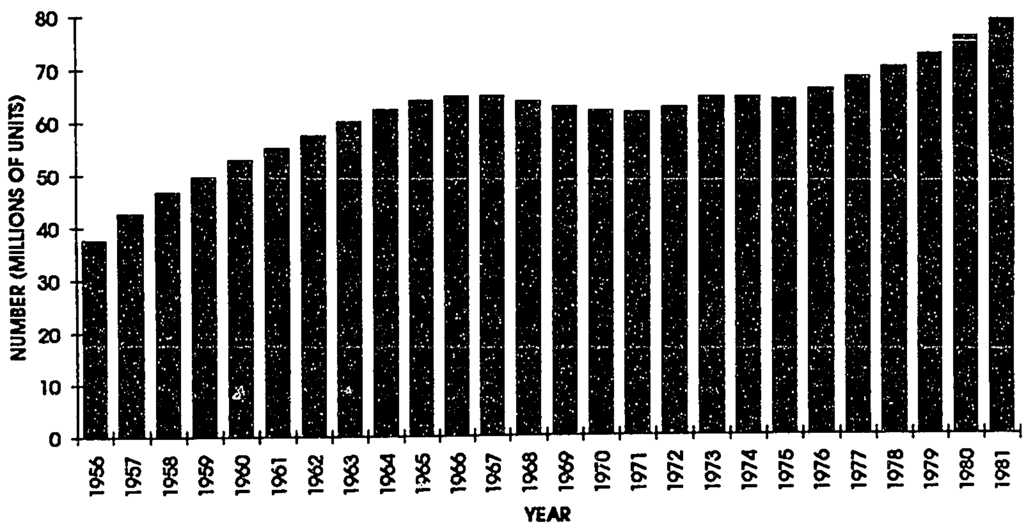
Year	Number millions of units	Year	Number millions of units
1956	37.6	1971	61.6
1957	42.7	1972	62.5
1958	46.8	1973	64.4
1959	49.7	1974	64.5
1960	52.9	1975	64.0
1961	55.1	1976	66.0
1962	57.5	1977	68.3
1963	60.2	1978	70.2
1964	62.4	1979	72.6
1965	64.1	1980	75.8
1966	64.8	1981	79.0
1967	64.8		
1968	63.7		
1969	62.7		
1970	61.9		

*Source: Television Factbook (as mentioned in Electronic Market Databook), Electronics Industries Association, 1982.

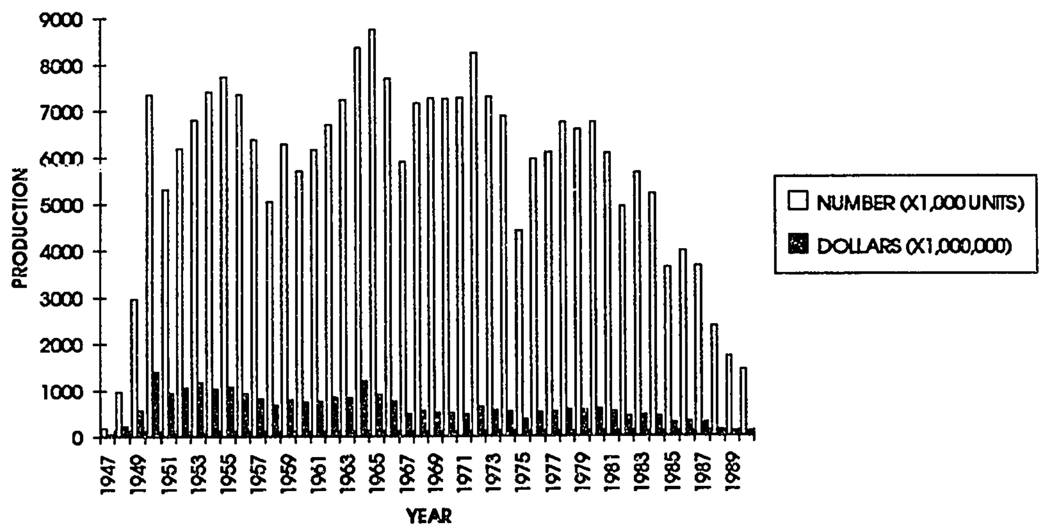
TABLE 3-2
MONOCHROME TELEVISION RECEIVERS PRODUCTION IN THE U.S.*

Year	Units X1,000	Dollars X1,000,000	Year	Units X1,000	Dollars X1,000,000
1947	179	50	1971	7,260	488
1948	970	226	1972	8,239	649
1949	2,970	574	1973	7,297	560
1950	7,355	1,397	1974	6,868	543
			1975	4,418	371
1951	5,312	944			
1952	6,194	1,064	1976	5,937	528
1953	6,807	1,170	1977	6,090	542
1954	7,405	1,040	1978	6,733	572
1955	7,738	1,068	1979	6,575	565
			1980	6,729	599
1956	7,351	934			
1957	6,388	831	1981	6,056	539
1958	5,051	686	1982	4,922	437
1959	6,278	806	1983	5,647	459
1960	5,709	750	1984	5,194	431
			1985	3,620	304
1961	6,168	757			
1962	6,696	851	1986	3,975	330
1963	7,236	841	1987	3,650	296
1964	8,360	1,210	1988	2,365	149
1965	8,753	910	1989	1,720	120
			1990	1,425	100
1966	7,702	756			
1967	5,907	494			
1968	7,160	566			
1969	7,265	523			
1970	7,253	505			

*Source: Electronic Market Databook, Electronics Industries Association, 1969, 1982, 1989, 1992.



GRAPH 3-1 MONOCHROME TELEVISION RECEIVER IN USE IN THE U.S.*
*Source: Television Factbook as mentioned in Electronic Market Databook, Electronics Industries Association, 1982.



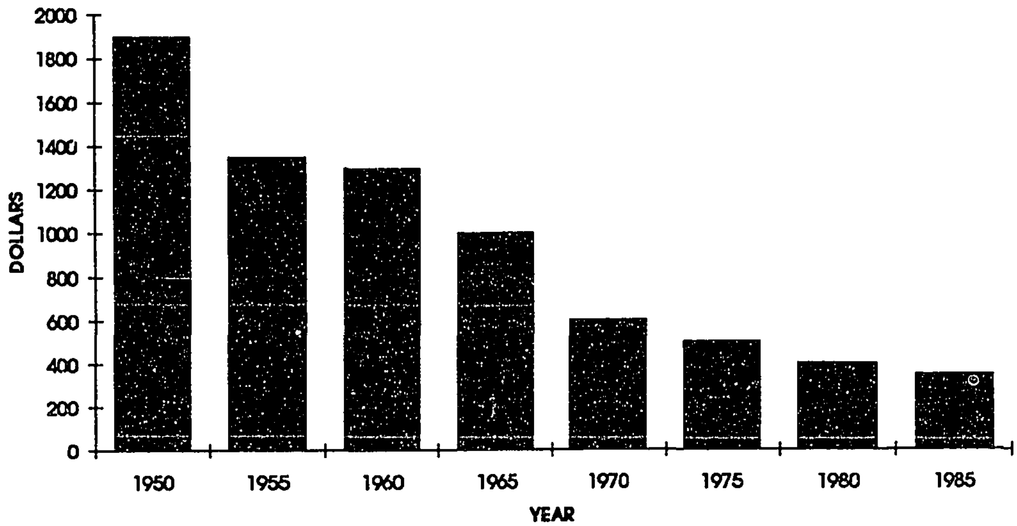
GRAPH 3-2 MONOCHROME TELEVISION RECEIVERS PRODUCTION IN THE U.S.*
*Source: Electronic Market Databook, Electronics Industries Association, 1969, 1982, 1989, 1992.

The rapid sales growth attracted many firms. Entry was relatively easy and inexpensive. By early 1950s, there were as many as one hundred and forty producing firms (Wooster, J.H., 1985). Small firms bought components and assembled them, while big producers like RCA, GE, Sylvania, Westinghouse, and Zenith produced their own components. Initially, the production was very labor intensive requiring fairly experienced workers. However, the learning curve was steep, and with the added momentum of marketing, prices began its rapid downturn. By 1970, monochrome receivers had penetrated almost 95% of American homes (See Graph 3-4 and Table 3-3).

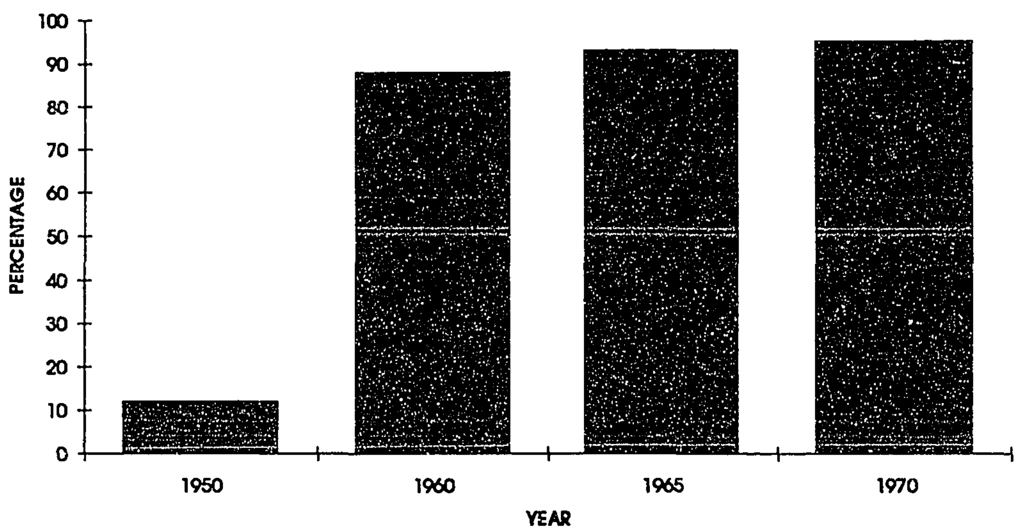
TABLE 3-3
PERCENTAGE OF U.S. HOUSEHOLDS WITH MONOCHROME RECEIVERS*

Year	Percentage of Households
1950	12
1960	88
1965	93
1970	95

*Source: Electronics Market Databook, Electronics Industries Association 1969, 1982.



GRAPH 3-3 PRICE OF TV RECEIVERS*
*Source: Electronic Market Databook, Electronics Industries Association, 1969, 1982, 1989, 1992.



GRAPH 3-4 PERCENTAGE OF HOUSEHOLD WITH MONOCHROME TV RECEIVERS*
*Source: Electronics Market Databook, Electronics Industries Association 1969, 1982.

Graph 3-1 and Graph 3-2 reveals that growth began to level off in the 1950s. The recession of 1957-1958 and the weak recovery the following two years 1958-1960 revealed the sensitivity of the television industry to the overall economic conditions. This dilemma was further worsened because the catastrophe occurred at a time when capacity expansion programs of various producers had just come on line (Wooster, J.H., 1985). Total units declined from 7.738 million units to 5.051 units during 1955 to 1958. It was not until almost ten years later in 1964, that the 1955 mark was surpassed.

During the following years, intense competition between firms resulted in an extended period of slowdown. Various price cutting strategies and struggle for market share led firms with conflicting goals. Firms tried to keep inventories lean and mean, while maintaining adequate supplies to meet the nationwide demand. They also tried to operate plants at technically efficient levels of operations and maintain adequate cash flows for repayment of debt financing that resulted from recent capacity expansion programs -- a pursuit to strive to excellence. The result however was negative and backfired. It caused irreparable damage to the industry. The inventory levels started swelling at unexpected rates, plants tended to operate much below technical level of efficiency, and debts began growing with every passage of time. The results were evident. Price increase was announced by traditional industrial leaders like RCA and Zenith. Respected firms like DuMont were a target for acquisition and outright financial failure. Of the one-hundred and forty firms in the industry at the dawn of the decade, fifty remained in 1956, and only twenty-seven survived by the dusk, i.e., 1960 (Hall, M., 1957).

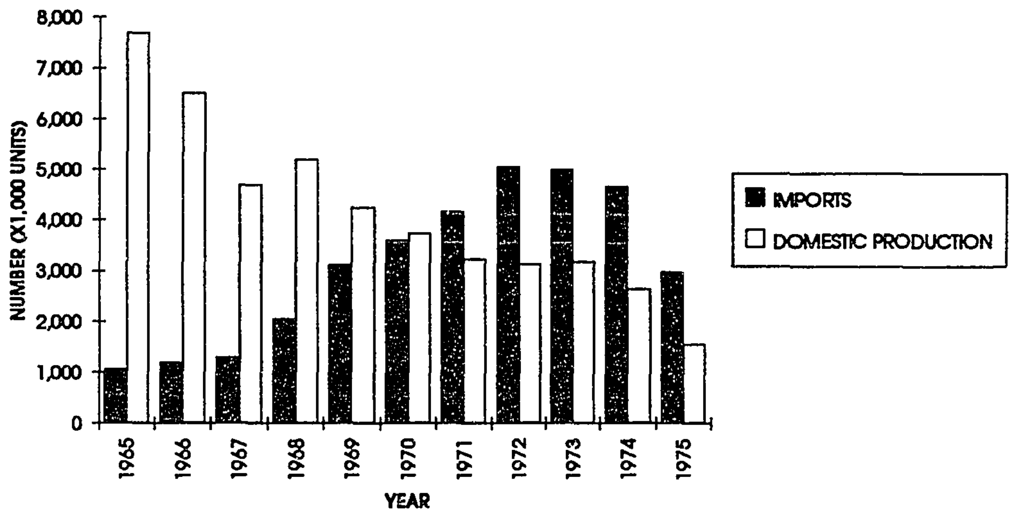
International trade in the television industry did not occur in the fifties or the early sixties. Europe and Japan were busy reconstructing their nations due to the destructions from World War II. Export of television receivers to those countries by United States was severely restricted due to trade barriers resulting from high tariffs. Japan opted for licensing agreements with the United States to fulfill its national demands. By 1968 the domestic markets of Japan had saturated and 88% of Japanese households had televisions in their homes (Electronics Industry of Japan, 1981). Due to excess capacity of production, sales were geared towards export, and United States was the prime target since it was a very viable and potential market.

The Japanese opted to use transistors and printed circuit design for its receivers that permitted simplification in design and made the receivers smaller, lighter, and cheaper, which made it very attractive to the U.S. market. Table 3-4 provides the overall import penetration in the U.S. It illustrates that before 1965 imports were minimal, but by 1977 it was more than four and a half times the domestic production, and accounted for over 80% of domestic consumption.

TABLE 3-4
IMPORT OF MONOCHROME TELEVISION RECEIVERS*

Year	Imports (X 1,000)	Domestic Production (X 1,000)
1965	1,061	7,692
1966	1,195	6,507
1967	1,290	4,697
1968	2,043	5,197
1969	3,121	4,243
1970	3,596	3,732
1971	4,165	3,220
1972	5,056	3,125
1973	4,989	3,173
1974	4,659	2,633
1975	2,974	1,557

*Source: United States Industrial Trade Commission, 1977, 1980, 1981.



GRAPH 3-5 IMPORT DOMESTIC PRODUCTION OF MONOCHROME TV RECEIVERS*
*Source: United States Industrial Trade Commission, 1977, 1980, 1981.

The shift from domestic receivers to imported ones was mainly due to price, which was a result of low production cost. Viability of offshore assembly was demonstrated by companies like Texas Instruments during the 60s. Between 1966 and 1971, six U.S. firms began production offshore in Taiwan, four in Mexico, and one in Hong Kong (Wooster, J.H., 1985). A substantial portion of import penetration was due to these offshore productions.

Many domestic firms were debilitated due to this evolution and survival was the prime motive of many firms. Globalization of production process enabled only firms with large capital and ability to withstand seismic shocks of economic cycle to thrive and survive within the industry.

The history of television does not end here. The hunger for more and the thirst for the better is a basic instinct built by nature in the hearts of humans. The next chapter discusses the history of color television.

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CHAPTER FOUR
DEVELOPMENT PHASE -- HISTORY OF COLOR TELEVISION

4.1 Background

Color television system is a development over monochrome television. It was the complexity of its technology and system that impeded the development of color television. The initial idea of transmitting in color is as old as monochrome television. In fact monochrome television may be considered as a color television that uses only one color, black but in various shades (gray scale). Similar to the development of monochrome television, color television can be divided into three stages. (Note: See Section 6.5). They are --

1. Idea generation and preliminary assessment stage,
2. Development and testing stage, and
3. Standardization and launch.

4.2 Idea Generation and Preliminary Assessment Stage.

In natural vision the brain perceives the scene through the optic nerve that is connected to the millions of retinal element in the eye with parallel fibers. (Note: This is parallel transmission as discussed in Chapter 3). The scenes are continuously projected on the eye. In artificial medium, such as celluloid pictures or television, the scenes are projected in rapid succession of still pictures. The perception to the eye however is continuous projection since the rate of rapid succession is higher than the critical refresh rate of the retina.

But, in contrast to celluloid film in which the whole of each picture is projected at once, television transmits the picture sequentially. (Note: This is serial transmission as discussed in

Chapter 3). At any particular instance of time only information relevant to only one element of the whole picture is transmitted through a channel. This is accomplished through the process of scanning. The resolution (number of pixels required for the summation of a picture) determines the scanning frequency. The scanning frequency in turn determines the total bandwidth required for transmission.

In monochrome television systems the channel comprises mainly of the luminous intensity level of the particular pixel and the location of the information. Synchronicity in pickup and display is thus a very important and critical issue since the whole scene needs to be reproduced with duplicate temporal and spatial information.

In color television additional information of color needs to be incorporated into the system. At first, this seems to be a formidable task, since thousands of different hue and saturation values need to be merged with the luminous information. However, this task is fairly simplified by the fact, established in Newton's time, that a color can be very closely represented by combining just three colors, known as primary colors (Shiers, G., 1977). Television uses red, blue, and green as primary colors in contrast to bluish red (magenta), greenish blue (cyan), and greenish yellow used in printing. In color television, three separate images, one in each of the primary colors, must be dissected in a particular sequence at the pickup stage and compiled in the same sequence at the display stage. An important implication of this is that all things being equal, the bandwidth of the color signal is three times that of monochrome television.

There are other difficulties that are exist in color television systems. Firstly the three separate images must be synchronously registered. Use of the field sequential system reveals better performance in overcoming this hurdle in contrast to the dot sequential system and the line sequential system. (Note: This is discussed in detail later in the chapter).

Secondly, rooted in the sequential nature and color system is the difficulty of a concept known as "color breakup." The successive fields of the screen occupy slightly different positions on the retina. However, this is present only in the field sequential system and viewers soon acquire a substantial tolerance of this effect under normal conditions.

Thirdly, since rapid motion of the picture causes rapid changes in information, the three images may not be properly registered causing what is called "color fringing." This effect along with the second one is taken care of by the tolerance effect. It is of paramount importance to faithfully reproduce the original image by taking care of color rendition and balance. So long as the dots, lines, and fields occur in the proper places and proper sequence, and as long as color rendition and balance are maintained, it is possible to produce high standard color images.

The reproduction technique employed in color television can in some way be related to color print reproduction, where pictures are reproduced by four impressions, one for each primary color and the fourth one for black.

The above attributes are related to the technical aspects of the development of color television. However, some other properties of a less fundamental technical nature, but of great economic importance need to be addressed. The transitional properties of the color system are -- compatibility, adaptability, and convertibility (Shiers, G. 1977).

Compatibility -- A compatible color system is one capable of producing monochrome television on existing monochrome receivers without modification. (Note: See Appendix)

Adaptability -- An adaptable color system is one in which existing monochrome receiver can be modified to receive color transmission in monochrome.

Convertibility -- A convertible color system is one in which existing monochrome receivers can be modified to receive color transmission in color.

The color system also needs to be judged according to the following characteristics.

Resolution -- The amount of detail the picture contains.

Flicker-brightness relationship -- The rate at which successive fields are scanned, which determines the brightness of the picture. This needs to be greater than that which can be perceived by the eye.

Continuity of motion -- The number of fields scanned per second which determines the continuity.

Efficient channel utilization -- The amount of information per Hz of bandwidth.

Color fidelity -- The faithfulness of reproduction of the original image.

Defects due to superimposition -- The overcoming of registration, color breakup, and color fringing.

Cost - This is the underlying factor.

Color television, a great achievement, was indeed a technical triumph. Baird, J.L., in England and Ives, H., in U.S. Bell Labs experimented with color in late 1920s, reviving ambitious schemes for color that was proposed from 1880 onwards (Kell, R.D., 1946). Baird continued his work throughout the war independently and had achieved experimental color transmission in 1938 over a ten mile path in London from the Crystal Palace to Dominion Theater (Osborne, B.W., 1968). He worked with a two-color 120 line picture on the red-cyan axis, using a line sequential signal and a large screen projection display. This was a significant improvement over his 1928 version and Ives's 1929 demonstration at Bell Laboratories.

4.3 Development and Testing

By 1949, there were three color television systems were being developed and tested in the United States. They were --

1. Color Television Inc. -- Line-Sequential System;
2. Columbia Broadcasting System -- Field-Sequential System; and,
3. Radio Corporation of America -- Dot-Sequential System.

Intensive development of color television was undertaken by CBS under the direction of Dr. Peter Goldmark (Fink, D.G., 1944). CBS began its color broadcast immediately after World War II using wide-band transmission techniques that had developed during the war. In 1946, RCA demonstrated a simultaneous three channel system that was compatible with the existing monochrome system but was quite unstable at that time. In March 1947, FCC made its decision that television should continue under existing monochrome standards, i.e., 6 MHz channel in the already assigned VHF spectrum. By September 1949 with the entry of CTI, there were three proponents of color television systems.

In other parts of the world other systems were being developed. They were -- 1. Germany's PAL system, and 2. France's SECAM system.

4.3.1 CTI Line-Sequential System

The essential attributes of this system were as follows --

1. It was a compatible system, employing the same number of lines per picture and same number of fields per second as the monochrome television. It permitted color images to be produced on a monochrome receiver in monochrome without modification.
2. Its resolution and large-area flicker performance were equivalent to that of the monochrome system. However, vertical resolution and small-area flicker were quite inadequate.
3. It suffered from registration difficulties.
4. Channel efficiency was not effective.

4.3.2 CBS Field-Sequential System

The essential attributes of this system were as follows --

1. It was not compatible with the existing monochrome television.
2. The vertical resolution was poorer than that of existing monochrome television receivers.
3. However, the color fidelity of this system was superior to other color systems.
4. The channel utilization of this system was satisfactory.
5. Conversion costs from existing monochrome receivers were significant.

4.3.3 RCA Dot-Sequential System

The essential attributes of this system were as follows --

1. This system was compatible with the existing monochrome system.
2. The resolution of this system was comparable to the existing monochrome television receivers.
3. The large-area flicker and continuity of this system was comparable to the existing system.
4. The color fidelity of this system suffered to a certain extent from uneven color balance in large areas.
5. The channel utilization of this system was the highest.
6. Substantial cost is incurred while converting.

4.3.4 PAL System

In England, in 1954, compatible NTSC transmissions were broadcast by the BBC on 45 MHz from Alexandra Palace and later from Crystal Palace (Osborne, B.W., 1968). These experimental transmissions used a Marconi adaptation of the NTSC system to the 405 line standard. The 405 line compatible NTSC color signal made full use of all the available picture definition of the shadow mask display tube (Pantchett, G.N., 1956). But after thirteen years in 1967, color transmission was switched to PAL (Phase Alternate Line) 625 line standard. The German system was adopted as an alternative color system for Europe by the CCIR decisive meeting on Oslo in July 1966 (Holm, W.A., 1968).

The PAL color system is a variant of NTSC in that it uses a constant luminance signal in which the luminance information is transmitted as amplitude modulation of the vision carrier, the two components of chrominance information being carried, within the bandwidth, as quadrature amplitude modulation of a suppressed subcarrier. However, one of these components is transmitted with a phase reversal on alternate lines (Osborne, B.W., 1968). PAL, compared to NTSC, offered easier receiver design tolerances, the elimination of hue control in the receiver, and immunity from the effects of level dependent phase distortion (EBU, 1965).

4.3.5 SECAM

In 1958, Henri de France published information on his Systeme de Television En Couleurs Sequentiel-Simultane, an important proposal for transmitting only one of two color difference signals at one time and thus eliminating design problems relating to the interaction of two simultaneously transmitted color signals. It was an effort to reduce the technical complications of the NTSC system by using memory to store color information. The sequential Couleurs a Memoire or SECAM color system was developed from that of de France by Campagnie Francaise de Television (Osborne, B.W., 1968). During the course of development there have been many versions of the SECAM system such as -- SECAM II, SECAM III, SECAM IV, and SECAM V (Reed, C.R.G., 1969).

4.4 Standardization and Launch

In the United States in 1950, the Federal Communications Commission (FCC) approved the RCA system. This was called the National Television System Committee (NTSC) color standard. Ten years previously this committee had set up the monochrome television standard approved by FCC in 1941 (Reed, C.R.G., 1969). The recommendations of the NTSC for commercial color television were adopted by FCC in December 1953. NBC carried the 1954 New Year's Day Tournament of Roses Parade in Pasadena, California in color (Fink, D.G., 1955). The NTSC system consisted of 525 lines with an associated color subcarrier frequency of approximately 3.58 MHz.

The development of the color television industry in the U.S. has transformed the nature of consumer electronics industry. It has also changed the American home and the very lifestyle of individual Americans. The Electronic Association of America (EIA) reports that in 1991, 98% of the American homes owned a television set, and more than 60% had two or more (EIA Electronics Market Data Book, 1992). In 1954, after the approval by the FCC of the NTSC color television standard, color television started its way into the American homes elevating the expectations of every individual. With the introduction of color television, a new era in the civilization of human beings that would bring social prosperity was observed in the horizon. The whole of the entertainment industry, information industry, and to some extent all other industries were significantly effected.

The color television industry has been very vibrant and has been a significant part of the American economy. Since 1980, its total contribution to the economy has grown 17.5%, from $15.4 billion to $18.1 billion. The industry employed over 240,00 employees in 1988 and contributed tax revenues in excess of $1.5 billion (Nathan, R.R., 1989).

Color television started making its way into the American homes only after the establishment of the color television standard NTSC by FCC in 1954. RCA, the proponent of the NTSC system, was the only domestic firm producing color receivers from 1954 to 1961. NBC which started its color transmission by broadcasting the Tournament of Roses Parade in 1954, was the only network transmitting color during those years with limited hours of programming (Fink, D.G., 1955).

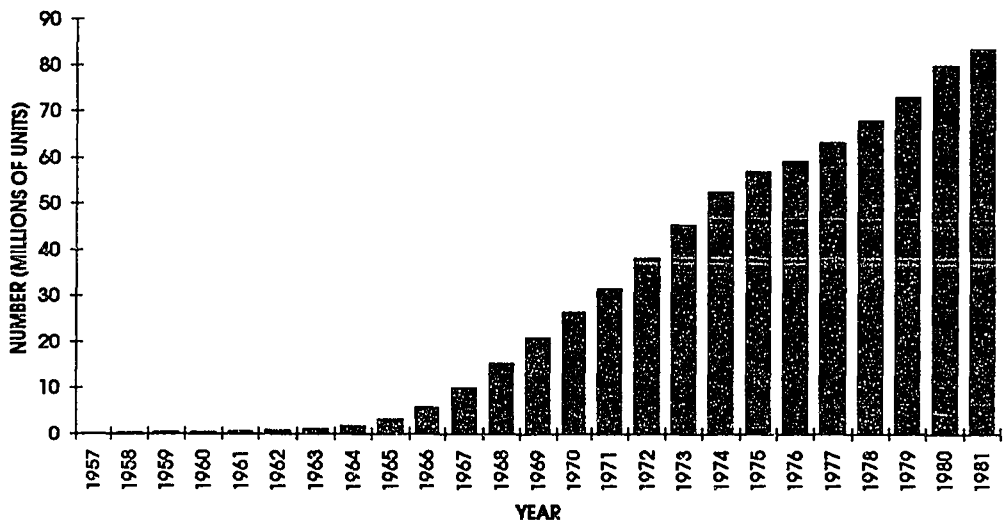
Due to the shake up in the monochrome market, the survivors shifted their efforts to production of costly and sophisticated color receivers. Even though these firms established some innovations of their own, most of the technology was licensed from RCA, and most of the key components like picture tubes and chroma circuits were purchased from RCA.

Table 4-1 and Graph 4-1 illustrates the number of color television receivers in use in the U.S. Table 4-2 illustrates the development of color television market and Graph 4-2 depicts it in a pictorial form. It can be observed that the price of the receivers continued to steadily decline. It can be observed that explosive growth in the color television industry started at about 1962. This was the time when the monochrome industry was facing dire problems with significant competition from the Japanese making itself felt. The growth has continued ever since, even to the present day.

TABLE 4-1
NUMBER OF COLOR RECEIVERS IN USE IN THE U.S.*

Year	Number (Millions of Units)	Year	Number (Millions of Units)
1956	-	1971	31.6
1957	.1	1972	38.2
1958	.2	1973	45.4
1959	.3	1974	52.6
1960	.4	1975	57.0
1961	.5	1976	59.3
1962	.7	1977	63.2
1963	1.0	1978	68.0
1964	1.7	1979	73.1
1965	3.1	1980	80.0
1966	5.8	1981	83.5
1967	10.0		
1968	15.3		
1969	20.9		
1970	26.4		

*Source: Television Factbook as mentioned in Electronic Market Data Book, Electronics Industries Association, 1982.

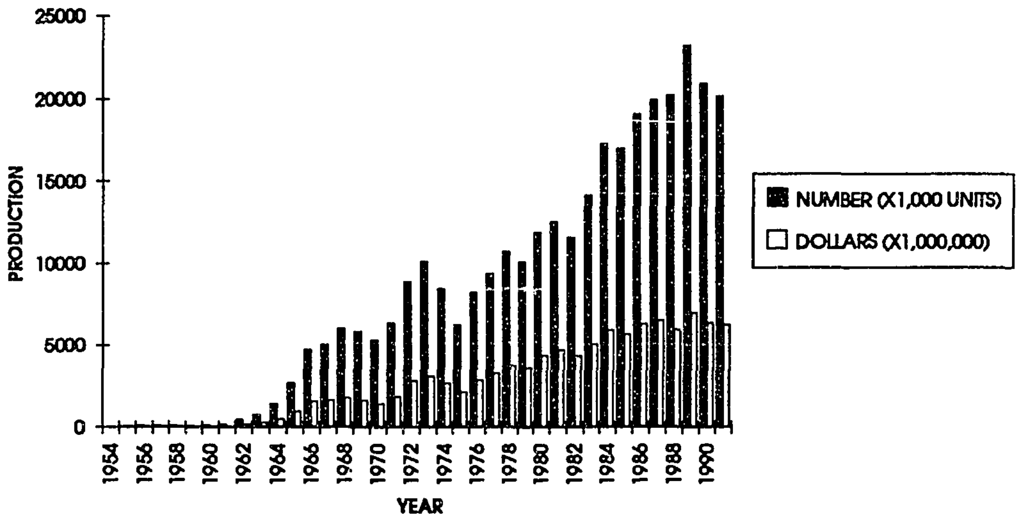


GRAPH 4-1 NUMBER OF COLOR TELEVISION RECEIVERS IN USE IN THE U.S.*
*Source: Television Factbook as mentioned in Electronic Market Data Book, Electronics Industries Association, 1982.

TABLE 4-2
COLOR TELEVISION RECEIVER PRODUCTION IN THE U.S.*

Year	Units X1,000	Value $X1000000	Year	Units X1,000	Value $X1000000
1954	5	2			
1955	20	10	1975	6,219	2,121
1956	100	46	1976	8,194	2,860
1957	85	37	1977	9,341	3,269
1958	80	34	1978	10,674	3,736
1959	90	37	1979	10,042	3,615
1960	120	47	1980	11,803	4,339
1961	147	56	1981	12,423	4,683
1962	438	154	1982	11,484	4,288
1963	747	258	1983	14,034	5,047
1964	1,404	488	1984	17,190	5,896
1965	2,694	959	1985	16,905	5,629
1966	4,707	1,549	1986	19,010	6,268
1967	5,042	1,643	1987	19,847	6,470
1968	5,982	1,806	1988	20,147	5,923
1969	5,803	1,653	1989	23,139	6,919
1970	5,303	1,428	1990	20,840	6,335
1971	6,338	1,853	1991	20,118	6,204
1972	8,845	2,825			
1973	10,071	3,097			
1974	8,411	2,658			

*Source: Electronics Market Databook, Electronics Industries Association, 1969, 1982, 1989, 1992.



GRAPH 4-2 COLOR TV RECEIVER PRODUCTION IN THE U.S.*
*Source: Electronics Market Databook, Electronics Industries Association, 1969, 1982, 1989, 1992.

From 1965 to 1969, RCA and Zenith accounted for 48% of the total number of color television receivers. Table 4-3 illustrates the cumulative color television receiver production by manufacturers from 1965 to 1969. There were no significant threats from foreign manufacturers during that period. European countries did not even begin color broadcasting until 1968 or later adopting the PAL (initiated by Germany) or SECAM system (initiated by the USSR and France). In 1960, Japan became the second country to start color broadcasting adopting the American NTSC system with licensing agreements with RCA. The growth of color television in Japan only started with the Tokyo Olympics Games in 1964. However, in the United States the burden of excess capacity was being felt. But due to difference in standards in the world television industry and trade barriers due to tariffs, export of color television receivers never conceptualized. Another problem was marketing. A strong presence in foreign market with targeted knowledge was necessary for foreign trade, because having lost the competition in monochrome television, the market presence was stolen by foreign competitors, especially the Japanese. Even before the Kennedy round of GATT negotiations for trade liberalization, foreign competitors had already established competitive edge. The U.S. presence in foreign market was only limited to licensing.

TABLE 4-3
MANUFACTURERS OF COLOR TELEVISION RECEIVERS 1965-1969*

Rank	Manufacturer	Units (X 1,000)	Percentage of Total
1	RCA	5,863	27.1
2	Zenith	4,743	22.0
3	Magnavox	1,982	9.2
4	Motorola	1,563	7.2
5	Warwick	1,550	7.2
6	Admiral	1,484	6.9
7	GE	1,417	6.6
8	Sylvania	1,101	5.1
9	Philco-Ford	913	4.2
10	Westinghouse	331	1.5
11	Emerson	307	1.4
12	Packard Bell	228	1.1
13	Olympic	110	0.5

*Source: Television Digest, February, 1970.

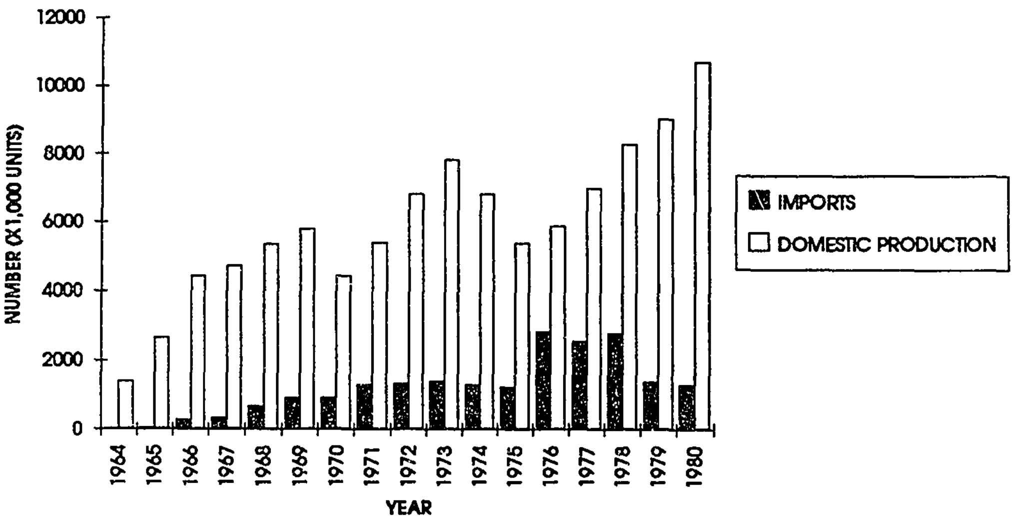
With the rapid expansion of the Japanese color television industry after 1964 and growing problems in the domestic market after 1967, the U.S. color television industry was being crippled with the passage of time. Between 1966 and 1973 Japanese production and consumption of color television took a mammoth leap, and Japanese producers like Matsushita supplanted leading U.S. producers. Japanese producers started catering to international needs by producing PAL and SECAM sets. In 1980, the U.S.accounted for 12.3% of Japan's exports, Europe accounted for 20.8%, and the rest of the world accounted for 55.6% (Electronics Industry Association of Japan, 1980).

Table 4-4 illustrates the import penetration of color television receivers into the U.S. Graph 4-3 depicts domestic production and imports.

TABLE 4-4
IMPORT OF COLOR TELEVISION RECEIVER IN THE U.S.*

Year	Imports (X 1,000 units)	Domestic Production (X 1,000)
1964	17	1,387
1965	43	2,651
1966	266	4,441
1967	318	4,724
1968	666	5,366
1969	913	5,803
1970	914	4,441
1971	1,281	5,398
1972	1,318	6,816
1973	1,399	7,828
1974	1,282	6,813
1975	1,215	5,389
1976	2,834	5,870
1977	2,539	7,005
1978	2,775	8,282
1979	1,369	9,012
1980	1,288	10,660

*Source: United States Industrial Trade Commission, 1977, 1980.



GRAPH 4-3 IMPORT/DOMESTIC PRODUCTION OF COLOR TV RECEIVERS*
*Source: United States Industrial Trade Commission, 1977, 1980.

The decade of the seventies and later part of the sixties was a period of crisis for the U.S. color television industry. Rapid progress in technology, unstable global economy, and varying patterns in international trade all accentuated the crisis. Towards the beginning of the eighties, the television industry was a mouse compared to the giant during the initial years of introduction of color television. Like the fate of the monochrome industry, the color television industry was destined to failure and an unexpected demise.

During that era, the basic design of the color television was undergoing rapid changes. Starting from vacuum tubes, the technology progressed towards transistorization, printed circuit boards, integrated circuits, and many more. This caused the receivers to be more reliable, of better quality, more durable, cheaper, and more portable. In general foreign manufacturers, especially Japanese, made this progression more rapidly than any U.S. firms. Japanese firms were much more advanced than U.S. firms in the adaptation of these new technologies of the color television receivers (Japan Economic Journal, 1971).

The mini-recession had caused a drop in sales and profits in 1967. The recovery of 1968 did not have any significant effect. During the period of 1971 to 1973, Nixon's New Economic Policy (NEP), which tried to ease off inflation by wage and price controls were in effect. Further a 10% import surcharge introduced on foreign trade caused sales and profits to reach record level. Table 4-5 illustrates the profits of television receivers. The recession of 1974-1975 again tapered the profits and caused the firms to be preys for takeover. Magnavox was purchased by Philips, Quasar was purchased by Matsushita, Philco-Ford sold its trademark to GTE-Sylvania, and Admiral was purchased by Rockwell. Overcapacity and keen competition still plagued the industry. The Ford-Carter expansion tried to stimulate the industry, but no observable effect was noticed. This caused extreme financial distress to many firms and construed them to fail and leave the industry. This problem was further exacerbated due to Japanese manufacturers like Hitachi, Toshiba, and Sharp opening production facilities in the U.S. (Wooster, J.H., 1985). Philips, Matsushita, and Sanyo were the most powerful firms, leaving Zenith and RCA behind (The New York Times, 1981). In 1976 Andrea Radio Corporation left the industry, followed by Rockwell-Admiral in 1978, GTE in 1981, and Sylvania selling off to Philips, while Zenith undertook massive restructuring with massive layoffs, divestiture, and decrease in wages (Business Week, 1981).

TABLE 4-5
PROFITS IN TELEVISION RECEIVER PRODUCTION*

Year	Net Operating Profits $ X 1,000,000	Percentage
1966	181	7.5
1967	66	2.8
1968	155	6.5
1969	134	6.3
1970	22	1.2
1971	183	8.7
1972	214	8.6
1973	159	5.8
1974	(31)	(1.2)
1975	13	0.6
1976	96	3.7
1977	81	2.8
1978	45	1.5
1979	24	0.8
1980	67	1.9

*Source: United States Industrial Trade Commission, 1977, 1980.

The turmoil in the U.S. television industry was a direct consequence of the changes in the Japanese industry, and their commitment to enter the U.S. markets. The Japanese domestic color television market became saturated quite abruptly (Note: See Table 4-6). The expanded capacity drive of the 1960s now posed a severe problem. The Japanese Economic Journal reported other problems. Increase in wages from 157 Yen in 1964 to 590 Yen and appreciation of the Yen by about 19 percent against the dollar were major problems (Japan Economic Journal, 1974). The response to these problems was automation that resulted in low operation cost, improvements in quality, and manufacturing efficiencies. To secure the U.S. markets the Japanese firms also started opening manufacturing facilities in the U.S. The direct consequence of this was a surge in imports, which resulted in the imposition of quotas in 1977 (USITC, 1981). Before the imposition of the quotas, there were two opposing views. One advocated that protectionism only promised increase in prices, while the other advocated protectionism to counter unfair trade practices. The Treasury Department began formal hearings in 1968. At the end of 1970, the Treasury Department discovered unfair trade practices on the part of the Japanese. They were accused and found guilty of dumping (USITC, 1981). The consequence of this was that the Japanese firms came under close scrutiny of the Tariff Commission.

TABLE 4-6
PERCENTAGE OF JAPANESE HOUSEHOLDS WITH COLOR RECEIVERS*

Year	Percentage
1968	7.0
1969	16.6
1970	31.8
1971	42.3
1972	55.6
1973	65.3
1974	73.1
1975	69.3

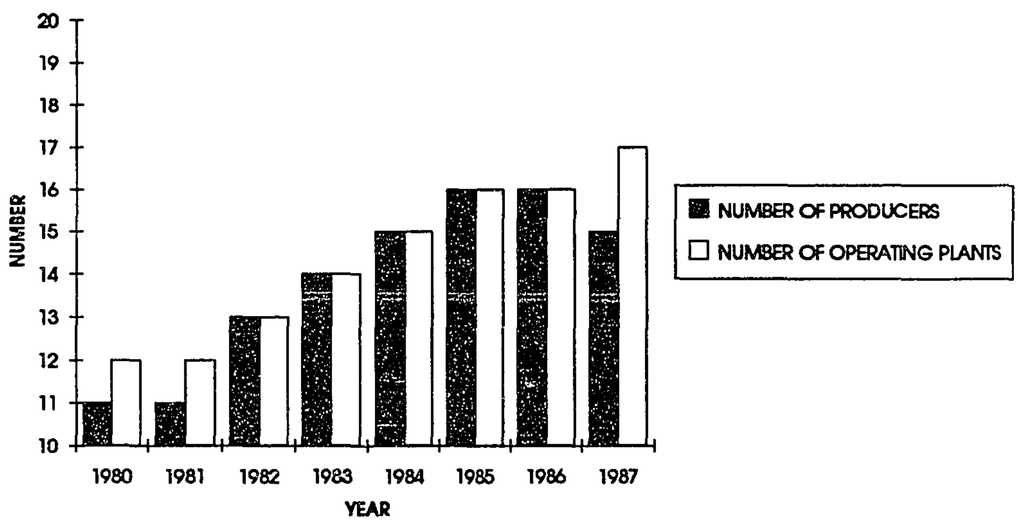
*Source: Economic Industry Association of Japan, 1976.

During the mid-seventies the Committee to Protect American Color Television (COMPACT) was organized comprising of members such as Corning Glass, Sprague Electric, GTE-Sylvania, etc., to weaken the Japanese presence in the U.S. market. RCA and GE did not join in because they expected to compete due to their high multinational bias. In the beginning of 1977, the International Trade Commission of the U.S. recommended a 25% duty increase, but negotiations between the Japanese government and the U.S. government resulted only in quotas on export during the Carter administration (Wooster, J.H., 1985).

The protectionism did not result in any concrete benefits. U.S. firms did not have the export orientation to cater to international demands. Meanwhile, Japanese firms almost wholeheartedly concentrated their efforts to exports and invasion of international markets. The U.S. firms further laid down their technical leadership to the Japanese firms. Being unable to follow the tracks of the Japanese, the U.S. firms finally yielded to the Japanese firms.

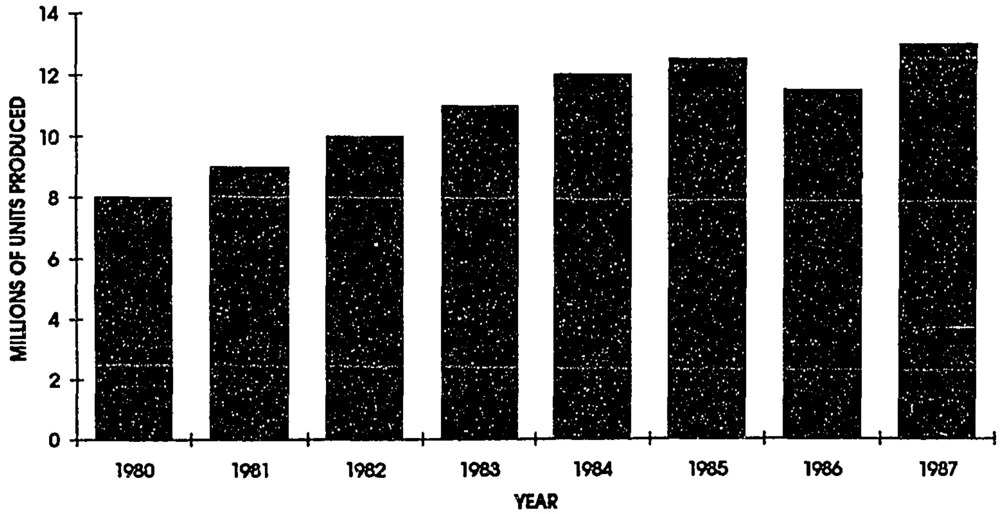
Graph 4-4 illustrates the number of U.S. color television manufacturing industries. A rapid rise can be observed beginning 1981

(Source: RRNA, 1989). However, it reaches to its peak in 1984 and then starts decreasing in 1987. Graph 4-5 indicates a slight increase in the number of units produced from 1980 to 1987 (Source: RRNA, 1989). The factory value however increased at a greater proportion in comparison to the number of units produced in the same period (See Graph 4-6) (Source: RRNA, 1989). Graph 4-7 illustrates that there has been almost an inverse relation between the factory value per employee and factory value per unit (Source: RRNA, 1989). The main cause of this is automation that has been brought into factories. Graph 4-8, Graph 4-9, Graph 4-10, and Graph 4-11 illustrate the economic contribution of U.S. color television manufacturing.

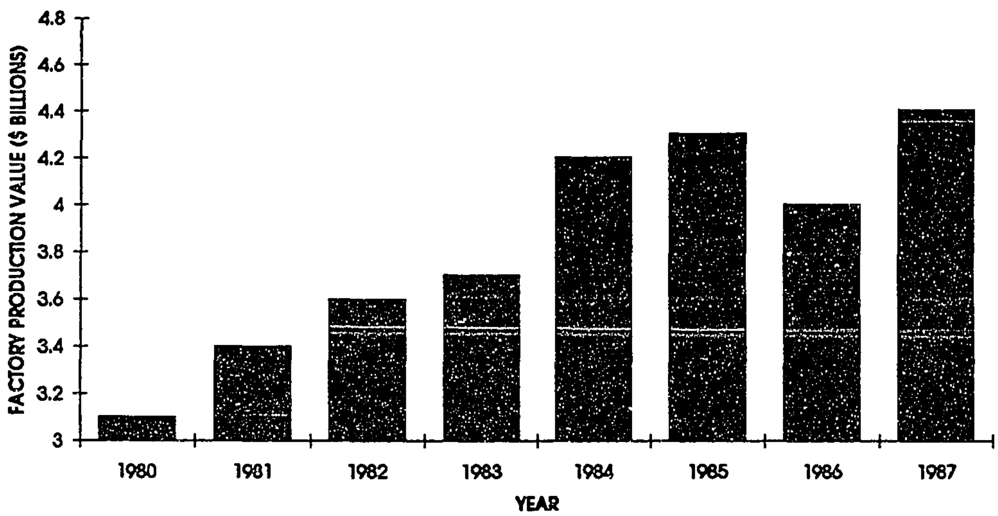


GRAPH 4-4 NUMBER OF PRODUCERS/NUMBER OF OPERATING PLANTS (COLOR TELEVISION) IN THE U.S.*

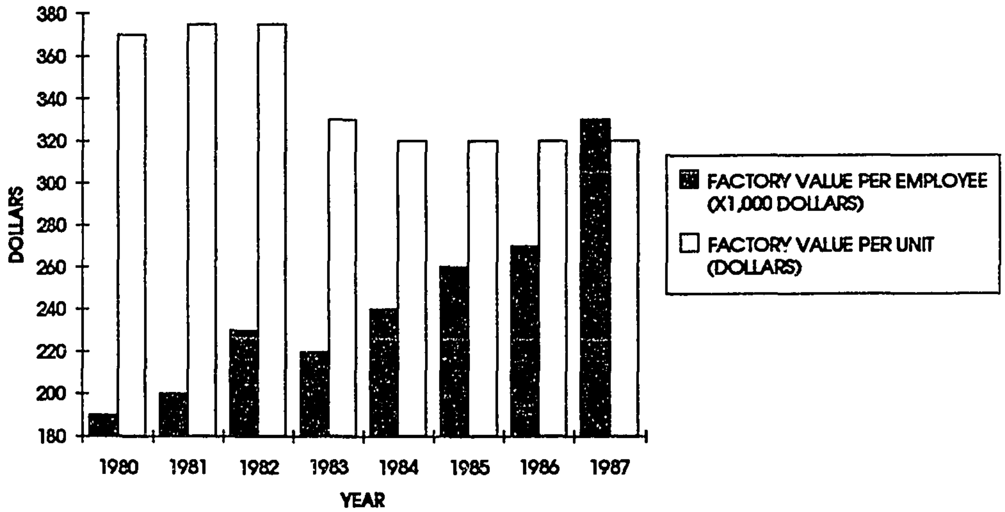
*Source: RRNA, 1989.



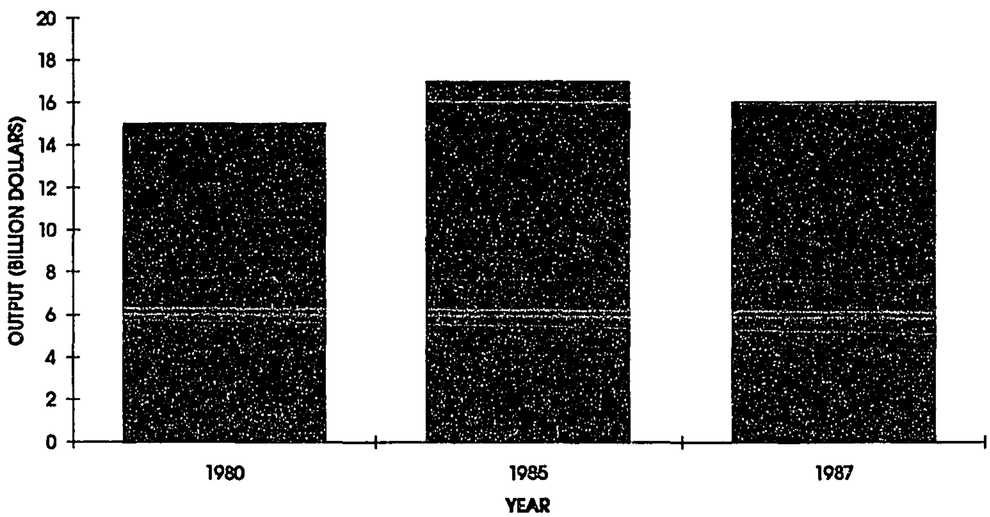
GRAPH 4-5 COLOR TELEVISION PRODUCTION IN THE U.S.*
*Source: RRNA, 1989.



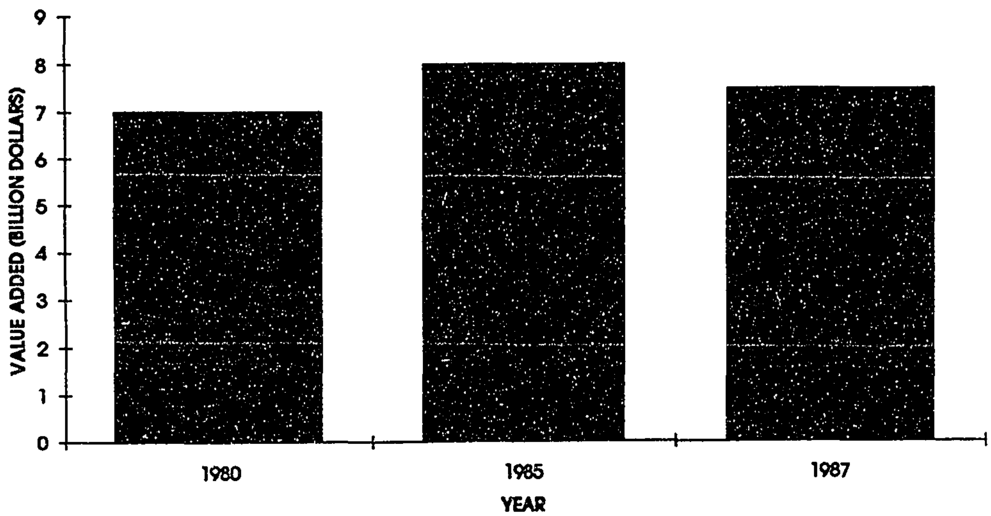
GRAPH 4-6 COLOR TELEVISION FACTORY PRODUCTION VALUE IN THE U.S.*
*Source: RRNA, 1989.



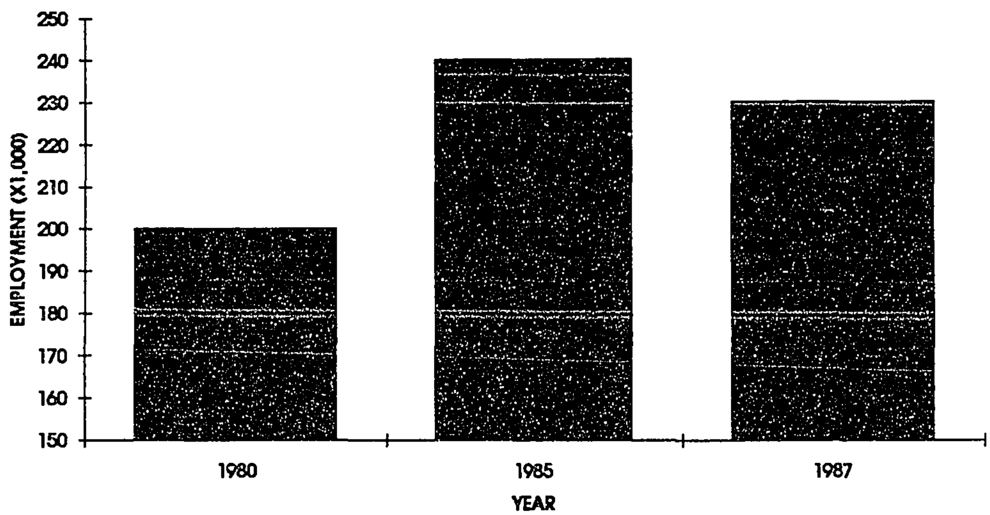
GRAPH 4-7 COLOR TELEVISION FACTORY VALUE*
*Source: RRNA, 1989.



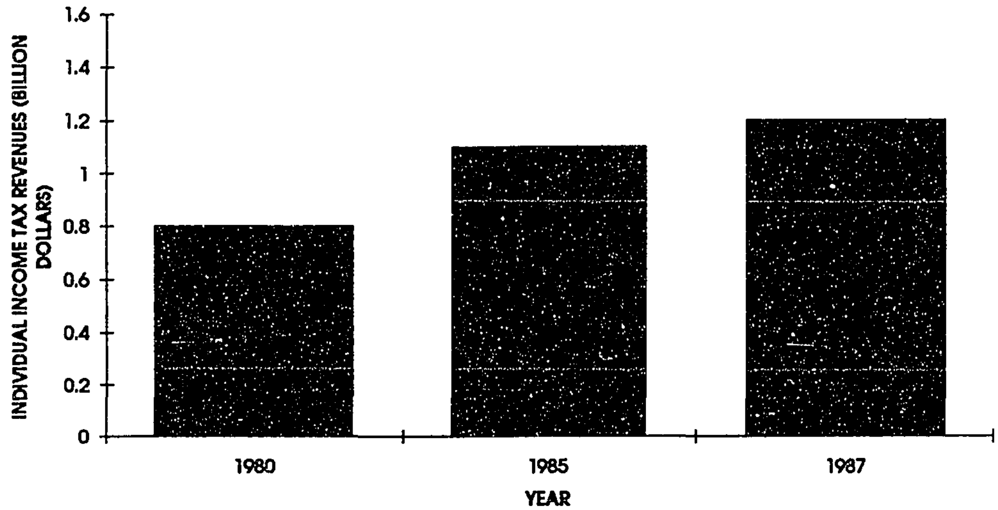
GRAPH 4-8 COLOR TELEVISION OUTPUT*
*Source: RRNA, 1989.



GRAPH 4-9 VALUE ADDED (COLOR TELEVISION)*
*Source: RRNA, 1989.



GRAPH 4-10 EMPLOYMENT DUE TO COLOR TELEVISION MANUFACTURING*
*Source: RRNA, 1989.



GRAPH 4-11 INDIVIDUAL INCOME TAX REVENUES*
*Source: RRNA, 1989.

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CHAPTER FIVE
INTEGRATION PHASE — HISTORY OF HIGH DEFINITION TELEVISION

5.1 Background -- HDTV: What is it?

High Definition Television (HDTV) is the next generation (third generation or sometimes called fourth generation) of television technology being developed by various organizations around the world. (Note: The first generation of television was monochrome television, the second generation was color television, and the third generation is HDTV. Sometimes HDTV is divided into two generations. The analog HDTV is referred to as third generation, and the digital HDTV is referred to as fourth generation). HDTV promises to bring sharper images to the TV screen, as well as superior digital stereo sound (similar to compact disc) and a wide screen picture to the audience. It is an attempt to create an electronic image equivalent to a 35 mm film production. High definition can be measured by the resolution of the picture or the number of active horizontal or vertical lines scanned on the television screen (generally referred to as the television raster). HDTV and Advanced Television (ATV) are sometimes used synonymously. ATV refers to any system that results in improved television audio and video quality, whether the methods employed improve or enhance the existing National NTSC transmission system, or constitute an entirely new system (FCC Notice of Inquiry, 1987). The present TV standard being used in the United States is a 40 year old NTSC standard that has 525 horizontal scanning lines with field rate of 60 Hz. This corresponds to approximately 350 lines of vertical resolutions and 350 lines of horizontal lines. With the increment of active lines on the raster, HDTV will scan many more lines and provide a clarity, sharpness, and low level of distortion that is available only on films. HDTV provides better motion picture, i.e., the wagon wheels don't go backwards anymore. It is not possible to increase the size of displays in conventional receivers because as displays using non-HDTV technology get larger, the viewer notices more defects and artifacts in the picture such as - interline flicker, line crawl, vertical aliasing, static raster, and cross color. CD quality audio is available with the use of digital stereo sound system in HDTV system. (Note: See Appendix A).

Early research on visual perceptions discovered that the qualities advocated by HDTV could only be realized when viewers sat closer to the screen than they do with conventional televisions. This resulted in a wider field of view which in turn increased the sense of presence of the audience viewing the picture. But in doing so the viewers were able to see the scanning lines on the raster, which resulted in a very disturbing picture often causing vertigo. To overcome this effect, the number of lines scanned had to be almost doubled. To further increase the sense of presence, researcher discovered that the aspect ratio (width of the picture compared to height) had to be increased. The following are five features that define the main areas of HDTV - High Resolution Display, Wider Aspect Ratio, Viewing Conditions, Color Rendition, Compact Disc Quality Sound.

Similar to the history of monochrome television and color television, the history of HDTV can be divided into three stages. They are --

1. Idea Generation and Preliminary Assessment Stage;
2. Development and Testing Stage; and,
3. Standardization and Launch.

(Note: See Section 6.5).

5.2 Idea Generation and Preliminary Assessment Stage

This stage can be further divided into three sections --

1. Before European Opposition;
2. European Opposition; and,
3. U.S. Initiatives.

5.2.1 Before European Opposition

The Japanese Broadcasting Corporation (Nippon Hyoso Kyokai) (NHK) started work on High Definition Television since 1968 which was initiated by Dr. Takahasi Fujio of NHK. On February 6-7, 1981, NHK demonstrated its 1,125 line system to more than 800 engineers attending the San Francisco SMPTE conference (Broadcasting, February 16, 1981). By using twice the number of scanning line and six times the bandwidth, the system produced cinema quality pictures. Among the viewers was, Francis Ford Copolla, who remarked that he envisioned making extensive use of the technology.

The Japanese HDTV was intended for DBS (Direct Broadcast Satellite). In February 1981, CBS brought together the art to show official Washington, not only that HDTV was possible, but that it was not all that far away. CBS's main purpose was to drum up support to reserve DBS frequencies by impressing federal regulators and legislators (Broadcasting, March 2, 1981). In the U.S., there was a debate going on about how the DBS would be used. STC, CBS, and NTIA, along with FCC were all involved.

On April 28, 1981, SONY demonstrated its full HDTV system. The previous demonstration did not include the video tape recorders. The aspect ratio of the television was the same 4:3. However, SONY claimed that it could easily demonstrate a better panoramic television with a different aspect ratio (Broadcasting, May 4, 1981).

In the September meeting, SMPTE had a discussion session for discussing the problems and prospects of HDTV. The session was to answer questions -- How, Why and When (Broadcasting, September 14, 1981). By now it was evident that the Japanese were pushing forward to establish their HDTV standard as the international standard.

During September 1981, Compact Video demonstrated its HDTV system in Los Angeles to the press and SMPTE. Its system ImageVision used 655 vertical scanning lines, an extra wide aspect ratio and 24 frames per second (Broadcasting, November 2, 1981). The heart of the ImageVision was the Phase Alternate Line Alternate Frame (PALAF) scheme that eliminated the phase error of NTSC.

In Spring 1983, ATSC was formed with a mandate to explore technology promising to improve the quality of video and, where possible, develop industry standards so the technology could be put to work (Broadcasting, April 30, 1983). It consisted of three groups --

1. The "Improved NTSC" group was to address the ongoing and evolutionary improvements in picture generated by NTSC standard through improvements in studio and transmission equipment and television receiver;

2. The "Enhanced Television" group was to investigate new production and transmission systems that retain the 525-line format and 4:3 aspect ratio; and,
3. The "HDTV" group was to look at systems like NHK HDTV systems and was to come up with a U.S. recommendation of a worldwide HDTV standard. (Note: See Appendix D)

From May 28 to June 2, 1983, proponents of high definition television production standard were pushing for a world HDTV standard at the International Television Symposium and Technical Exhibition in Montreux, Switzerland (Broadcasting, June 6, 1983). Japan demonstrated its HDTV system and was pressing for its standard to be adopted. (Note: Proponents at this early period were interested in adoption of their own standard so that they could lock in their customers and earn monopoly rent). Philips demonstrated its "Hi-Fi Zero" prototype PAL receiver. The system enhanced the picture quality by increasing the field rate to 100 fields per second. The C-MAC system developed by IBA of Britain was a very talked about issue. This was the standard that was going to be adopted by the European Broadcasting Authority for direct broadcast satellites in Europe. During this symposium, the CCIR Director Kirby announced that HDTV standard would be taken up in the interim CCIR fall meeting in Geneva. (Note: See Appendix D for a discussion on "HDTV Proposals in the United States").

In September 1983, CBS announced its HDTV system that was compatible with existing television sets, in accordance to the recommendation of the ATSC (Advanced Television Systems Committee). In its system the first channel would carry a 525-line signal and a second channel called the augmentation channel would carry additional 525-line signal with 5:3 aspect ratio. This was a 1,050-line system. It used the TMC (time multiplex component) video processing scheme for transmission (Broadcasting September 26, 1983). (Note: See Appendix I).

In March 1984, ATSC came up with three key parameters for a worldwide HDTV production standard (Broadcasting, March 19, 1984). The parameters were -- 1,125-lines, 5:3 aspect ratio, and 80 per second field rate.

By June 1984, there were three systems competing head on (Marketing and Media Decisions, June 1984). The two channel compatible system was proposed by CBS. A semicompatible extended definition television system was proposed by Philips. Finally a single channel non-compatible system was proposed by NHK. (Note: See Appendix D).

At the International Broadcasters Convention held in London, England on September 25, 1984, NHK announced the NHK MUSE system to squeeze the 24 MHz or 27 MHz DBS channel to 8 MHz (Broadcasting, October 1, 1984). NHK also informed the convention that due to the failure of two of the three tubes of NHK's BS2A DBS satellite launched in January, its HDTV program was being delayed.

By January 1985, the U.S. ATSC supported 60 per second field rate, even though the EBU (European Broadcasting Union) and others were skeptical about converting 60 field to 50 fields (Broadcasting, January, 28, 1985). The race to achieve a worldwide HDTV production standard would be taken up in the CCIR October 1985 meeting. ATSC was going to make two proposals -- the first proposal was the 1970's NHK 1,125 lines, 60 fields, and 2:1 interlace scanning; and, the second was RCA's 750 lines, 60 fields, and progressive scan.

On March 19, 1985, the "HDTV Technology" group of ATSC approved a document specifying an international HDTV studio standard using NHK developed 1,125 lines, 60 fields per second, and 2:1 interlace scanning technology, by a three to two margin (Broadcasting, March 25, 1985). (Note: This was a premature decision as will be shown later on in this chapter). The committee also recommended the standard be based on a temporal rate of 60 Hz, an aspect ratio of 5.33:3, and a separate luminance and two color difference component signals. This proposal would be submitted to the plenipotentiary meeting of CCIR in Geneva from October 16 to November 1, 1985.

During the biennial Montreux Television Symposium held from June 6 to June 12, 1985, many developments were recognized. The two decisions made by EBU were well elaborated (Broadcasting June 17, 1985). One key EBU decision made in the spring was to hold off making any specific recommendation on HDTV production standards until further study on the problem of standards conversion was conducted. A second important EBU decision made earlier that year was to complete standards for transmission from direct broadcast satellite systems projected for launch by several countries over the next two years. The standard was for a family of MAC. Further, the Soviets, who were expected to be in favor of the NHK standard, announced that they had submitted their own separate HDTV proposal on the 50 Hz based system to the CCIR.

In September 1985, the EBU failed to approve the NHK offered parameters in its meeting in Tunisia (Broadcasting, September 30, 1985).

5.2.2 European Opposition

At a meeting in Geneva from September 30 to October 2, 1985, the interim working group of the CCIR agreed to forward to the next decision level group documentation of the HDTV production system developed by the NHK. However, a footnote was added by some European members expressing reservations.

The interunion meeting of nine international broadcast unions garnessed support for the NHK system held in Prague from February 17 to 23, 1986. The North American National Broadcasters Association (NANBA), the Asia Pacific Broadcasting Union (ABU), the Iberian Peninsula South American Television Organization, the Inter American Broadcasting Association and the Caribbean Broadcasting Union endorsed the CCIR proposed HDTV parameters (Broadcasting, March 3, 1986). However, the European Broadcasting Union (EBU), Eastern Bloc countries represented by the International Radio and Television Organization (OIRT), and the Arab States Broadcasting Organization noted that they required extra time for additional studies. The union representing African countries abstained form voting.

In March 1986, the French government appealed to postpone the standardization of HDTV studio technology (Broadcasting, April 14, 1986). The HDTV studio standardization was to be taken up in the plenary session of CCIR in Dubrovnik, Yugoslavia, in May 1986. The French emerged as the most vocal oppositionist to the 1,125 line proposal, because of its interest in version of MAC transmission and component display technology developed by Dutch manufacturer Philips.

German manufacturers, at a press conference in Dallas on Sunday, April 14, 1986, announced that it would join France and the Netherlands in submitting a joint proposal to the world standard body CCIR asking that efforts to standardize HDTV studio signals be delayed for further study (Broadcasting, April 21, 1986).

In a major setback to HDTV studio standardization the CCIR agreed to delay standardization for at least four years in May 1986 (Broadcasting, May 19, 1986). The U.S., Canada, and Japan backed the 1125/60 standard that was opposed by majority of West European countries. In a strong showing of opposition one week prior to the opening of the CCIR plenary, 12 nations of the European Economic Commission (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and the United Kingdom), unanimously agreed that a choice on standards was premature and a further study period of at least two years was required.

At the biennial International Broadcasting Convention in Brighton, England on September 1986, an experimental HDTV system was first demonstrated by Philips of the Netherlands and a display by BBC of a signal compression technique now under development at its laboratories (Broadcasting, September 29, 1986). The Europeans opposed the 1125/60 HDTV standard and inclined to their 1250/50 HDTV standard.

5.2.3 American Initiatives

In October 1, 1987, NBC announced at a press briefing that it had developed an advanced television system for terrestrial broadcasting (Broadcasting, October 5, 1987). NBC said its advanced compatible television or ACTV was jointly developed with the David Sarnoff Research Center and General Electric/RCA Consumer Electronics. It would provide a picture with double the current 525 scanning lines and fewer of the imperfections of today's NTSC color TV transmission standard, all within the current 6 MHz channel allocation.

In October 1987, the FCC formed the "blue ribbon" advisory panel on advanced television consisting of top executives from throughout the television industry including the chief executives of the three major networks, the country's second largest multiple cable system operator, the largest pay cable service and consumer receiver manufacturers (Broadcasting, October 12, 1987). The panel would recommend policies, standards and regulations to facilitate the orderly and timely introduction of ATV (Advanced Television) services in the U.S. (Note: See Appendix B).

In this same month (October 1987), the U.S. Congress declared itself in on HDTV (Broadcasting, October, 12, 1987).

By October 1987, there had been a number of HDTV proposals. They were -- NHK's MUSE system, NYIT's VISTA, North American Philips' HD-NTSC, NBC's ACTV, and Del Rey Group's HD-NTSC (Broadcasting, January 12, 1987). (Note: See Appendix D).

In a vote that took place at the ATSC -- the result was 26 were for HDTV 1,125/60, 16:9 aspect ratio production standard based on the system developed by Japan's NHK; 11 were against; and, 8 abstained. The voters included NAB, NCTA, EIA, IEEE, ABC, CBS, NBC, HBO, GE, AT&T, PBS, etc. (Broadcasting, January 11, 1988).

On January 27, 1988, the Europeans detailed the research on 1,250 line, 50 Hz frame rate production and transmission system by Eureka, a consortium of 18 European countries that had earmarked $180 million for HDTV research, during a tutorial sponsored by FCC entitled "High Definition Television: A European View." It was pointed out that although FCC and its HDTV industry advisory committees were primarily interested in finding ways of terrestrial broadcasting, Eureka's highest priority was finding a system for direct satellite broadcasting (Broadcasting, February 1, 1988).

On February 1988, ABC, CBS, NBC, NAB, AMST, AITS, and to a lesser degree PBS, in partnership in formed the ATTC, which was a non-profit organization governed by a board of directors with representatives from each founding contributor, and its main objective would be to perform comparative laboratory and field tests for each advanced television proposal and make subjective quality comparisons and spectrum alternatives (Broadcasting, February 22, 1988). It was to function "as a service to the television industry and assist the FCC Advisory Committee and the ATSC."

5.3 Development and Testing

At the NAB convention of ATV at Las Vegas in April 1988, the proponents of HDTV gave their demonstrations (Broadcasting, April 18, 1988). The Japanese NHK's system was demonstrated. In response to demand for compatibility and to build a bridge of time NHK demonstrated six new Muse variations -- three 9 MHz or MUSE-9 systems and three 6 MHz or MUSE-6 systems. NBC demonstrated its ACTV I and ACTV II. NYIT demonstrated its prototype of HDTV transmission system. (Note: See Appendix D).

The Del Rey Group was also present at the convention. Other proponents were Faroujda Laboratories Inc., which showed what it called SuperNTSC.

Two other proponents of ATV systems were missing. One was Philips' NTSC compatible, two channel system employing progressive scanning scheme, and the other was MIT's two step transmission standard.

In July, 1984, Tele-Communication Inc. (TCI) announced that it would back the Faroudja Labs SuperNTSC HDTV approach (Cablevision, July 4, 1988). In the agreement TCI would allow Faroudja to use its facilities in Pacifica and Sunnyvale, California for its on-site testing.

On August 15, 1988, Broadcasting announced that the second stage in the development of HDTV transmission standard by the FCC advisory committee began in Wednesday, August 10 in Washington. After having spent several weeks reviewing the ATSC's first interim report, drafted by the planning subcommittee, the systems subcommittee began preparation for the second report, tentatively due February 1, 1989, which would provide further recommendations to the FCC. The first report, which was approved by the ATS blue ribbon committee and sent to FCC in June 1988, identified some attributes of the various advanced TV systems that should be tested and some of the tests that should be performed (Broadcasting, August 15, 1988). The second report would provide a "characterization of the proponent systems and some outlook on the testing phase." The third report would provide the test results. The final report would recommend to the FCC a satisfactory television transmission system or systems. Eighteen proponents had stated their intent to take part in ATS testing process. (Note: See Appendix I).

The test was to be performed by six task forces --

1. A group that would develop terrestrial test policies and procedures;
2. A group that would decide what kinds of equipment would be needed;
3. A group that would procure needed equipment;
4. A group that would decide source material to be used;
5. A group that would decide test procedures for alternative media; and,
6. A group that would decide test procedures for subjective assessment.

Zenith Electronics Corporation in August moved to secure its place in the HDTV race (Broadcasting, September 5, 1988). It proposed an analog-digital system SC-HDTV for broadcasting HDTV over unused VHF and UHF channels without interfering with existing NTSC stations. (Note: See Appendix D).

On September 2, 1988, USSR's chief technologist, Henrikas Yushkiavitshus, called on engineering elites to a set world production standard (Broadcasting September 12, 1988). In the meeting it was pointed out that USSR planned to organize tests in Moscow of various HDTV systems -- principally three. One would be NHK's 1125/60, another Eureka's 1250/50, and the third USSR's 1350/50.

On September 1, 1988, FCC tentatively decided to require HDTV broadcast to be compatible with conventional and ubiquitous NTSC sets in the same way NTSC color broadcasts were compatible with black and white sets (Broadcasting, September 5, 1988). And although it also tentatively decided that it would not make additional spectrum outside VHF and UHF bands available for HDTV, it said that there was enough spectrum within the broadcast bands to accommodate the enhanced service.

FCC also launched an inquiry from broadcasters on the relative advantages of three allocation schemes --

1. that no additional spectrum be made available;
2. that a 3 MHz channel, not necessarily contiguous be made available to augment the main channel; and
3. that a 6 MHz channel, not necessarily contiguous, be made available to augment the main channel or to simulcast HDTV during transition period.

(Note: See Appendix I).

To generate interest in Washington for a national policy regarding the development of HDTV in the U.S., the House Telecommunication Subcommittee brought together several competing HDTV broadcasting systems in Capitol Hill in September 1988 (Broadcasting, September 12, 1988). The competitors were David Sarnoff Laboratories (ACTV), Del-Rey Group (HD-NTSC), Faroudja Laboratories (SuperNTSC), New York Institute of Technology (VISTA), NHK (MUSE), North American Philips (HDS-NA) and Zenith (SC HDTV). There were eleven additional systems under consideration by the FCC HDTV advisory committee.

On September 12, 1988, the FCC heeded to intense pressure from broadcasters and tentatively concluded that advanced television systems should be compatible with present day receivers but that any additional spectrum needed for its provision should be squeezed out of the current VHF and UHF bands.

The major HDTV contestants as of September 21, 1988, as reported in New York Times, September 21, 1988, were -- NHK MUSE, ACTV, VISTA, HDS, HD-NTSC, and SC HDTV.

The schedule for testing HDTV systems at Advanced Television Test Center (ATTC) Alexandria, Virginia were announced by ATS as given in Table 5-1 (Broadcasting, October 2, 1989).

TABLE 5-1 SCHEDULE FOR TESTING BY ATTC

May 25, 1990	SuperNTSC developed by Faroudja Laboratories
July 17, 1990	Genesys Transmission Sys. by Production Sys.
September 5, 1990	ACTV I by David Sarnoff Research Center
October 25, 1990	Narrow MUSE by NHK
December 13, 1990	MUSE 6 by NHK
February 11, 1991	Spectrum Compatible HDTV by Zenith
April 2, 1991	ACTV II by David Sarnoff Research Center
May 21, 1991	HDS-NA by North American Philips
July 12, 1991	Channel compatible system by MIT

On October 1989, Electronics magazine published that digitized HDTV was turning the heat. The advent of multimedia was the main magnet for this development (Electronics, October 1989). Further, computer industries and telephone industries were pressing this further.

On September 4, 1989, Faroudja Laboratory announced the first advanced television broadcast to be viewed by the public within six weeks (Multichannel News, September 4, 1989). This would be the first transmission in the SuperNTSC format.

In a last minute entry into the FCC sponsored HDTV trials, New York City based General Instruments Corporation proposed an all digital broadcasting scheme called DigiCipher for the U.S. HDTV standard (Electronic Business, August 20, 1990). The benefit of digital signal is that it can be of lower power than analog. This meant that co-channel interference could be reduced, if not eliminated. Error correction is an added advantage. This added an extra dimension to the FCC testing. Further there would be closer integration of television and computers.

In December 1990, Zenith announced an all digital HDTV system (Broadcasting, December 24, 1990). The all-digital Spectrum Compatible

(HDTV) SC-HDTV would employ an 787.5 line, 59.94-field, progressive scan format. It was scheduled for test in October 1991. Zenith developed this system in partnership with AT&T Bell Laboratories and AT&T Microelectronics. In November 1990, The Advanced Television Research Consortium (ATRC) composed of NBC, Thomson Consumer Electronics, North American Philips, and David Sarnoff Research Center announced its all digital system. This brought three of the six proposals to be all digital. The other proponent MIT was underway to have an all digital system. The fifth proponent NHK Narrow-MUSE announced that it would not convert its all analog system. The sixth proposal backed by ATRC, the ACTV, was to remain analog.

In January 30, 1991, two competitors in the effort to develop a standard for transmitting HDTV, MIT and General Instruments Corporation, announced that they would work together to develop an all-digital technology (The New York Times, January 31, 1991). This meant that all but one of the proponents had digital systems.

On April 3, 1991, the FCC Advisory Committee announced that there would be a delay in starting the testing of the six proposed designs and they would not begin until July 1991 (Los Angeles Times, April 3, 1991). The delay was primarily due to the design modifications of the proponents from analog to digital. The competitors were -- a partnership between AT&T and Zenith Electronics, another partnership between General Instruments Corporation and MIT, a consortium of Philips, NBC and David Sarnoff Research Laboratory, and the Japanese broadcaster NHK.

In October 1991, the FCC voted 5-0 to propose awarding new channels for broadcasting HDTV only to existing broadcasters, reserving the benefits of HDTV broadcasting for the current generation of TV stations (Wall Street Journal, October 25, 1991, Washington Post, October 25, 1991). The agency would provide a separate channel to broadcasters to simulcast its conventional TV signal.

In December 1991, GI demonstrated its prototype of HDTV to reporters (New York Times, December 3, 1991). In March 12, 1992, Zenith Electronics and AT&T gave their first public demonstration of their digital HDTV system (Wall Street Journal, March 13, 1992).

Testing of the six proposed systems began on July 1991 in Alexandria, Virginia (The New York Times, August 18, 1991). Five of the systems were true HDTV, which provides wide screen picture with twice the resolution, and sound as clear as CD. The sixth provides modest improvements using current broadcast standards to transmit improved pictures. The test would be used to answer the following questions --

1. Can the signal fight statics?
2. Will the signal reach outlying suburbs? and,
3. Will the screen pick up interference from adjacent channels?

The testing was to be conducted in the following manner. The proponents would supply transmitters and receivers. Technicians would connect them with wire. The broadcast test bed would simulate distance. The torture chamber would subject the signal to a wide range of interference (noise). The signal would then be recorded in a videotape. These tapes would be viewed by a panel of non-experts in Canada, who would rate the quality of the pictures -- the sharpness of images, richness of color, details in moving picture, and crispness of sound. The key to success for each system would be its ability to generate signals that would be robust enough to travel long distances and benign enough to keep from generating too much of their own interference.

During that period of 1991, the Japanese felt pessimism with their new system. Their system designed mainly for satellite broadcasting could become obsolete before it even took off (Business Week, April 1, 1991). It was expected that the Japanese would lose more than the $1 billion that they spent on developing HDTV for 20 years. NHK, aided by two ministries and eleven technical firms, had led Japan's effort to invent and promote HDTV. The technology offers denser resolution, wider screen, richer clarity; but the obstacles have been -- weak start on developing programs, rapid improvements of technology, competing digital systems developed in U.S., and international opposition on agreement of standards (The Christian Science Monitor, March 16, 1992).

5.3 Standardization and Launch

Trade was the major issue in the Washington Conference "HDTV and Business of Television of 1990's" sponsored by the Denver-based law firm of Davis, Graham & Stubbs in September 1988 (Broadcasting, September 19, 1988). This was a shift from engineers and executives who have been concentrating on what should be the standard to how the decision will affect the American Economy. Earlier in the year the National Telecommunication and Information Administration, an arm of the Commerce Department, had released a report showing that the advent of HDTV in the U.S. could provide a shot in the arm for nation's trade and economic policies (Cablevision, September 26, 1988). The study said that if the U.S. gets its foot in the door early, potential sales of HDTV equipment could top $150 billion by the beginning of the 21st century and a spark of welcome explosion in the American job market. (Note See Appendices E, F, and G).

Prior to this in June 1987, the issue had drawn attention in Capitol Hill in hearings by House Telecom Subcommittee (TV Digest, June 27, 1988). The highlights were -- networks' pleas on spectrum to be set aside, economy and security, free market forces not being enough, and distinct U.S. standards. To fuel up the HDTV program several alternatives were suggested --

1. Government should decide as soon as possible on HDTV standards;
2. Government should partially fund HDTV research;
3. Government should make its own HDTV relevant research available;
4. Government should provide antitrust immunity to allow companies to cooperate on HDTV research;
5. Government should provide tax incentives for research; and,
6. Congress should fund nationwide procurement program such as committing to buy HDTV for every classroom, military installation, or PBS station.

(Note: See Appendix H).

As HDTV approached, the questions of programming came into the arena. The fancy technology was not enough by itself. Without programs to watch, nobody would buy the new sets (The Economist, October 1, 1988). Without an audience to watch them, no producers would make HDTV programs. How could this HDTV circle be broken? Japan and Europe came up with two different answers. Japan planned to sell the equipment to program makers first; to begin with, it did not plan to use HDTV for broadcasting at all, but to make films for cinema. Europe's plan seemed to be more logical -- to introduce HDTV for television audiences gradually, by making it compatible with existing television sets. However, Japan's plan was not foolish as it sounds. An HDTV film is cheaper to make than a celluloid because easy-to-use electronics lowers production costs and wage costs also.

At the IBC in Brighton, England, during September 23-27, 1988, the European alliance, the Common Market sanctioned Eureka, led by Philips, Thomson, and Bosch, showed for the first time its working HDTV system with all the basic elements of the chain, all based on 50 Hz using 1250 lines on a screen with an aspect ratio 16:9 (Broadcasting, October 3, 1988). Only 14 months ago at the International Television Symposium in Switzerland at June 1987, the group had only a black and white progressive scan HDTV studio camera and a wide screen receiver to show. At the convention Eureka announced that it planned to propose the 1250/50 progressive scan production standard at meetings in 1990 of the world standards body CCIR.

Broadcast and cable television experts, appearing at November 10, 1988 at the Electronics and Aerospace Convention in Arlington, Virginia, expressed consensus of opinion on several key elements --

1. A mix of HDTV transmission systems must initially be put into practice;
2. The transmission standards adopted by the FCC must allow quality crossover to all other delivery systems;
3. Standard setters must aim for the highest end of enhanced or advanced resolution because true HDTV video disk and video cassette would raise consumer expectations; and,
4. Widespread consumer marketing of HDTV could be much as a decade away.

In December 1988, another participant in the development of HDTV technology stepped in -- the U.S. Department of Defense. The Pentagon's

Defense Advanced Research Project Agency (DARPA) said that it planned to solicit proposals from video display manufacturers and research labs for the twin purposes of development of low cost resolution displays for defense application and the perpetuation of vital video display and semiconductor manufacturing industries in US (Broadcasting, December 26, 1988). The defense department saw video display for a number of different applications -- training simulators, and mobile command centers. The other goal of the Pentagon was that the vital American electronics industries produce HDTV equipment.

On June 1989, DARPA announced that it would award five companies contracts to develop HDTV (Broadcasting, June 19, 1989). It selected Texas Instruments Inc. of Dallas, NewCo Inc. of San Jose, Rachem Corp. of Menlo Park, and Projectvision Inc. of New York to receive awards to pursue proposals dealing with projection display technology. A contract to develop gas plasma flat panel was given to Photonics Technology Inc. of Northwood, Ohio. The original Broadcast Agency Announcement (BAA) release said that DARPA indicated that half of $30 million would ultimately go to video processing development. More than 80 companies applied for the award. Among foreign companies to apply were Japan's Sony Corp., France's Thomson, and Dutch Philips.

On September 11, 1989, the National Advisory Committee of Semiconductors made an interim recommendation to President Bush to launch a national HDTV initiative to sustain competitive position in the industry (Electronic News, September 11, 1989). It mentioned that a robust HDTV industry could provide an important element in a successful reentry into consumer electronics industry. This sparked additional policy debates on HDTV funding (Multichannel News, September 18,1989). The American Electronic Association was appealing for a billion-dollar federal investment in HDTV to retaliate against the Japanese, while free market conservatives adhered to market forces to shape the future of HDTV. The Department of Commerce announced that it decided against nurturing HDTV as a key industry on September 18, 1989.

During this period Japan had made considerable progress in HDTV. Japan had launched an experimental hour long broadcast bounced daily by satellite BS-2 to prototype HDTV sets (about 80 locations) scattered throughout the country on June 2, 1989, using MUSE signals (IEEE Spectrum, October 1989). Europe had planned experimental broadcast in 1991. Meanwhile, the U.S. was bogged down trying to determine a standard and the economic importance of HDTV. The National Space Development Agency, Tokyo, had planned to launch broadcast satellite BS-3a in 1990 and BS-3b in 1991. With the launch of BS-3a full HDTV broadcast was planned in late 1990. MPT, Tokyo had heavily promoted HDTV in 1988 during the Seoul Olympic games, by installing 208 prototype HDTV sets at 81 locations.

In October 23, 1989, Rep. Edward Markey (D-MA), Chairman of the House Telecommunications Subcommittee, speaking to members of the Federal Communications Bar Association announced that he would introduce a bill to the Congress that would help the U.S. industries compete by pooling grant money for research and development, and provide temporary antitrust-law exemptions for consortiums dedicated to develop emerging technologies (Multichannel News, October 23, 1989). This step was in retaliation to the Bush Administration's backing away from substantial government involvement in nurturing this fledgling HDTV industry.

Just as important as the standards for transmission and studio, was the technology for the display of this HRS. To date most of the displays are big and bulky. Five new display technologies are competing for success. They are Active Matrix LCD, Plasma Technology, Electroluminescence (EL), Vacuum Microelectronics, and Deformable Mirrors (Business Week, February 26, 1990). (Note: See Appendix J).

During the 17th Plenary Assembly of the International Radio Consultative Committee (CCIR) held in Dusseldorf, Germany, during May 21 to June 1, 1990, no final decision could be reached on HDTV standards (Broadcasting, June 4, 1990). The assembly officially approved 23 separate HDTV system parameters, including a 16:9 aspect ratio and color characteristics, but there was still disagreement on matters of scanning parameters that govern picture resolution and the rate at which the picture is changed. Therefore there seemed three scenarios possible --
1. No world HDTV production standard would be set (most likely outcome);
2. A compromise format would be adopted, in which most but not all parameters would be agreed upon (most desirable outcome); and,
3. A world standard would be approved (quite impossible outcome). The question would not be discussed until the CCIR plenary session in 1994 or later.

There was a minor setback for HDTV standard setting efforts in September 1990, when the house legislation containing FCC funding for evaluation ran aground (Broadcasting, October 1, 1990). The Commerce Committee removed the bill (H.R. 4933) due to the Foreign Affairs

Committee's effort to review it, killing its chances for passage during the 101st Congress.

The fiery destruction of the Atlas/Centaur rocket in April 1991 caused a set back in Japan's ambitious plan to begin the world's first commercial broadcasting of HDTV (Wall Street Journal, April 22, 1991). The mishaps would delay plans by Japanese government and industry officials to introduce a new satellite channel by November that would deliver eight hours a day HDTV programs.

During July 1991, Japanese firm Sanyo Electric Company and California semiconductor maker LSI Logic Corporation agreed to team up to design electronic chips for HDTV (New York Times, July 16, 1991, Wall Street Journal, July 16, 1991). This would boost the Silicon Valley chip maker's share of the Japanese consumer electronic market. In August 1991, three Japanese companies (Fujitsu Ltd., Sony Corp. and Hitachi Ltd.), announced that they were pooling their resources and technology with Texas instruments Inc. to develop microchips for HDTV (New York Times, August 16, 1991, Wall Street Journal, August 16, 1991). This provided a further boost to the American consumer electronic business. On June 14, 1991, Eastman Kodak had announced that it would work with BTS Broadcast Television Systems GmbH of Germany to jointly develop and market a way to convert film reels so that it could be played on HDTV (Wall Street Journal, June 14, 1991). Meanwhile Motorola and Toshiba Corporation were already working together on HDTV chips.

A fourth consortium between Japanese companies and American companies to develop HDTV was formed in November 1991. Eight Japanese companies led by NEC Corp., Matsushita Electric Industrial Co., and

Mitsubishi Electric Corp., and two American companies, LSI Logic Corp. and VLSI Technology, announced that they would join together to design semiconductors for HDTV (Wall Street Journal, November 18, 1991). The other consortiums are Motorola Inc. and Toshiba Corp., LSI Logic and Sanyo, and Texas Instruments, Fujitsu, Hitachi and Sony.

In November 25, 1991, NHK launched a daily eight-hour test program on HDTV (HiVision) (New York Times, November 26, 1991, Wall Street Journal, November 26, 1991, Washington Post, November 26, 1991). There had been delay due to the failure of launching of broadcast satellite of Japan earlier.

During the WARC that was held in February-March 3, 1992 new spectrums was allocated to HDTV (The Economist, March 7, 1992). However, HDTV ran into some problems. Europe and Japan wanted the 21 GHz band, which America uses for research. America wanted the 17 GHz, which Europe uses for fixed telephone links. Therefore, it was decided that different regions would have different frequencies.

In April 1992, FCC took a decision that it would give TV stations five years to broadcast in HDTV once the agency approves a standard and makes channel available. FCC also proposed 15 year time period for total HDTV conversion (Broadcasting, April 13, 1992). Broadcasters did not take this decision to be favorable and blasted the FCC decision. Some thought that this was a good decision by giving the nation a new standard and a deadline.

On March 23, 1992, GI broadcasted from WETA-TV's transmission tower on River Road in Maryland to a five foot wide video screen in the U.S. Capitol, the world's first over the air digital signals (Washington

Post, March 24, 1992). The demonstration was intended to show that digital TV works.

On March 24, 1992, The Wall Street Journal announced that the ACTV, proposed by ATRC consisting of David Sarnoff Research Center, NBC, Philips, and Thomson, was quietly dropping out (Wall Street Journal, March 24, 1992). This caused the number of contestants to decrease to five. This same day the advisory group of FCC conducting the tests announced that there was a five months delay. Hence the results could not be out until late 1993 (New York Times, March 25, 1992).

The FCC outlined a broad regulatory framework on April 9, 1992. Under the plan, companies that own ordinary television stations would be given a second channel to broadcast HDTV. This two channel arrangement would be maintained during a 15 year transition in which the consumers would have a choice between the conventional TV system and HDTV. At the end of the transition, the broadcasters would relinquish one channel (The New York Times, April 10, 1992, Washington Post, April 10, 1992). Under the plan, broadcasters would have a five-year period, starting 1993, to apply and build an HDTV station and no more than four years after that initial period to program the HDTV channel as they wanted (Wall Street Journal, April 10, 1992). By 2008, the agency proposed, broadcasters would have to turn in their conventional channels and broadcasts solely in HDTV. FCC also mentioned that HDTV would not constitute a new service but an improvement on an existing one. The agency voted 5-0 to reserve new HDTV stations for existing broadcasters for at least two years, effectively blocking new entrants into the HDTV broadcast market (Wall Street Journal, April 10, 1992). This action by the FCC received criticisms from the broadcasters who complained that FCC did not take the cost of implementation into account (Broadcasting 13, 1992). The FCC did indicate that it was willing to take comments from broadcasters who were the ones to be affected at grass roots level.

By April 1992, the ATTC in Alexandria, Va., had already tested the NHK HDTV system (Business Week, April 27, 1992). The other four remaining digital systems only differed slightly. Two of them were interlaced systems, and the other two were progressive systems.

It was announced in May 7, 1992, that two of the four rival groups agreed in principle to hedge their bets by splitting royalties if either of them won the competition (New York Times, May 8, 1992). The new alliance would unite two groups, one consisting of General Instrument Corporation and MIT and the other consisting of Zenith Electronics Corporation and AT&T. The pact was formed to reduce financial risks. The Wall Street Journal reported that the winning group would get about two-thirds of the royalties, while the losers would collect about one-third (The Wall Street Journal, May 8, 1992). This was a good sign and a positive development because more companies would be backing up a single standard. Further the groups would work together to refine the selected system.

On May 29, 1992, Zenith Electronics and AT&T sent HDTV signal 75 miles, in the first long distance test of digital transmission (The Wall Street Journal, May 29, 1992). This indicated that the system could cover the distances required for conventional television.

The test showed that --

1. Digital TV signals did not suffer from "cliff effects";
2. Programming carried out on a low powered digital signal could produce near perfect, interference free images even when a higher power signal is sharing the same channel from a nearby transmitter; and,
3. Shots taken with standard TV equipment could be upgraded to be shown on a HDTV system (Chicago Tribune, May 31, 1992).

In May 1992, the broadcasters presented a unified front opposing the FCC's fifteen years deadline for conversion into HDTV. However, other players such as AT&T and Land Mobile Communication Council (LMCC) supported FCC's plan, since they agreed that tieing up frequency spectrum uselessly was not prudent. The NTIA therefore suggested a review process at the end of 1998 (Broadcasting, July 27, 1992).

In the Baltimore Convention Center, GI demonstrated its DigiCipher HDTV system using the Ku-band SBS-6 system in the first week of August 1992 to several thousand Satellite Broadcasting and Communication Association (SBCA) members (Broadcasting, August 10, 1992).

The HDTV race had penetrated the IC design market. Numerous companies were trying to develop ICs that would be integrated into the HDTV system. VRAM (Video random access memory) chips that would store and retrieve segments of the whole image were being developed by TI, Hitachi, Toshiba, and NEC. ICCs (image compression chips) that would delete all but the most crucial data from a picture were being developed by Intel, AT&T, C-Cube, and Sony. GCs (graphic controllers) that would help create or alter image on a display, even spinning on an axis in three dimensional space were being developed by AMD, Intel, Integrated Device Technologies, and LSI Logic. DVPs (digital video processors) that would mix video, graphics, and text for use in video-conferencing or multimedia presentations were being developed by Cirrus Logic, Philips, Chips & Technologies, Brooktree, and Sierra Semiconductor (Business Week, August 24, 1992).

During that period digital television posed a new problem to the broadcasters. According to the FCC, the broadcasters would be locked into the HDTV system. However, other delivery systems, such as cable and other multimedia channel competitors could exploit two paths -- 1. the HDTV path; and, 2. the NTSC digital path. It was realized that if digital NTSC pre-empts HDTV and dominates the market the broadcasters are disadvantaged. If both digital NTSC and HDTV survive, the broadcasters still have a problem, but if consumers embrace HDTV, the broadcasters have at least a path (Broadcasting, August 24, 1992).

It was announced by the ACATS that it would select a finalist for field testing on February 8, 1993 (Broadcasting, September 28, 1992).

In May 1993, the four competing systems agreed to join in to form a Grand Alliance, and present a unified system (Broadcasting and Cable, July 12, 1993). The primary reason for doing so was that their systems were quite similar to each other. It was expected that a system should be ready by May 1994.

In June 1993, the FCC got its first official look at the specifics of the HDTV grand alliance's proposed system. The alliance laid out a detailed plan for developing and constructing its joint system, and promised that pending details, such a transmission method would be ironed out by November 30, 1993. Other critical items, such as the audio and digital compression systems would be worked out that summer

(Broadcasting and Cable, July 12, 1993). The FCC was pressing the alliance to adopt 1,080 X 1,920 pixel system to make it compatible with overseas systems. The FCC committee consisted of four working groups -- scanning format, data transportation, transmission, and audio. The fifth group would study the details of the system. The alliance would test and verify itself before turning the prototype to the committee.

In October 21, 1993, the Broadcast Caucus (group of industry trade and major networks) acknowledged the major victory for broadcasters with the unveiling of the details of the Grand Alliance system (Broadcasting & Cable, October 25, 1993). The alliance committed to support the emerging MPEG-2 compression system and settled on the six MHz channel, and CD-quality Dolby AC-3 music system. Most of all they agreed to use the 1920 X 1080 line interlaced system. The FCC also announced that it hoped to have a full HDTV broadcast standard by the end of 1994.

With the announcement in February by The Grand Alliance that it was closing in on the last portion of its terrestrial standards (HDTV Report, February 2, 1994) and TI's announcement that it planned to offer DMDs (digital micrometer devices) to replace the CRTs, it was evident that HDTV was finally coming to fruition. On February 16, 1994, the transmission scheme (VSB) that was proposed by Zenith was recommended as the new standard for HDTV (Business Week, March 7, 1994).

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CHAPTER SIX
HISTORICAL ANALYSIS

6.1 Background

This chapter draws together the contents of Chapter 3, Chapter 4, and Chapter 5. As mentioned in Chapter 2, Section 2.5.2, this chapter discusses Step II of the Research Design, which is "Historical Analysis." The contents are analyzed and the entities involved in the history of television are identified and isolated. This is discussed in Section 6.2. The relationships between and among these entities are discussed in Section 6.3. Trend analysis is performed in Section 6.4. The Stages and Phases in the development of a high technology product is described in Sections 6.5 and 6.6 respectively. In Section 6.7, the stages, the phases, the entities, and their relationships are put together. Section 6.8 discusses the changes in the relationships among and between entities in the various segments of the phase-stage matrix. Section 6.9 integrates all the above section to come out with a Product Development Model. Finally in Section 6.10, hypotheses are formed to that would be used to validate the model.

(Note: In this study "among entities" refers to between manufacturers, between research organizations, between customers, and between government agencies; and "between entities" refers to between manufacturers and research organizations, between research organizations and customers, between customers and government agencies, between government agencies and manufacturers, between manufacturers and customers, and between research organizations and government agencies).

6.2 Entity Identification

In this study entity has been identified as "something that has real existence" (Hornby, A.S., Gatenby, E.V., & Wakefield, H., 1972). Only entities that have occupied prominent positions in the television race have been considered.

The entities have been isolated through historical analysis. Other literature and publications dwelling upon the premises of high technology have been coherent with the isolation made in the study. The entities identified through historical analysis are as follows -- 1. Manufacturers, 2. Research Organizations, 3. Customers, and 4. Government Agencies (Note: See Chapter 3, Chapter 4, and Chapter 5).

Mosco, V., in his book "The Pay-Per Society: Computer and Communication in the Information Age" has identified some six dimensions of policy analysis, among which four are directly relevant to this study -- Markets (Customers), Industrial Organizations (Manufacturers), Bureaucracy (Government), and Audience (Research Organizations) (Mosco, V., 1989). The other dimensions -- time and space, have been taken into consideration in an indirect manner. For example, time has been taken into consideration while traversing through the various phases and stages in the development of high technology product. Others in the literature have identified the four entities as -- Providers, Users, Regulators, and Civic Organizations, which corresponds to -- Manufacturers, Customers, Government Agencies, and Research Organizations respectively.

The definitions of the entities in this study are provided in the following sections.

6.2.1 Manufacturers

These are people, groups, organizations, etc. (individual or collection) who are involved in activities such as producing, fabricating, building, constructing, casting, setting up, tooling, etc., in the development of a high technology product. (Note: See Chapter 1 for the definition of "high technology product"). Their main interests are profits and efficiency and they do so through competition and cooperation with the various entities. Examples of manufacturers involved in our study are given in Table 6-1. The list contains manufacturers that have made the news, i.e., ones that have been active participants in television history, however, it is not exhaustive.

6.2.2 Research Organization

These are people, groups, organizations, etc. (individual or collection) who are involved in the investigation undertaken in order to discover new facts and ideas, get additional information, and come out with additional information or ideas for the social good, equity and access through the mode of professionalism and expertise (The Advanced Learner's Dictionary of Current English, 1972). Examples of Research Organizations involved in our study are given in Table 6-1. Similar to Section 6.2.1, the list contains research organizations that have made the news, i.e., ones that have been active participants in television history, however, it is not exhaustive.

6.2.3 Customers

These are people, groups, organizations, etc. (individual or collection) who are involved in buying the products and using them. Their interests are access, efficiency, and value, and they avail it through the means of competition and/or cooperation with other entities. Literature and also the historical analysis has revealed two levels of customers. Examples of Customers involved in our study are given in Table 6-1. (Note: They have not been classified as Level I or Level II).

6.2.3.1 Level I Customers

These are people, groups, organizations, etc. (individual or collection) who purchase the products and use it to deliver some other product to Level II customers. NBC, CBS, and ABC are some examples of this type of customer. They purchase broadcast and television equipment from various manufacturers to produce programs that are meant for the use of Level II customers. They are sometimes referred in the telecommunications literature as "suppliers."

6.2.3.2 Level II Customers

These are people, groups, organizations, etc. (individual or collection) who purchase the products from manufacturers and use it for their own end use. In other words, these are the final consumers.

(Note: Though most products have two levels of customers, there are some that have only one level. For example, when television products manufacturers such as Zenith, RCA, Magnavox, etc., are considered, they have two levels of customers -- Level I: ABC, CBS, NBC, etc., and Level II -- Ordinary viewers of television programs. On the other hand if television program producers such as ABC, CBS, NBC, etc., are considered, they have one level of customers -- Ordinary viewers. In this study, both the levels of customers have been integrated into one unit for the simplicity of analysis and also to make the end model more generic). This leads to an assumption made for this study.

Assumption: Both Levels of Customers, Level I and Level II can be represented as elements of the same entity set.

6.2.4 Government Agencies

These are people, groups, organizations, etc. (individual or collection) whose interest is in power, efficiency and equity for the public interest through regulations advocating and adhering to certain policies. Telecommunications literature use the term "regulators" in place of "government agencies." Examples of Government Agencies involved in our study are given in Table 6-1. (Note: It can be seen that semi-government agencies have also been included in this entity set. Also other non-government agencies, such as standards organizations, have been included in this entity set. The reason for this is "all these organizations are bureaucratic in nature"). This leads to an assumption made in this study.

Assumption: Bureaucratic organizations can represent elements of a common entity set called the government agencies.

(Note: Some of the organizations are elements of different entity sets simultaneously, and thus have been placed in more than one column. All of the elements are not mutually exclusive and may fall in the intersection of the sets formed by the entities). This leads to an assumption made for this study.

Assumption: Each element of an entity set at any particular instance in development of a product belongs to only one entity set at any particular instance of time even though even though the element may lie in the intersection of two or more entity sets.

TABLE 6-1
ENTITIES INVOLVED IN THIS STUDY

MANUFAC.	RESEARCH ORG.	CUSTOMERS	GOVERNMENT AGENCIES
Admiral	SMPTE	ABC	U.S. CONGRESS (LEGISLATIVE)
Emerson	NHK (JAPAN)	CBS	WHITE HOUSE (EXECUTIVE)
GE	ITU	NBC	SUPREME COURT (JUDICIARY)
Magnavox	NANBA (INT)*	NHK (JAPAN)	FCC
Motorola	ABU (INT)	GENERAL AUDIENCE	NTIA
Olympic	David Sarnoff Research Center	IEEE	ATSC
Packard Bell	Del Rey Group	HBO	ITU (INT)
Philco	EUREKA (INT)	PBS	EBU (INT)
RCA	AMST		NANBA (INT)
Sylvania	NAB		ABU (INT)
STC	AEA		OIRT (INT)
Warwick	EIA		ASBO (INT)
Westinghouse	ATTC		ATTC
Philips	NYIT		NTSC
SONY	Faroudja Labs		DOD
GI	MIT		
	DOD		
	DARPA		

*Note: INT refers to international organizations. (The list is not exhaustive).

6.3 Entity Relationship

In section 6.2, entities were classified into four divisions -- 1. Manufacturers, 2. Research Organizations, 3. Customers and 4. Government Agencies. These entities are organic structures (Ronen, S., 1986) and therefore have relationships among themselves (between manufacturers, between research organizations, between customers, and between government agencies) and between themselves (between manufacturers and research organizations, between research organizations and customers, between customers and government agencies, between government agencies and manufacturers, between manufacturers and customers, and between research organizations and government agencies) during the course of a product development. Figure 6-1 illustrates this diagramatically.

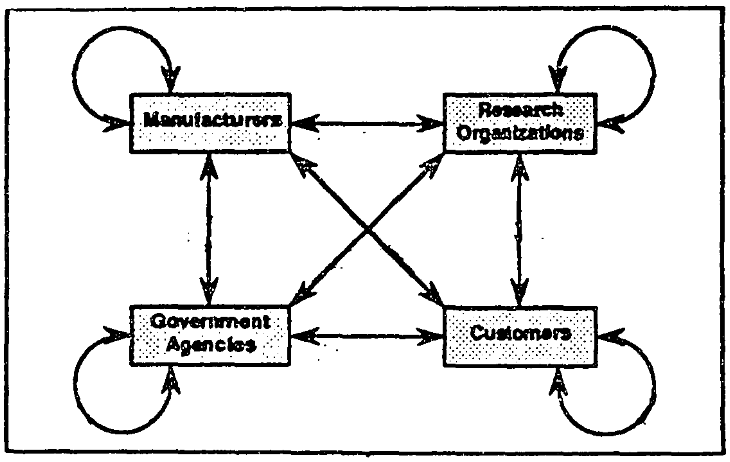

FIGURE 6-1 ENTITY RELATIONSHIP

In Chapter 1, it was discussed that competition and cooperation, which are antithetical approaches, are the two most important relationships among entities. Others in the literature have also pointed out "competition" and "cooperation" as being important in analyzing discourse and controversies. Throughout the history of television, competition and cooperation have affected the development of television. Competition occupied a very important role in the development of monochrome television. The manufacturers (RCA, Zenith, Magnavox, etc.) were competing throughout. The research organizations, which were represented by individuals, were also in this mode of relationship. There were not many government agencies and customers, and thus their relationship is not very distinct. The manufacturers and research organizations were also competing during the early period, but cooperated towards the end (i.e., during standardization and launch). (Note: See Chapter 3 for detail. See also Section 6-7).

In the development of color television these two relationships also appear. But in comparison to monochrome television where the elements of the entity sets were few, color television had a significant number of elements. The relationships among them were also complex. (Note: See Chapter 4 for detail. See also Section 6-7).

In the development of high definition television, these two modes of relationship have occupied the central stage. The reason for this will be more clear in Section 6-7.

In Figure 6-2, relationships between entities are imposed on Figure 6-1. The relationship is on a scale from 1 to 5. Scale 1 indicates full competition, Scale 2 indicates more competition than cooperation, Scale 3 indicates neutral, Scale 4 indicates more cooperation than competition, and Scale 5 indicates cooperation. Figure 6-2 illustrates this diagramatically.

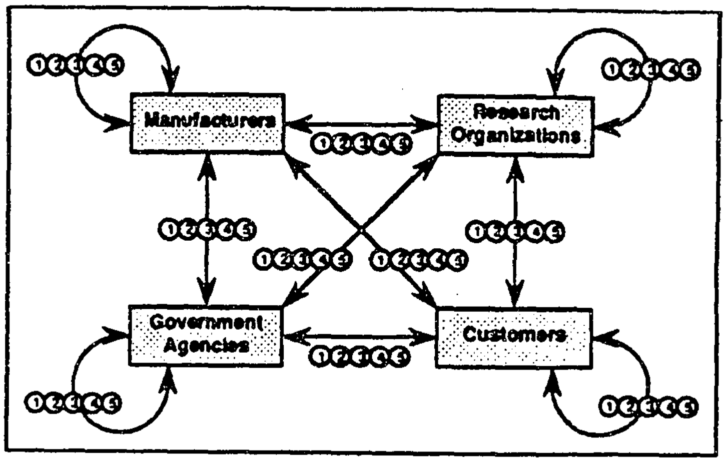

FIGURE 6-2 COMPETITION/COOPERATION ENTITY RELATIONSHIP

6.4 Trend Analysis

We can observe a number of trends from the historical analysis of television. They are as follows --

1. Technology Complexity -- With the passage to time, the product technology is becoming more and more complex. One of the factors that has contributed to the technology complexity is that with the passage of time, the technology has shifted from mechanical to analog electronics, and is finally shifting from analog electronics to all digital electronics. See Table 6-2.

2. Participant Increment -- With the passage of time (monochrome -- color -- high definition), the number of individuals involved in an entity set is increasing.

3. Shift In Market -- With the passage of time, markets have shifted from national to international, and finally it is shifting to global.

4. Complementary Products -- With the passage of time, the number of complementary products are increasing.

6.4.1 Technology Complexity

Table 6-2 illustrates the changes in technology that has taken place in the history of television.

TABLE 6-2
TECHNOLOGICAL COMPLEXITY

MONOCHROME	COLOR	HIGH DEFINITION
Radio tech. +	Monochrome +	Color +
Video Display tech.	Color	Computer tech.
MECHANICAL + ANALOG ELECTRONICS	ANALOG ELECTRONICS	DIGITAL ELECTRONICS

6.4.1.1 Monochrome Television

Monochrome television system technology was fairly simple. It consisted of only two parts. The first one "audio" could easily be incorporated in the television system because the radio system was already quite developed and its manufacturing and marketing foundations were fairly well established. The only addition was the component "Video" or the luminescence signal. Video signal was different from audio signal because two components -- luminescence information and spatial information, were embodied in it. The luminescence information could be incorporated within the system in a similar manner as audio information. Bright scenes meant higher amplitude signal and dark scenes meant small amplitude signal. The biggest difference between audio signal and luminescence signal was the bandwidth. This was due to the great amount of information that had to be conveyed by the luminescence signal in contrast to the audio signal. The bandwidth of the luminescence signal was about 6 MHz while the bandwidth of the audio signal was about 10 kHz. Accommodating the third component, the spatial information, was a big technological accomplishment (Note: See Chapter 3). To incorporate the spatial information, the concept of synchronization system had to be devised which read and wrote the picture much faster than the eye could distinguish.

6.4.1.2 Color Television

Color television system had a fourth component incorporated in it. (The first component was audio information, the second was luminescence signal, the third component was spatial information and the forth component was color information). Further color information was itself made up of three primary colors -- red, blue, and green, which were combined in various ways to yield all possible combination of color. Therefore, the fourth component brought along with it added information on hues and also the saturation of each color. Thus the amount of information that had to be transmitted and received in color television was almost doubled. Further, since monochrome televisions had already established quite an acceptance in the marketplace, it was very necessary to have the new color television system to be compatible with the existing monochrome television. Therefore, another factor that complicated the technology -- the compatibility issue -- was introduced by the advent of color television. The technology of color television was similar to monochrome except it was more elaborate (audio circuit, luminescence circuit, and color circuit) and complex.

6.4.1.3 High Definition Television

Development of HDTV had been instigated basically by two prime motives. The first was the desire for higher resolution resulting in crisper pictures that could display fine details with rich colors. (The present TV is considered inadequate because it is generally compared to the 35mm celluloid pictures and is considered far inferior). The second motivator was the desire for a wider screen. This would enhance the sense of presence of the viewers thus creating an illusion for the viewer to be more participatory. (With the present TV if the screen width is increased, grains tend to appear causing deterioration of the picture and the wheels of the wagon move backward). But most of all HDTV is an integration of computer technology and television technology. The forthcoming digital HDTV integrates the available digital technology, display technology, signal processing technology, memory technology, with other technologies that are still being developed in various laboratories around the world.

6.4.1.3.1 Bandwidth Requirements

The challenge for the engineers and designers was therefore accommodating enhancements that required greater bandwidth to accommodate the increment in information. The number of scanning lines, aspect ratio, frame or fields per second called the repetition rate, and the scanning methods (progressive or interlaced) are determinants of the bandwidth requirements. (Note: Interlaced scanning is less suitable for computer displays. Interlaced scanning was adopted by the conventional TV system to have a reduction in the bandwidth of the signal).

The bandwidth required and number of scanning lines is determined by the relation $y = f(x^2)$, where 'y' is the bandwidth and 'x' is the number of lines. This relates to squaring the bandwidth with doubling the number of lines. The present 525 lines/60 HZ NTSC system (which uses interlaced scanning) requires 4.2 MHz of bandwidth to accommodate the video signal (which takes into account both the chrominance and luminance signal). Actually, if each of the three primary colors which (red, blue and green) are accommodated without any technique for bandwidth reduction, 8.4 MHz would be needed for each color. Therefore the total bandwidth would be 8.4 MHz + 8.4 MHz + 8.4 MHz ~ 25 MHz. However matrix encoding of the color signals using phase-encoding reduces the bandwidth to 4.2 MHz. This is a significant reduction. The forthcoming HDTV signal may (the word may has been used, because the final format has yet to be decided upon) comprise 525 X 2 = 1050 lines. This would cause the bandwidth to be squared, i.e., 4.2 X 4.2 ~ 18 MHz.

Change in the aspect ratio from the present 4:3 to the proposed 16:9 would increase the bandwidth to approximately 24 MHz. If progressive scanning is used instead of the present interlaced scanning, the bandwidth would be doubled to approximately 48 MHz. This bandwidth is eight times the present bandwidth allocated to various television broadcasting stations which is 6 MHz. Without some technique for compression this would be beyond the range for broadcasting.

6.4.1.3.2 Compression

Compression and bandwidth reduction are possible by taking advantage of the psycho-visual and statistical attributes of the picture. With proper signal processing considerable bandwidth reduction is possible. Among the attributes are -- 1. The color resolution perceived by the eye is low; 2. The resolution of moving pictures as perceived by the eye is low; and, 3. There is a high correlation between adjacent pixels (both vertical and horizontal) and adjacent frames. (Note: Advances in digital compression techniques enable further compression).

The raw data from the camera may contain data rates of the order of 1 giga bps. Taking the above into consideration and combining it with modulation techniques, bandwidth compression of the order of 30 to 40 is possible, which would bring the signal bandwidth to 6 MHz.

6.4.2. Participant Increment

Table 6-3 illustrates the increment in participants. (Note: Only the important ones have been considered.

TABLE 6-3
PARTICIPANTS

MONOCHROME	COLOR	HIGH DEFINITION
Manufacturers	**Manufacturers**	**Manufacturers**
Zenith	Zenith	Zenith
RCA	RCA	RCA
GE	GE	GE
Sears	Sears	GI
Panasonic	Panasonic	Panasonic
Motorola (Quasar)	Motorola	Motorola
Sony	Sony	Sony
Sanyo	Sanyo	Sanyo
Ward	Emerson	BTA
Admiral	Admiral	GENESYS
Philco	Philco-Ford	Del Rey Group
Sylvania	Sylvania	Cox Enterprises
Sharp	Sharp	Sharp
Hitachi	Hitachi	Hitachi
Magnavox	Magnavox	Magnavox
Toshiba	Toshiba	Toshiba
	Westinghouse	Scientific Atlanta
	Olympic	AT&T
	Philips	Philips
	Warwick	INTEL
		IBM
		APPLE
		Avelex
		Fujitsu
		MagnaScreen
		Ovonic
		Photonics
Research Organiz	**Research Organiz.**	**Research Organiz.**
Willibough Smith	Jenkin Labs.	Genesys Labs
Joseph May	RCA Labs	RCA Labs
Alexander Bell	CBS Labs.	NBC Labs
Alexander Bain	NBC Labs	NBC Labs
Frederick Bakewell	David Sarnoff Labs	David Sarnoff Labs
George Sweeney	Sony Labs	Sony Labs
William Crookes	Zenith Labs	Zenith Labs
Adriano de Paiva	Panasonic Labs	Panasonic Labs
Denis Redmond	GE Labs	GE Labs
John Perry	Sanyo Labs	Sanyo Labs
William Arynton	Sharp Labs	Sharp Labs
William Sawyer	Hitachi Labs	Hitachi Labs
Constantin Senlecq	Magnavox Labs	Magnavox Labs
Maurice Leblanc	Toshiba Labs	Toshiba Labs

TABLE 6-3 (CONTINUED)
PARTICIPANTS

Paul Nipkow	NHK Labs	Del Rey Group Labs
Marcel Brillouin		Avelex Labs
Charles Jenkins		MIT
John Baird		NYIT
David Sarnoff		MagnaScreen Labs
Vladmir Zworkin		Ovonic Labs
		Photonics Labs
		NHK Labs
		Faroudja Labs
		TI Labs
		ATRC (Consortium)
		ATA (Consortium)
		GE/AT&T(Consortium)
		Grand Alliance
Customers	**Customers**	**Customers**
See Chapter 3	See Chapter 4	See Appendix
Government Agen.	**Government Agen.**	**Government Agen.**
FCC	FCC	FCC
NTSC	NTSC	NTSC
ITU	ITU	ITU
ISO	ISO	ISO
ANSI	ANSI	ANSI
IEEE	IEEE	IEEE
NAB	NAB	NAB
SMPTE	SMPTE	SMPTE
	ABU	ABU
	EBU	EBU
	EIA	EIA
	AEA	AEA
		ATSC
		ATRC
		NTIA
		NANBA
		AMST
		DOD
		DARPA
		NASA
		DOC

6.4.3. Market Shift.

Table 6-4 illustrates the shift in market.

TABLE 6-4
MARKET SHIFT

MONOCHROME	COLOR	HIGH DEFINITION
Markets are national and only some of the developed countries are involved	Markets are international and most of the developed countries are active participants	Markets are global and almost all the countries in the world are involved

6.4.4 Complementary Products.

Table 6-5 illustrates the number of complementary products.

TABLE 6-5
COMPLEMENTARY PRODUCTS

MONOCHROME	COLOR	HIGH DEFINITION
No complementary product	Video recording and reproduction systems -- VTR & VDP	Video recording and reproduction systems -- VTR & VDP
	Electronic Video Games (analog)	Electronic Video Games (digital)
		Complementary Products of Computers

(Note: The above trends have been drawn through historical analysis of television. See Chapter 2, Chapter 3, and Chapter 4).

6.5 Stages in Development of a High Technology Product

Literature has identified the stages in the development of a high technology product by the "Product Development Lifecycle." There have been numerous stages that have been identified in the Product Development Life Cycle by various experts. Ronkainen has suggested five stages of a product development process consisting of -- concept, feasibility, product and process development, scale-up, and standardization (Ronkainen, I, 1985). Cooper has identified a seven stage cycle consisting of -- idea, preliminary assessment, concept, developments, testing, trial and launch (Cooper, R.G., 1983). Hill, Alexander and Cross have described a five stage process consisting of -- preliminary appraisal, product and market research, process research, prototype testing and production, and commercialization (Hill, R.M., Alexander, R.S., & Cross, J.S., 1975).

Analysis of the previous chapters and the literature on PDLC, the stages can be appropriately depicted as follows --

Stage 1 -- Idea Generation and Assessment;

Stage 2 -- Development and Testing; and,

Stage 3 -- Standardization and Launch.

(Note: Others have used many stage models. However, for simplicity the study has shrunk the stages into just three. Use of more than three would make the analysis fairly cumbersome (as will be evident in the next Chapter) and would hamper availing deep insight into the process). This leads to an assumption made for this study.

Assumption: Three stages (which has shrunk other stages into them) can depict the development of a high technology product.

6.5.1 Idea Generation and Assessment

This is where the process of development of a high technology begins. An idea results when technological possibilities are matched with an expected market demand. Ideas of a new product may come out through internal dynamics of an organization and they may be subject to the external dynamics between various entities -- among manufacturers, among research organizations, among customers, among government agencies; or between various entities -- between manufacturers and research organizations, between research organizations and customers, between customers and government agencies, between government agencies and manufacturers, between manufacturers and customers, and between research organizations and government agencies. Ideally, it may be spotted in the marketplace: a competitor's idea, and recognition of customers needs (both direct and implied). Market pull results in the generation of many ideas for a high technology product, but technology "push" ideas -- where the idea comes from basic research or technology discovery -- also play an important role, particularly in the case of radical innovations or breakthrough products (Cooper, R.G., 1983). However, due to diversity in the market brought about by globalization and availability of many products it is difficult to detect the specific market pull. Considerable research and resource, both capital and labor, may be necessary to pin-point the specifics.

During this stage the viability of the idea is considered. This stage is highly correlated with complexity of technology. Tentative decisions are made during the evaluation of the idea and tentatively positive ones are forwarded. The decision is tentative because of the lack of information necessary to take a committed decision. Questions such as the following are brought out in this stage (Michaels, E.A., 1989) --

1. Does the idea cohere with the industry's policy, mission, plans, philosophies, strategies, current products/services, organization structure, and operating methods?
2. Does the company have the resources, facilities, and expertise?
3. Is it do-able?
4. Is it feasible?

After a tentatively positive decision is made, the idea is subject to an assessment. Both market assessments and technical assessments are made during this stage. Information about the market -- via quick market study using in-house information and relying on secondary data, is used to determine the attractiveness and the prospects of the idea. In-house opinions, as well as those solicited from outside, are used to further strengthen the assessment. The decisions are mainly qualitative.

6.5.2 Development and Testing

In this stage the exact concept and strategy are formulated. The definition of what the product is, who is it aimed at, and how is it positioned is necessary in this stage (Kotler, P., 1988). Understanding the link between the product and its value is of prime interest. Cooper R.G. (1988) has elaborated the link as illustrated in Figure 6-3.

ATTRIBUTE		BUNDLE		
FEATURES	------------>	OF	---------->	VALUE
DESIGN		BENEFITS		

FIGURE 6-3 LINK BETWEEN DESIGN AND VALUE

Source: Cooper, R.G., 1988.

The value is perceived differently with respect to each player. The reason for this is primarily because of the lens through which each of the players observes the product. An important tool useful in this stage is the development of product protocol (Crawford, C.M., 1984). The protocol is an all party agreement on what the product will be.

This stage determines whether the product will be a winner. It is necessary to understand whether the product will be accepted in the market. It is also necessary to determine whether the product is in accordance to what it was designed for. Both marketing aspects, as well as the technical aspects, are crucial in this stage.

The actual product development begins in this stage. Resources engaging R&D, engineering, and industrial are mobilized. To validate the product's design, tests are performed. Prototypes are tested to determine any flaws and improvements. (Note: Most of the testing is done in house). Consumer acceptance tests are performed to identify any defects and modifications that are necessary. With respect to HDTV this stage would determine compatibility, interoperability, scalability, and harmonization (Liebold, M., May 21, 1991). Also, questions regarding statics, coverage, interference, etc., would be determined in this stage. It is important to avoid "feature creep," i.e., continually adding new design elements causing delays (Michaels, E.A., June 1989).

6.5.3 Standardization and Launch

The existence of standards (or lack of them) can greatly affect consumer behavior and the efficiency within which the economy operates (Bensen, S.M., & Johnson, L.L., November 1986). Standards allow compatibility among different manufacturers, which allows mass production, economies of scale in manufacturing and marketing, VLSI implementations, and other benefits that decrease price and further increase acceptance. Further, there are standards that are enforceable by law. It is imperative that the product meets those standards.

This is the final stage and therefore activities border around the market. The consumers are the primary focus group during this stage. The final market assessment and acceptance are made in this phase.

6.6 Phases in the Development of a High Technology Product

In performing historical analysis of the development of television from monochrome television, to color television, and finally to high definition television, three distinct phases can be observed. (Note: See Section 6-4). They are as follows --

1. Invention Phase;
2. Development Phase; and,
3. Integration Phase.

6.6.1 Invention Phase

"Invention" is an object that has been created and does not exist before (Hornby, A.S., Gatenby, E.V., & Wakefield, H., 1972). The period in which the above occurs or takes place is called the "Invention Phase." It is when the product is first introduced.

The product is novel during this phase. However, the components of the product need not necessarily be novel. Generally, most of the components are quite familiar and popular. But the combination itself is not. An example will illustrate this. The example is drawn from historical analysis of television.

Monochrome television, which can be associated with this phase, is very illustrative. (Note: See Section 6.4.1.1). Radio technology, which made it possible to listen through space, was fairly well established during this phase. The technology of converting electrical energy to optical energy with the means of CRT was also fairly well established. Combination of the above two technologies, with a few improvements, would enable transmission of both audio and video information through space. Thus monochrome television was invented.

From Section 6-4, the following deductions for this phase can be made --

1. Technology during this phase of product development is rather simple. Only the bare minimum to accomplish the task is incorporated;

2. The number of elements is the entity set in the product development is considerably low;

3. The market for the product is basically national; and,

4. The number of complementary products associated with the product is almost non-existent.

6.4.2 Development Phase

During this phase some modifications are made to the product generally in terms of additions. These are minor enhancements to the already existent product.

Analyzing the history of television it can be observed that the attribute of color was added to monochrome television. Monochrome television integrated transmission of audio information with video information. However, the video information only consisted of luminescence information and the hue and saturation information was missing. In color television this was an added component to the monochrome television. Addition of this component did not imply addition of complex technology, or the adoption of completely new technology. Monochrome television had one circuit and system for luminescence signal, and color television was just a monochrome television that had three parallel circuits and systems, one for each of the primary colors -- red, blue, and green.

From Section 6-4, the following deductions for this phase can be made --

1. Technology during this phase of product development is simple but more elaborate;

2. The number of elements is the entity set in the product development is higher than that of the "Invention Phase";

3. The market for the product is international; and,

4. The number of complementary products associated with the product is few but significant.

6.4.3 Integration Phase

During this phase two different products, and hence technologies, are brought together and merged into one completely new product.

As for television, it is being integrated with computers. Therefore, both television technology and computer technology are being integrated in high definition television.

From Section 6-4, the following deductions for this phase can be made --

1. Technology during this phase of product development is very complex and elaborate since it draws from two completely different technologies;

2. The number of elements is the entity set in the product development is lot higher than that of the "Invention Phase" or "Development Phase." It draws from two different products;

3. The market for the product is global; and,

4. The number of complementary products associated with the product is a lot since complementary products from both the products that are being integrated is drawn in.

6-7 Stage, Phase, Entity and Relationship Diagram

From Section 6-5 and 6-6, it can be deduced that each phase consists or the three stages. Therefore, the stages and phases can be arranged as a matrix with the ordinate being phase and abscissa being the stages. Figure 6-4 illustrates this matrix. The matrix thus has nine segments. The entity relationship diagram of Figure 6-2 can be placed in the segments.

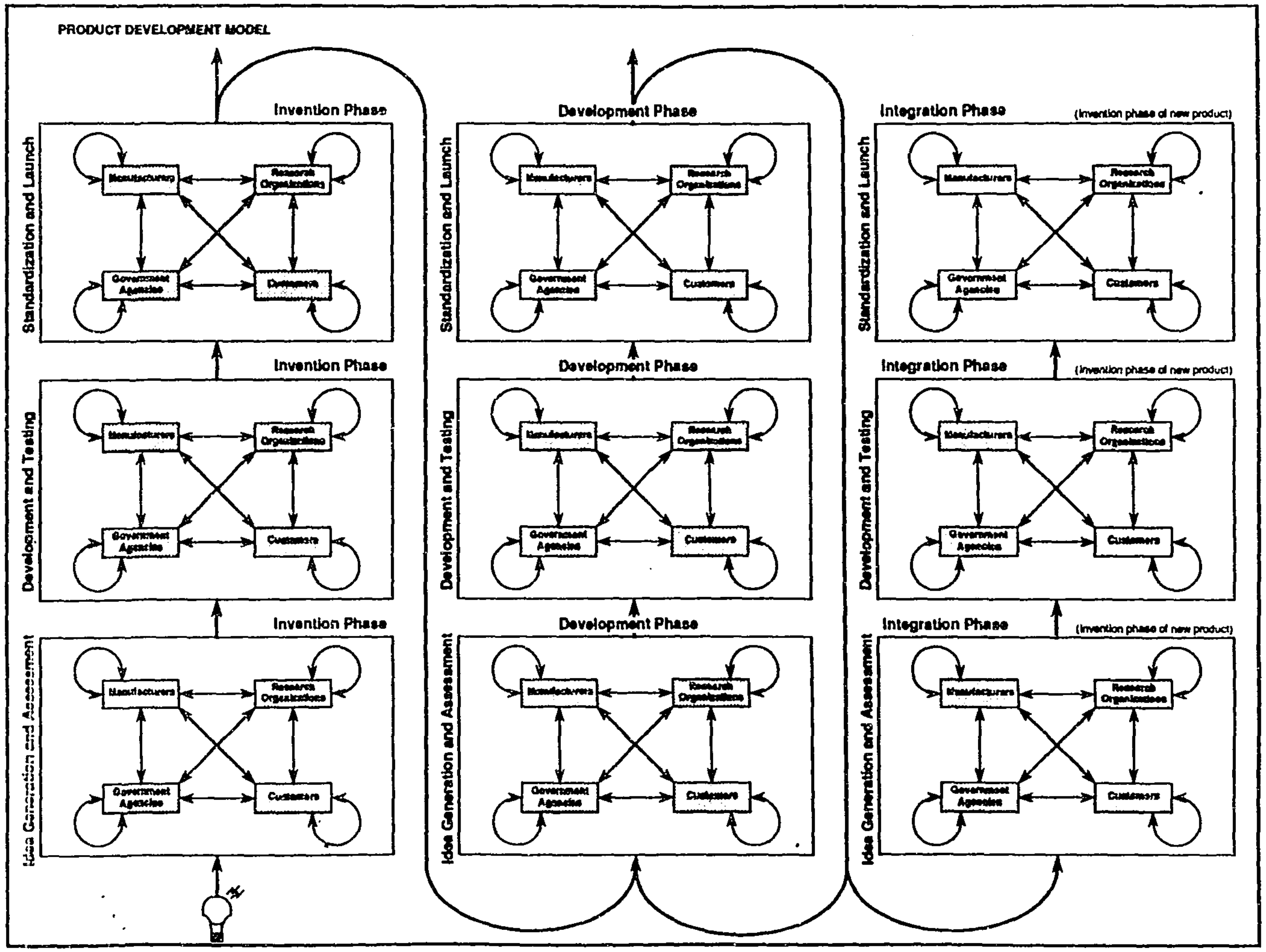

FIGURE 6-4 STAGE/PHASE/ENTITY/RELATIONSHIP DIAGRAM

6.8 Changes in Entity Relationship

6.8.1 Classical Economics

In Chapter 1, it was deduced that classical economics espoused competition as its the strongest weapon.

Therefore, the relationship for the "among entities" categories, i.e., between manufacturers, between research organizations, between customers, and between government agencies, is competition; and the relationship for "between entities" categories, i.e., between manufacturers and research organizations, between research organizations and customers, between customers and government agencies, between government agencies and manufacturers, between manufacturers and customers, and between research organizations and government agencies, is also competition. This is true for all the three stages -- idea generation and assessment stage, development and testing stage, and standardization and launch stage, as well as for all the three phases -- invention phase, development phase, and integration phase.

These relationships can be superimposed on Figure 6-4 to obtain Figure 6-5. Figure 6-5 depicts the Product Development Model according to classical economics.

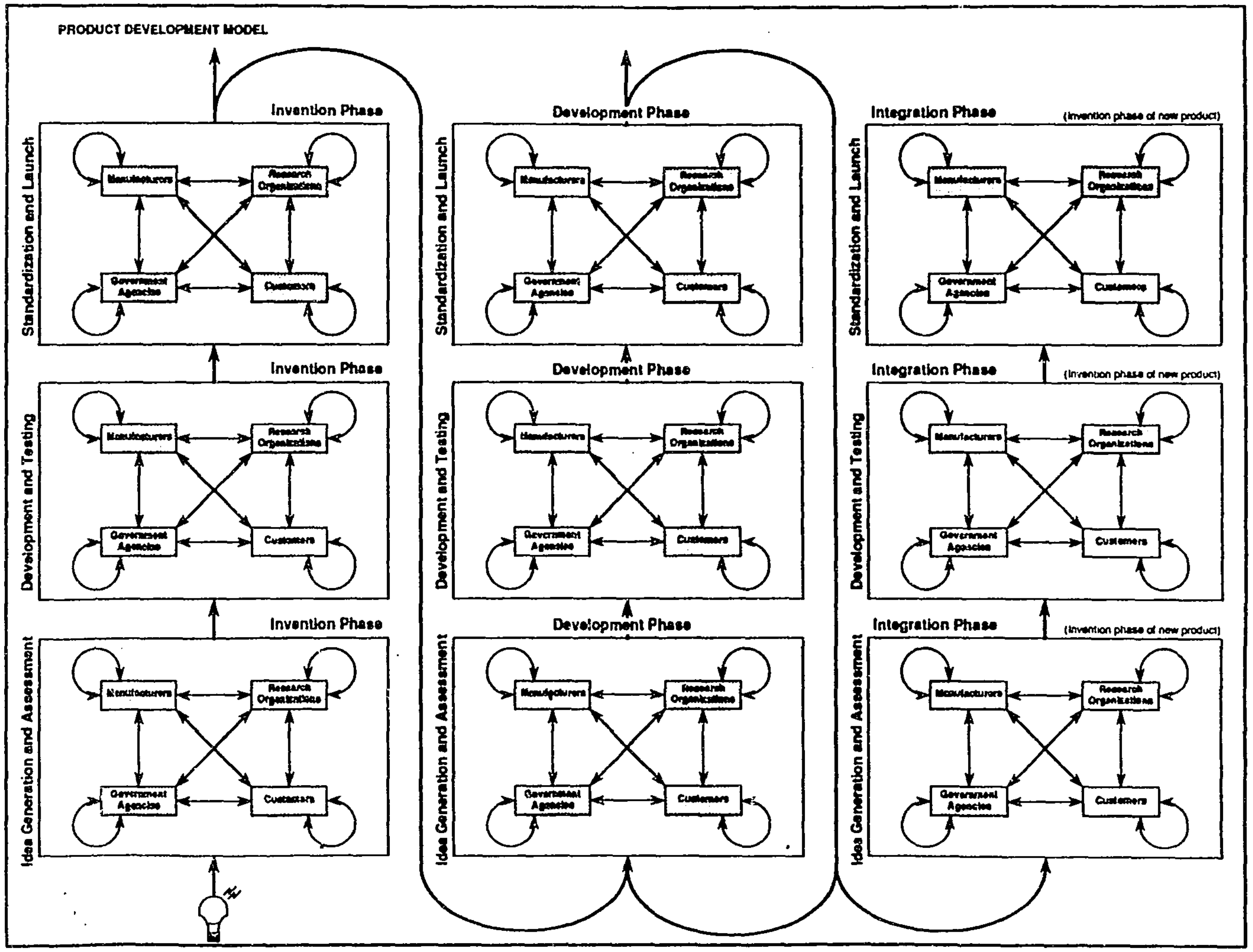

FIGURE 6-5 PRODUCT DEVELOPMENT MODEL (CLASSICAL ECONOMICS)

6.8.2 Historical Analysis

While performing historical analysis of television, it can be observed that Figure 6-5 needs to be modified.

It can be observed that "competition" was most pronounced during the "Idea Generation and Assessment Stage" of the "Invention Phase" (Monochrome television) between and among entities. However, during the "Standardization and Launch Stage" it can be observed that there was considerable "cooperation" between entities (between manufacturers and research organizations, between research organizations and customers, between customers and government agencies, between manufacturers and customers, and between research organization and government agencies. Numerous literature and publications on "Standardization and Marketing" have identified that "cooperation" is most important between entities during this stage. However, looking at the entities and their relationship among themselves (between manufacturers, between research organizations, between customers, and between government agencies), it can be observed that their relationship remains to be competitive. (Note: This had been a result of the anti-trust law that restricted entities from getting together (especially manufacturers)). During the "Development and Testing Stage," the relationships between the entities remain "neutral." This is largely due to the transition of relationship from "competition" to "cooperation" from "Stage 1" to "Stage 3." It can be observed that the relationship between themselves changes from "competition" to "cooperation" as it traverses from "Idea Generation and Assessment Stage" to "Standardization and Launch Stage." It remains "neutral" in the "Development and Testing Stage." This is also due to the result of the entities being organic (Ronen, S., 1986). Being organic they respond to external stimulus. However, their inertia and momentum restrict rapid responses. Thus the neutrality in relationship between entities in the "Development and Testing Stage" can be largely attributed to the consequence of this phenomenon since the transition in relationship is from competition to cooperation.

From the above analysis the following can be deduced --

1. The relationship among entities in any phase does not change from "Stage 1" to "Stage 2" to "Stage 3." (As for the Invention Phase it is competition); and,

2. The relationship between entities in any phase changes from "competitive" to "neutral" to "cooperative" from "Stage 1" to "Stage 2" to "Stage 3."

When traversing from "Phase 1" to "Phase 2" to "Phase 3" it can be observed that "Phase 3," i.e., "Integration Phase" (HDTV) is most tumultuous. The delay in the development of HDTV has meant stagnation in economy and relates directly to inefficient allocation of resources. (Note: It has been more than 20 years since HDTV was first conceived). The primary reason of this was the subscription to "competition" as the relationship mode. It can be observed that during the initial years of HDTV, the elements of the entities were competing among and between themselves head on. It was only after detection of delay and its discovery by the entities, did the relationship mode begin to change from "competition" to "cooperation." (Note: See Section 6.8.2.1 for a detailed discussion on the position taken by various entities during the development of HDTV).

The relationship for "among entities" thus changed from "competition" during the "Invention Phase" to "cooperation" during the "Integration Phase." The relationship is "neutral" during the "Development Phase," largely due to the entities being organic in nature. (Note: See discussion above).

From the above analysis the following can be deduced --

1. The relationship among entities in any stage changes from "competitive" to "neutral" to "cooperative" from "Phase 1" to "Phase 2" to "Phase 3"; and,

2. The relationship between entities in any stage does not change from "Phase 1" to "Phase 2" to "Phase 3."

6.8.2.1 Position Taken by Various Elements of the Entities in the Integration Phase (High Definition Television)

6.8.2.1.1 Manufacturers Position

During the early stages of the development of high definition television, the manufacturers of television competed among themselves. The manufacturers of computers were not at all involved. After a long period of time it was discovered that this head on competitive relationship was only detriment to the industry. The computer industry also felt the dire need to actively participate in the HDTV race.

Zenith Electronic Corporation had been the most vocal manufacturer. It has brought out discrepancies in U.S. industrial policies. Jerry Pearlman, Chairman and President of Zenith, mentioned, "Cooperation should be fostered in our market between manufacturers of electronics products so that they can become more be competitive in the global market (Pearlman, J.K., March 22, 1989)." The manufacturers have recently advocated --

1. R&D must be supported through cooperative methods for multiple years;
3. The standard setting process should not be subverted by relentless pressures;
4. Government must provide funding, modify antitrust and tax codes, and encourage and direct relevant government procurements;
5. Manufacturers should be permitted to cooperate among themselves; and,
6. Manufacturers should serve their customers and the customers in return should suggest their expectations.

Today, after the formation of many consortiums, one final mammoth consortium the "Grand Alliance" has been formed between the final proponents of the HDTV system. It is thus evident that the relationship that is most suited in this phase is cooperation among the elements of the entities.

6.8.2.1.2 Research Organization Position

The main objective of most of the HDTV proponents was to reap profits from sales of patents. They provided various arguments in favor of their system and appealed to the public to adopt their system. They were all subscribing to the doctrine of competition.

During the early phases of HDTV development, the various proponents were not able to design a system that was feasible. Further, the designers of the two products that were being integrated (computer and television) were not getting together. They were following their own paths. Only after discovering that this was a fatal attempt, did the research organizations begin to form consortiums culminating in the Grand Alliance.

During the early years Professor W.F. Schreiber of MIT was a very vocal advocate and mentioned that "NHK-MUSE system was simply a scaled-up version of the existing analog NTSC system, with all its shortcomings except composite video (Schreiber, W.F, May 31, 1989)." It took no advantage of the enormous progress in cheap and powerful integrated circuits and digital technology. The researchers at MIT viewed that the important goal of obtaining maximum quality with allowable spectrum would only be facilitated by abandoning the NTSC system and developing a totally new system that does not have to be decodeable by NTSC receivers. However, they felt that the new system needed to be channel compatible so that realignment of channel assignments would not be necessary. Further, they advocated receivers with open-architecture to provide maximum flexibility in receiver design. (Note: The other type of receiver that was being advocated was the "multiport receiver." (Collins, J., June 23, 1988). Moreover, the MIT researchers made clear that their support was against the adoption of NHK system. But their point was drowned in the midst of controversies. However, after the formation of the Grand Alliance, their point of view was taken seriously.

6.8.2.1.3 Customers Position

It can be observed that during this phase the customers were competing during the early period. They wanted to gain the advantage for themselves. They wanted HDTV to serve their own needs. The total number of customers far surpassed that of the other sets, but their voice when divided resulted in no more than a whisper. Realizing this, representative organizations were formed through cooperation. Presently through this mode of relationship "cooperation," they have been able to participate actively in the HDTV development.

6.8.2.1.4 Government Agencies Position

The government's position has been very controversial. This has been largely the consequence of the political influence of the ruling party. The Republicans believed, advocated, and strongly practiced the "hands off policy." There were two distinct schools of thought -- the "Activists," and the "Skepticists." (Note: See Appendix H for a detailed discussion of the position taken by the two schools). During the initial years of the development of HDTV the government agencies took a rather adversarial stance. It was later, after the Democrats took power, did the government form partnerships. The mode of relationship has thus been cooperative.

6.9 Product Development Model

Taking the above changes of relationships among entities and between entities while traversing through the Stages and Phases into consideration and modifying Figure 6-5, we get Figure 6-6 which is the Product Development Model. (Note: The thin line indicates competition, the medium line indicates neutral relationship, and the thick line indicates cooperation).

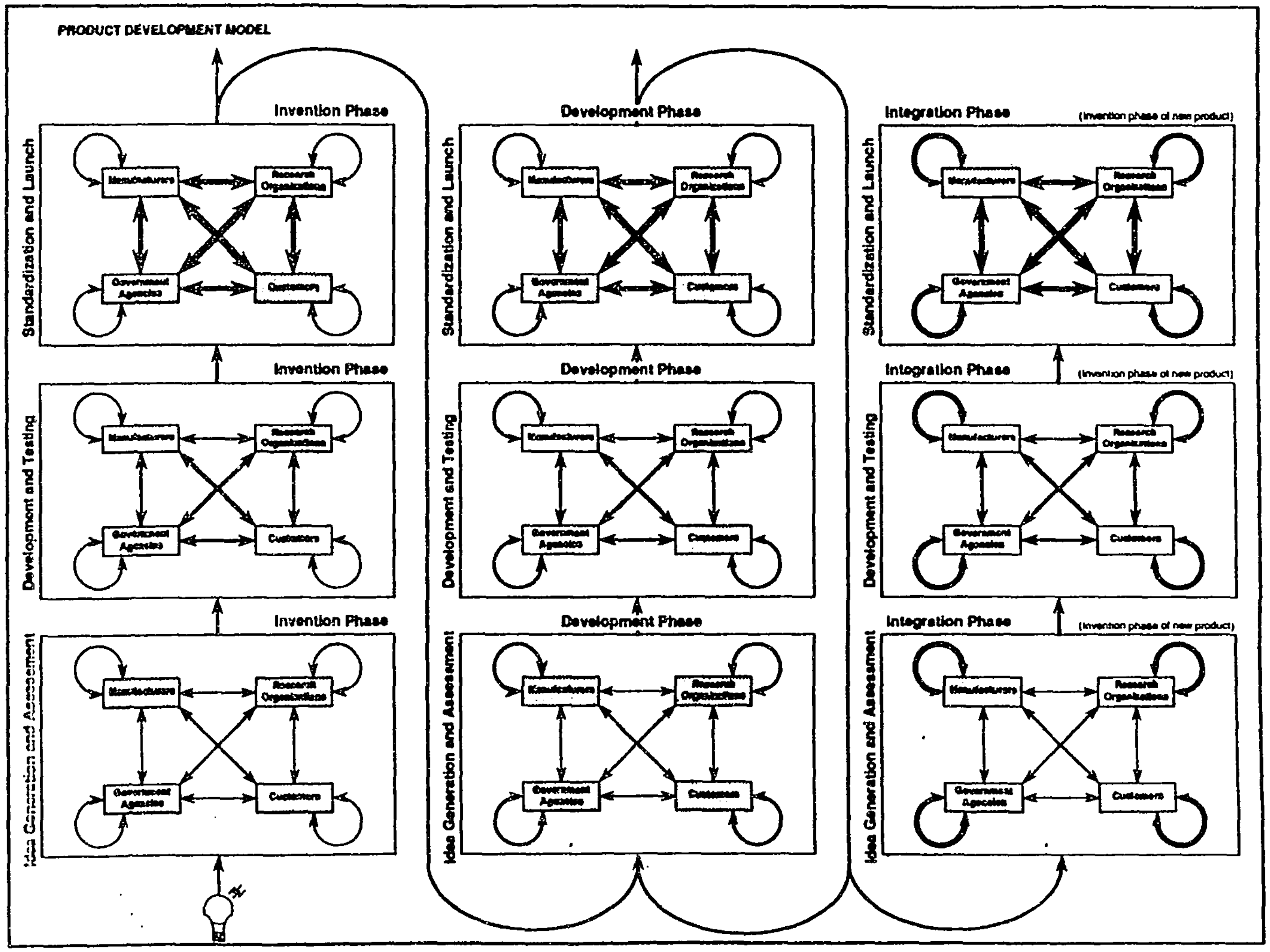

FIGURE 6-6 PRODUCT DEVELOPMENT MODEL

6.10 Hypotheses Formulation

The hypotheses are formed by taking the following deductions made in Section 6.8 into consideration.

Deductions made are as follows --

1. The relationship among entities in any phase does not change from "Stage 1" to "Stage 2" to "Stage 3." (As for the Invention Phase it is competition);

2. The relationship between entities in any phase changes from "competitive" to "neutral" to "cooperative" from "Stage 1" to "Stage 2" to "Stage 3";

3. The relationship among entities in any stage changes from "competitive" to "neutral" to "cooperative" from "Phase 1" to "Phase 2" to "Phase 3"; and,

4. The relationship between entities of any stage does not change from "Phase 1" to "Phase 2" to "Phase 3."

The hypotheses are --

1. Research hypothesis: Relationship among entities in "Stage 1" IS SAME AS Relationship among entities in "Stage 2" IS SAME AS Relationship among entities in "Stage 3." (Note: For the same phase);

2. Research hypothesis: Relationship between entities in "Stage 1" IS NOT SAME AS Relationship among entities in "Stage 2" IS NOT SAME AS Relationship among entities in "Stage 3." (Note: For the same phase);

3. Research hypothesis: Relationship among entities in "Phase 1" IS NOT SAME AS Relationship among entities in "Phase 2" IS NOT SAME AS Relationship among entities in "Phase 3." (Note: For the same stage); and,

4. Research hypothesis: Relationship between entities in "Phase 1" IS SAME AS Relationship between entities in "Phase 2" IS SAME AS Relationship between entities in "Phase 3." (Note: For the same stage).

(Note: Stage 1 is Idea Generation and Assessment stage, Stage 2 is Development and Testing stage, and Stage 3 is Standardization and Launch stage. Phase 1 is Invention phase, Phase 2 is Development phase, and Phase 3 is Integration phase).

The above research hypotheses can be broken down for each entity. Appendix K illustrates the null hypotheses and alternate hypotheses.

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CHAPTER SEVEN
FIELD SURVEY AND DATA ANALYSIS

7.1 Background

This chapter discusses Step III, "Field Survey" of the Research Design and Plan. (Note: See Chapter 2, Section 2.5.3). The first four sections discuss --

1. Open ended interview survey to isolate factors (Section 7.2);
2. Closed ended questionnaire survey to confirm factors (Section 7.3);
3. Closed ended questionnaire survey to test model and hypotheses (Pilot survey) (Section 7.4); and,
4. Closed ended questionnaire survey to test model and hypotheses (Final survey) (Section 7.5).

They are arranged in accordance to the four events of Step III of Chapter 3 (Research Design and Methodology). Finally Section 7.6 (Event 4/Step III) discusses the outcome of the results of the Surveys.

7.2 Open Ended Survey

This survey, along with others, was conducted in parallel with Step II "Historical Analysis" (Note: Sections 2.4.3, Sections 2.5.2, and Chapter 6). The primary purpose of this survey was to solicit factors that are important in the development of a high technology product. The factors were isolated independently through historical analysis also. (Note: See Section 6.3). The survey consisted of an open ended question. The questionnaire was suggested through historical analysis. (Note: See Appendix M for the question). The questionnaire was administered to eight Communication and Information Sciences (CIS) Ph.D. students. (Note: See Appendix L for a list of the subjects). The answers to the questionnaire were analyzed through "content analysis." (Note: See Section 2.4.1.2.1).

7.2.1 Questionnaire Development

Historical Analysis (Chapter 6) suggested the question for this survey. It was evident during the historical analysis that a product goes through three distinct phases -- Invention Phase (Chapter 3), Development Phase (Chapter 4), and Integration Phase (Chapter 5). To elucidate some of the concepts investigated in this study, it was necessary to associate these phases with some product. Since this study focuses on television, its association with the phases as an illustrative example seems most relevant. Therefore, in the development of the questionnaire for this survey, monochrome television was associated with the "invention phase," color television was associated with the "development phase," and HDTV was associated with the "integration phase." The questionnaire consisted of two sections (Section 1 and Section 2).

7.2.1.1 Section 1

Section 1 was included to explain the concepts and terminology that were being advanced in the questionnaire. Basically its purpose was to focus and guide the responses of the subjects. (Note: This is a very necessary and important step when content analysis is being incorporated as a tool for isolating factors because it determines the complexity in analysis (Carney, T.F., 1972)).

7.2.1.2 Section 2

Section 2 included the real question. The question was formulated to obtain constrained and focused, yet comprehensive responses. (Note: This is very important, because it determines largely the outcome of the content analysis). This section also solicited questions that the subjects thought were most relevant along with the factors that they deemed as most critical in the development of a high technology product. The word "most" had to be explicitly included to restrict the responses to only the very important ones.

7.2.2 Questionnaire Administration

The questionnaire was administered to eight CIS (Communications and Information Sciences) Ph.D. students at the University of Hawaii at Manoa (UHM). (Note: See Appendix L for a list of subjects). CIS Ph.D. students were selected because of their interdisciplinary backgrounds and diverse interests due to the nature of the CIS program. Further, all of the CIS Ph.D. students have been associated closely with high technology products, and therefore are familiar with the topic of study. The questionnaire was administered through the telephone. The responses (audio) were recorded in the answering machine of the telephone in five of the eight cases. In three of the eight cases, the subjects preferred to hand in a hard copy of their responses. Among the three hard copies, two were handed in person, while one was sent through the fax.

(Note: The questionnaire was administered by telephone to remove any non-verbal clues or cues that could be passed on in recording the responses. This would confound the result and complicate the analysis. (Note: See Sections 2.5.3.1)).

7.2.3 Content Analysis

The most simple form of content analysis was used in this study (Carney, T.F., 1972). It was not necessary to have an elaborate analysis because the factors that were isolated during this survey would be compared through convergence test with the results obtained through the historical analysis. Further a separate survey was conducted to confirm the factors. (Note: See Sections 7.3).

Two categories of word listing were established for the purpose of content analysis. One category was under "competition" and the other was under "cooperation." The following sources were used to establish the list of words in the categories --

1. The Random House Dictionary of the English Language, 1987,
2. The American Heritage dic.tion.ar.y of the English Language, 1992,
3. Webster's Third New International Dictionary of the English Language, 1976,
4. Roget's II The New Thesaurus, 1988, and
5. The Advanced Learner's Dictionary of Current English, 1972.

(Note: See Appendix N for the list of words).

After the categories were formed, "word count" was used to compute the number of occurrences of those words during the responses. This was compared to the total number of response words and a percentage was calculated. The standard that was established was 5% of occurrence. (Note: This standard was established through intuitive reasoning). Adjectives, articles (definite and indefinite), common adverbs, common verbs (transitive and intransitive), conjunctions, interjections, prepositions, and pronouns were not included in the total number of response words count. Appendix N illustrates the word counts and percentage.

7.2.4 Results

From Appendix N, it can be seen that there are 32 words in the category "Competition" and 35 words in the category "Cooperation." The response percentages in both the categories are well above 5% except for two cases in the "cooperation" category. One hundred percent of the responses in the category "Competition" were above the standard, i.e., 5%, while 75% of the responses in the category "Cooperation" were above the standard. Competition and cooperation were thus isolated as being the most important factors in the development of a high technology product.

(Note: One very interesting observation of the survey was that -- all of the subjects wanted some time to think over the question before they provided their responses.)

7.2.5 Convergence Analysis

This analysis is rather simple since only two relationships "competition" and "cooperation" are being compared. Both were isolated through historical analysis and this survey. The results of the two studies thus converge.

7.3 Factor Confirmation

"Competition" and "Cooperation" as two modes of relationships were isolated through the "Open ended survey" which included the responses of subjects who were familiar but were not directly related with the development of high technology product. They were only associated with it indirectly. The next event in the "Research Design" was to confirm these relationships by asking "Closed Ended" questions to subjects directly involved with the development of high technology product.

7.3.1 Questionnaire Development

The questionnaire development was a rather simple process. The question asked if the subjects "agreed" or "disagreed" with isolation of "competition" and "cooperation." The subjects were asked to mark the respective area. They were also asked to provide any comment they deemed appropriate. (Note: See Appendix P for the questionnaire).

7.3.2 Questionnaire Administering

The questionnaires were administered to subjects selected randomly through "The Hawaii High Technology Business Directory, 1991." The subjects were either the president, vice-president, director, or manager. They were directly involved in the development of a high technology product. (Note: See Appendix O for a list of subjects). The questionnaire was sent and received through fax. The process of sequential sampling was used. Sequential sampling was possible because of the knowledge of anticipated responses. The response variation was limited to 5%, and when steady state response was observed, questionnaire administering was terminated and result analysis was performed.

7.3.3 Results

Out of the ten subjects, eight responded. Out of the eight responses, everyone except one agreed with the isolation of "competition" and "cooperation." However, the subject who did not agree, commented that "competition and cooperation are not only the most important ones, but there may be others too depending on the situation."

The "Closed Ended" survey resulted in the confirmation of the isolation "competition" and "cooperation."

7.3.4 Convergence Analysis

The results obtained from Chapter 6 "Historical Analysis," Sections 7.2, and this section all converge to "Competition" and "Cooperation."

7.4 Pilot Survey

To get a feel for the response distribution, to answer the questions in Sections 2.4.1.3, and to determine the appropriateness of the questionnaire, the pilot survey was conducted (Alreck, P.L., & Settle, R.B., 1985).

7.4.1 Questionnaire Development

The questionnaire consisted of three sections --

1. Section 1 -- Personal information and comments of the subjects;
2. Section 2 -- Explanation of the study and survey; and,
3. Section 3 -- Questions in a Likert Type scale. (Note: See Appendix R for a sample questionnaire).

7.4.1.1 Section 1 -- Background

This section asked for personal information such as -- name, major, address, telephone numbers and comments. The comment section was the most important since it would be used to determine the format of the final questionnaire.

7.4.1.2 Section 2 -- Explanation

This section provided a brief description and explanation of the concepts and terminology that was involved in this study. Example illustration was used for clarification. The dynamics of product development were also illustrated. Finally, the technique for marking the subjects' responses was presented. For the sake of brevity and efficiency, the total explanation was accommodated in a single page.

7.4.1.3 Section 3 -- Questions

This section contained the questions to be answered by the subjects. The questionnaire was based on the "Product Development Model." (Note: See Sections 6.9).

This section consisted of three pages, one for each phase -- Invention Phase, Development Phase, and Integration Phase. Each of the pages (phases) was divided into three columns--

1. Column 1 -- Idea Generation and Preliminary Assessment Stage;
2. Column 2 -- Conceptualization, Development, Testing, and Trial Stage; and,
3. Column 3 -- Standardization, Launch and Commercialization Stage.

Each of the columns (stages) was divided into ten rows. Each row consisted of the possible interactions between the entities --

1. Row 1 -- Between Manufacturers and Research Organizations;
2. Row 2 -- Between Government Agencies and Research Organizations;
3. Row 3 -- Between Customers and Research Organizations;
4. Row 4 -- Between Research Organizations;
5. Row 5 -- Between Government Agencies;
6. Row 6 -- Between Manufacturers and Government Agencies;
7. Row 7 -- Between Customers and Government Agencies;
8. Row 8 -- Between Manufacturers;
9. Row 9 -- Between Customers and Manufacturers; and,
10. Row 10 -- Between Customers.

Each of the entity relationships consisted of a Likert Type Scale consisting of five boxes. It ranged from "full competition" on the extreme left to "full cooperation" on the extreme right. The intermediate boxes consisted of "more competition than cooperation" to "neutral" to "more cooperation than competition." The subjects were asked to mark the box that they deemed most relevant.

7.4.2 Questionnaire Administering

The questionnaire was administered to nine subjects. (Note: A total of ten subjects were included in the sample for the Pilot survey. However, one of the subjects failed to return the questionnaire). The subjects were CIS Ph.D. students and Engineering Ph.D. students at the

University of Hawaii. Engineering Ph.D. students were included to make the sample more representative of the total population involved in the development of high technology product. The questionnaire was either hand delivered or sent through fax. The reply was received in a similar manner. (Note: See Appendix Q for a list of the subjects).

7.4.3 Results

Appendix S presents the results of the Pilot survey. The table also contains the analysis of the obtained data. The subjects are arranged from 1 to 9. The appendix contains seven tables as follows --

1. Table S-1 -- Idea Generation and Assessment Stage;
2. Table S-2 -- Development and Testing Stage;
3. Table S-3 -- Standardization and Launch Stage;
4. Table S-4 -- Invention Phase;
5. Table S-5 -- Development Phase;
6. Table S-6 -- Integration Phase; and,
7. Table S-7 -- Notes for Tables S-1 to S-7.

The Tables S-1 to S-6 consist of various relationships of the entities, which are --

1. Manufacturer-Manufacturer;
2. Research Organization-Research Organization;
3. Customer-Customer;
4. Government Agency-Government Agency;
5. Manufacturer-Research Organization;
6. Research Organization-Customer;
7. Customer-Government Agency;
8. Government Agency-Manufacturer;
9. Manufacturer-Customer; and,
10. Research Organization-Government Agency.

The response means, modes, medians, and the theoretically determined values are illustrated sequentially in the tables (Note: See

Section 6.9). The percentage change of the response means, modes, medians, and theoretically determined values are also illustrated. Correlation coefficients have been calculated for the response means, modes, and medians with the theoretically determined values, and also, for the percentage change for the response means, modes, and medians with the percentage change of the theoretically determined values, which are illustrated in Table S-8.

It can be seen that there is a positive correlation between the columns. The correlation of the response means with the theoretical values is more than 60%. Positive correlation implies that the data sets are moving together (Hildebrand, D.K., & Ott, L., 1983, Spiegel, M.R., 1961). The correlation between percentage change of mean with the percentage change of the theoretical value is about 80%. (Note: The percentage change correlation is very important for this study, because this study concentrates on the changes in relationship between entities when a product traverses through various stages and phases). High positive correlation helps in proving the following -- The response of the sample is coherent with that of the theoretical values (Zeller, R.A., & Carmines, E.G., 1978). However, it should be pointed out that conclusions cannot be put forward with high level of confidence.

7.4.4 Outcome

Due to the coherence of the data, as is evident from the positive significant correlation coefficient, the following deductions can be readily produced --

1. Relationship among entities remains the same in Stage 1, Stage 2, and Stage 3 for the same Phase. (In other words, it does not change). The relationship for Phase 1 remains more competition than cooperation, for Phase 2 remains neutral, and Phase 3 remains more cooperation than competition.

2. Relationship between entities does not remain the same in Stage 1, Stage 2, Stage 3 for the same Phase. The relationship for Stage 1 is more competition than cooperation, for Stage 2 is neutral, and Stage 3 is more cooperation than competition.

3. Relationship among entities does not remain the same in Phase 1, Phase 2, and Phase 3 for the same Stage. The relationship for Phase 1 is more competition than cooperation, for Phase 2 is neutral, and for Phase 3 is more cooperation than competition.

4. Relationship between entities remain the same in Phase 1, Phase 2, and Phase 3 for the same Stage. The relationship for Stage 1 it is more competition than cooperation, for Stage 2 is neutral, and for Stage 3 is cooperation than competition.

To increase the confidence of the outcome, it is necessary to perform more rigorous statistical tests and analysis. However, the Pilot Survey was conducted primarily to the answer the following questions (See Sections 2.4.1.3) --

1. Is the question necessary?
2. Is the questionnaire repetitious?
3. Does the question contain more than one idea?
4. Can the respondents answer the questions?
5. Could it be made more specific?
6. Is the question clear?
7. Is the response format adequate?
8. Can the items be arranged so that particular answers can preclude the need to answer others?

The questionnaire consisted of a Likert type scale ranging from full competition to full cooperation in five jumps only once for each relationship between the entities for each stage and for each phase. Therefore, there are no redundant questions. Since competition and cooperation have been placed at the two ends of the Likert type scale, the number of questions has been halved.

Due to some very constructive comments, very significant changes and developments had to be incorporated into the Final Survey.

Some of the important comments were as follows --

Comment 1 -- The questionnaire is confusing because it contains three pages. (Note: Some subjects felt comfortable in moving between Stages, others felt comfortable in moving between Phases, while others felt comfortable in moving between entity relationships). Since the questionnaire moved through Stages in one page of the questionnaire and moved through Phases between pages of the questionnaire, it seemed uncomfortable to answer the questions to some subjects due to the constraint imposed by the format of the questionnaire.

Comment 2 -- The explanation of the questionnaire was not very simple. Some of the subjects found it difficult to imagine a product moving through the stages and phases. (Note: The explanation section of the questionnaire had to be made more simple to enable respondents to concentrate on the relationships).

Comment 3 -- Tabular formatting of the questionnaire constrains the process of thinking. (Note: The format forced the subjects to think in only a certain manner. It demobilized their comparative answering).

While developing the final questionnaire, all the above questions and comments were considered. (Note: See Section 7.5).

7.5 Final Survey

The results of the Pilot Survey were incorporated in forming a completely clean and error free questionnaire which the subjects would find convenient in answering, as well as enjoy it. There were changes made in all the sections of the questionnaire.

7.5.1 Questionnaire Development

The questionnaire put forward the same questions as the Pilot Survey (Section 7.4), but there were major changes made in accordance to the short-comings of the Pilot Survey. The Final Survey consisted of three sections. (Note: See Appendix U for a sample of the questionnaire).

7.5.1.1 Section 1 -- Background

This section was similar to the Pilot Survey with only two minor changes (Section 7.4.1.1). "Major" was changed to "Title." (Note: "Major" was used in the Pilot Survey because the subjects were students. "Address" was used in the Final Survey because the questionnaire was distributed to subjects that were directly involved in the development of high technology product). Another change made was in the address section. Full address was provided in the Final Survey to enable the subjects to mail back (or Fax back) their response.

7.5.1.2 Section 2 -- Explanation

There were major changes that were made in this section. This was very important since many of the subjects commented on the complexity of the explanation of the Pilot Survey. The length of the explanation was increased from one page for the Pilot Survey to two pages for the Final Survey.

The process, concepts, and terminology of a high technology product development were illustrated diagramatically. There were two diagrams presented. Diagram 1 explained the movement of a high technology product through the various stages and phases. Diagram 2 explained the relationship between the entities.

The explanation was divided into three parts. The first part was provided to thank the subjects. The second part "The Study" explained the process, concepts and terminology used in this study. The third part "The Survey" explained the technique of answering the questions. This section was greatly changed because the question format for the Final Survey was very different from that of the Pilot Survey. The Likert type scale was changed from square to oval for the Final Survey.

7.5.1.3 Questions

The questions were all accommodated in one page. This was to offset the constraints that some of the subjects of the Pilot Survey observed while trying to move within stages and phases. It further enabled ease in comparative answering. The questions were presented diagramatically.

The x-axis consisted of the three phases and the y-axis consisted of the three stages. A matrix was thus formed consisting of nine elements, which fell in the respective intersections of the Phases (1, 2, & 3) and Stages (1, 2, & 3). Each element of the matrix contained an entity relationship diagram (Section 6.3) with a Likert type scale in each segment of the relationship. The path of the product development was also indicated. The names of the stages were changed from "Idea Generation and Preliminary Assessment Stage, Conceptualization, Development, Testing, and Trial Stage, and Standardization, Launch, and Commercialization Stage" to "Idea Generation and Assessment Stage, Development and Testing Stage, and Standardization and Launch Stage" to narrow down the focus. (Note: See Section 6.5).

7.5.2 Questionnaire Administering

The questionnaires were administered to people who were directly involved in the development of a high technology product. (Note: See Appendix T for the list of participants). Since the subjects needed to be experts they were isolated through the means of personal contacts. (Note: Personal contacts had to be used to ensure that they were involved directly in the development of high technology product. Some companies involved in high technology product development have a policy of not discussing the specific areas of involvement of its various employees. Most of the participants were from Silicon Valley area, which is the cradle of high technology product development). The participants were from high technology companies such as -- Advanced Design Systems, DELL Computers, HAL Computer Systems, Landis & Gyr Systems, VLSI Technology Inc., 3M, SITE Services, etc. The companies' status was verified through the AEA Directory (1990-1).

The process of selective sequential sampling was used. (Note: See Section 2.4.2.2). Sequential sampling was used because the responses were anticipated prior to the data analysis. A total of twenty-five subjects was used for the study. The questionnaire was administered and extra effort was made to ensure its return. This was done primarily to for two reasons --

1. The questionnaire was quite complex consisting of four pages and a total of ninety questions to be answered. This required a considerable

time (approximately 45 minutes) and effort on part of the subject, which at times tended to cause the subjects to procrastinate and not respond.

2. Not being able to get back some responses would confound the analysis of the data, since one extra variable would be brought forward.

Appendix V illustrates the responses of the Field Survey. It consists of six tables, one for each stage and one for each phase. The table lists sequentially -- the relationships, and the responses of the twenty-five subjects. The overall mean variation with the addition of each sample is illustrated graphically in Appendix W in accordance to the various elements of the matrix. (Note: See Section 7.5.1.3).

The values reach steady state at around 18 for Graph W-1, 10 for Graph W-2, 9 for Graph W-3, 8 for Graph W-4, 12 Graph W-5, 14 Graph W-6, 6 Graph W-7, 8 Graph W-8, and 18 for Graph W-9. A sample of 25 is therefore a safe value.

7.5.3 Result

Appendix X illustrates the analysis of the obtained data. It consists of six tables. The table lists sequentially -- the relationships, the mean of the responses, the mode of the responses, the median of the responses, the theoretically determined values, the standard deviation of the responses, the pooled standard deviation, the test statistics, hypotheses test for 2T test, hypotheses test for 1T test, and the p-values.

Correlational analyses were performed for the response means, modes, and the medians with the theoretically determined values and are listed in Appendix Y.

7.5.3.1 Correlation Analysis

From Appendix Y, it can be observed that there is a strong correlation of the response means, modes, and medians with the theoretical determined values. Table 7-1 illustrates the correlation of the response means, modes, and medians with the theoretical determined value.

TABLE 7-1 CORRELATION OF MEAN, MODE, AND MEDIAN WITH THE THEORETICAL VALUE

	RESPONSE MEAN	RESPONSE MODE	RESPONSE MEDIAN
DIVISION 1			
Part 1	.968	.973	.957
Part 2	.957	.945	.994
Part 3	.973	.985	.981
DIVISION 2			
Part 1	.963	.994	.98
Part 2	.984	.947	.99
Part 3	.975	.959	.943
AVERAGE CORRELATION	.97	.967	.974

The use of correlation coefficient helps in determining the movement of the two data sets, but does not enable determination of precise data association (Zeller, R.A., & Carmines, E.G., 1978). From the computed correlation coefficient it can be concluded that the response value is similar to that of the determined theoretical values due to high positive correlation. The correlation coefficients of the mean, mode, and the median are all greater than .95. All three of the data sets (mean, mode, and median) can therefore considered as good predictors or estimators of the theoretical value. Mean Test, Mode Test, and Median Test have been used to analyze the data.

7.5.3.2 MEAN Test

The mean test was used for testing hypotheses. In other words, whether to reject or not reject the null hypotheses, and in turn accept or reject the research hypotheses.

7.5.3.2.1 Hypotheses Testing

The hypotheses were tested using one and two tail t-test. The two tail test was used to determine the equality or non equality of the sample means, and the one tail test was used to determine whether the anticipated sample mean was greater than the other.

The following t-test was used since the population standard deviation was unknown.

HYPOTHESIS TEST

$H_o:y_1-y_2=D_o$ $(D_o=0)$

$H_a:y_1-y_2>D_o$ (One tail)
$:y_1-y_2<=>D_o$ (Two tail)

$TS:t=((y_1-y_2-D_o)/(S_p(\text{SQUARE-ROOT}(1/n_1+1/n_2))$
where $S_p= \text{SQUARE-ROOT}(((n_1-1)s_1s_1+(n_2-1)s_2*s_2)/(n_1+n_2-2))$

df = n_1+n_2-2 (degrees of freedom)

In this study $n_1=n_2=n=25$
$RR:t>t_a$
$:|t|>t_a/2$
where a = significance level.

The significance level for the t-test has been established to be .05. The rejection region for two tail test is therefore 2.02 and for one tail test is 1.68.

The anticipated results of the hypotheses are illustrated in Appendix Z. In the anticipated results, the ones that were not supporting the research hypotheses have been marked with "X." The appendix consists of seven tables. Tables Z-1 to Z-6 illustrates the hypotheses tests. There are six tables (t), each table consists of ten relationships (r), and each relationship consists of three segments (s). Therefore there are a total of (t x r x s) = (6 x 10 x 3) = 180 hypotheses that are being tested once through the two tail t-test and again through one tail t-test. Out of the 180 hypotheses 25 could not support the research hypotheses in the two tail test, and 34 could not be supported by the one tail test. Therefore, 86.11 percent of the research hypotheses were supported and 13.89 percent were not supported by the two tail t-test. 81.11 percent of the research hypotheses were supported and 18.89 percent were not supported by the research hypotheses by the one tail test. Table 7-2 illustrates the refuted research hypotheses categorized according to Stage, Phase, and Entity relationships.

TABLE 7-2 REFUTED RESEARCH HYPOTHESES

STAGE	2T	1T	PHASE	2T	1T
IDEA GEN. & ASSESS.	4	6	INVENTION		2
DEVELOP. & TEST.	5	6	DEVELOPMENT	4	4
STAND. & LAUNCH	4	8	INTEGRATION PHASE	8	8
	13	20		12	14
AMONG ENTITIES			**BETWEEN ENTITIES**		
MANUFACTURERS	3	5	MANUFAC.-RESEARCH ORG.	4	4
RESEARCH ORG.			RESEARCH ORG. CUSTOMER	5	5
CUSTOMERS	2	2	CUSTOMER-GOVT. AGENCY	3	4
GOVT. AGENCIES	3	3	GOVT. AGENCY-MANUFAC.	4	6
			MANUFAC.-CUSTOMER	1	4
			RESEARCH ORG.-GOVT. AGEN.		1
	8	10		17	24

From Table 7-2, it can be observed that 13/20 (2T/1T) (two tail/one tail) research hypotheses are refuted while traversing between phases, while 12/14 (2T/1T) are refuted while traversing between stages. Also 8/10 (2T/1T) research hypotheses are refuted in the "among entities" categories and 17/24 (2T/1T) research hypotheses are refuted in the "between entities" categories.

From Appendix Z it can be observed that the 3/5 Refuted Research Hypotheses (RRH) for Manufacturer-Manufacturer (M-M) is 1/2 for traversing between Stage I (SI) and Stage II (SII) and 2/3 for traversing between Stage II (SII) and Stage III (SIII). There are no RRH for Research Organization-Research Organization (RO-RO). For Customer-Customer (C-C) the 2/2 RRH are 1/1 for SI-SII and 1/1 for SII-SIII. For Government Agency-Government Agency (GA-GA) the 3/3 RRH are 2/2 for SI-SII and 1/1 for SII-SIII. For M-RO the 4/2 RRH are 2/2 for Phase II to Phase III (PI-PII) and 1/1 for SI-SII. For RO-C 5/5 RRH are 0/1 for PI-PII, 2/2 for PII-PIII, and 1/1 for SI-SII. For C-GA 3/4 RRH are 1/2 for PI-PII, 1/1 for PII-PII, 1/1 for SI-SII. For GA-M 4/6 RRH are 0/2 for PI-PII, 2/2 for PII-PII, and 1/1 for SI-SII. For M-C 1/4 RRH are 1/2 for PI-PII, and 0/2 for PII-PIII. For RO-GA 0/1 RRH is 0/1 for PII-PII.

(Note: The 4/2 RRH for PIII-PI are not important for this study since the concentration is between PI-PII-PII and SI-SII-SIII).

Most of the RRH are associated with Customers and Government Agencies. The reason of this was clarified after performing in-depth analysis and inquiries. Most of RRH are associated with the quadrant SII and PII, i.e., the intersection formed by Development and Testing Stage, and Development Phase. This is evident because this quadrant is subject to and experiences a two dimensional transition. Since the two transition vectors (Stage vector and Phase vector) intersect at this point, the effect is multiplicative.

From Appendix X it can be observed by looking at the P-Value that a number of RRH are very sensitive to the changes in significance level. If the significance level is altered by a slight amount 19/27 RRH of the total 25/34 RRH will not be refuted. 5/4 RRH for PIII-PI and SIII-SI are not important as mentioned above. Thus only 20/30 RRH needs explanation.

7.5.3.2 MODE Test

Comparison of mode and the theoretical value reveals that there is a strong correlation between the two. Appendix Y lists the correlation coefficients. They are as follows .973, .945, .985, .994, .947, and .959. When such strong correlation is observed, the best form of analysis is visual comparison. (Note: See note below).

From Appendix X it can be observed that 18 modes out of a total of 180 differ from the theoretical value. It can be also be observed that most of these differences are associated with the quadrant formed by SII and PII, Customers, and Government Agencies.

7.5.3.3 MEDIAN Test

Similar to the Mode Test, visual comparison test is best suited for analysis of the data because of the high correlation of the median with the theoretical value. The correlation coefficients are .957, .994, .981, .98, .99, and .943.

(Note: Visual comparison can be performed when the data points meet the following conditions -- 1. The number of data points are small; and, 2. The steps of the data point are limited and few. For the Mode Test the steps of the data are 1, 2, 3, 4, 5, and for Median Test the steps are 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5. The number of steps for the Mean is infinite. Thus Visual comparison is futile for the Mean Test).

From Appendix X it can be observed that 42 Medians of the total 180 differ from the original. However, if values 1-1.5 are assigned 1, values 2.5-3.5 are assigned 3, and values 4.5-5 are assigned 5 a totally different result is obtained. (Note: Values as above can be assigned, because values less that 1.5 implies strong support for competition and values above 4.5 imply very strong support for cooperation. Values from

2.5 to 3.5 imply strong support for neutrality). If values as above are assigned, only 10 out of 180 differ. The differences can be associated with Quadrant SII-PII, Customers, and Government Agencies.

7.5.3.4 Explanation of Data Differences

It has been made vivid from the above data analysis, that the data differences can be associated with quadrant SII-PII, Customers, and Government Agencies.

7.5.3.4.1 Quadrant SII-PII

Most of data differences are associated with this quadrant SII and PII, i.e., the intersection formed by Development and Testing Stage, and Development Phase. As mentioned above, this is evident because this quadrant is subject to and experiences a two dimensional transition. Since the two transition vectors (Stage vector and Phase vector) intersect at this point, the effect is multiplicative. Quadrants SII-PI, SII-PII, and SII-PII are subject to one dimensional transition vector the "Stage Vector." Quadrant SI-PII, SII-PII, and SIII-PII are subject to the transition vector the "Phase Vector." The directions of the vectors are along the ordinate and abscissa axis. The determination of the magnitude of the vectors is beyond the scope of this study. It can however be concluded that the effect of the intersection of these vectors at quadrant SII-PII is multiplicative.

Thus the differences in the data values in this quadrant are only an effect resulting from the two transitional vectors. Hence data differences can be attributed to the entities Customers and Government

Agencies. It can fairly well be stated that these entities are responsible for the data differences.

7.5.3.4.2 Customers

The errors due to Customers can be attributed to the confusion in associating with term "Customers." It was pointed out in Section 6.2.3, that there are two levels of customers. It was ascertained after performing some inquiry, responses varied with respondents who differentiated the levels and those who did not. The differentiation was due to awareness. It was assumed that clarification of this concept would focus and direct the attention of the subjects to a constrained answer. Therefore, questionnaire did not differentiate the different levels of customers. This effect was noticed in the Pilot Survey Phase also.

7.5.3.4.3 Government Agencies

The errors due to Government Agencies can be attributed to the confusion in associating with "Government Agencies." Though there are many government agencies, they all fall under the same umbrella of one government. With that respect, one can expect the policies and actions of the various agencies to be coherent with the policies of actions of the central system. Thus the policy and action of any one agency is assumed not independent of each other. Therefore, responses included those that were biased to a certain relationship (Competition or Cooperation). Thus effect is largely due to the subscription to a particular type of the political doctrine. It relates to outcomes which considers the other relationship void, i.e., if cooperation exists competition is void, and if competition exists cooperation is void. (Note: See Appendix H for a discussion on this issue).

7.6 Final Model Development

Taking the above discussions in Sections 7.5.1 to 7.5.2, and Chapter 6 into consideration the outcome of this study the final model for high technology product development can produced. Figure 7-1 illustrates the PRODUCT DEVELOPMENT MODEL. (Note: The thin line indicates competition, the medium line indicates neutral relationship, and the thick line indicates cooperation).

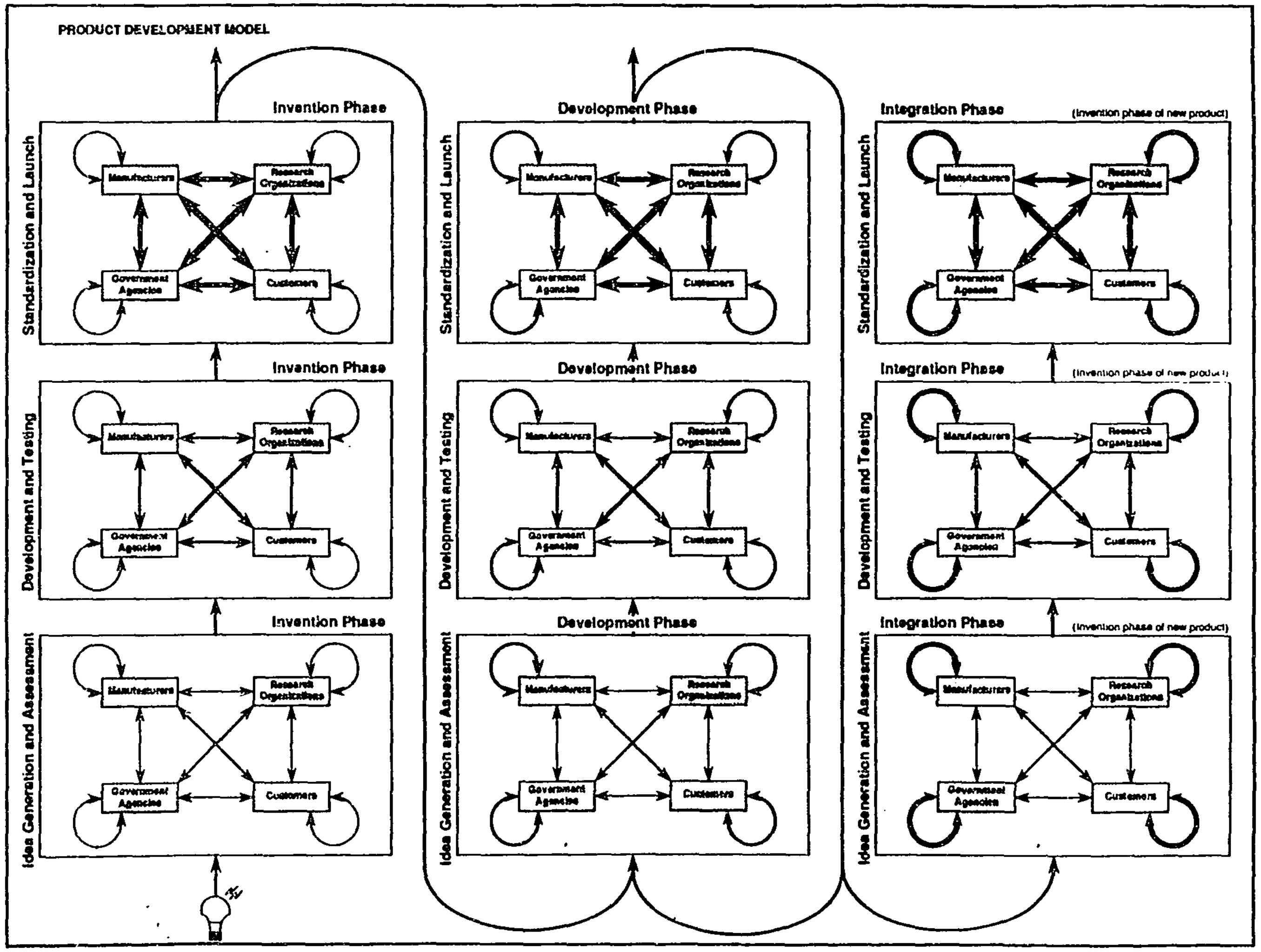

FIGURE 7-1 PRODUCT DEVELOPMENT MODEL

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CHAPTER EIGHT
CONCLUSION

8.1 Background

In this chapter, the summary of the study is provided in Section 8.2. In Section 8.3 the history of a product is discussed. This is followed by a discussion on the implications of this study in Section 8.4. The utility of the Product Development Model is illustrated in Section 8.5. The limitations of this study are explained in Section 8.6. The chapter concludes with a final statement in Section 8.7.

8.2 Summary of the Study

This study began (in Chapter 1) by introducing, developing and elaborating the concepts of the two modes of relationships between entities, viz. competition and cooperation in the development of high technology product and identifying the entities. The concepts were discussed in the light of economic theories. The chapter illuminated on the ideas to be presented and forwarded in the following chapters.

In Chapter 2, the research design and the methodologies that were used in this study were explained and discussed. Even though many methods were discussed in the chapter, only the methods that were most relevant for this study were discussed in detail. The research plan for carrying out the study was also presented.

Case study using historical analysis was one of the most important methods that were used in this study. Therefore, Chapter 3, Chapter 4, and Chapter 5 furnished materials that were necessary for Chapter 6 where the history of a television was analyzed to develop the Product

Development Model. It was discovered that a product goes through three phases -- Invention Phase (where the product is initially conceived); Development Phase (where the conceived product undergoes some modifications); and, Integration Phase (where the product is combined with some other product). In each of these phases the product goes through three stages -- Idea Generation and Assessment Stage (where the product is in the minds of people and in paper); Development and Testing Stage (where the product is in the laboratories); and, Standardization and Launch Stage (where the product is brought out in contact with the consumers).

The four entities -- manufacturers, customers, research organizations, and government agencies are responsible in the successful development of a high technology product were isolated. Their mode of relationship is either competition, or cooperation. Historical analysis revealed that the mode of relationship changes and is different at the various positions of the product development. To successfully develop a product it is necessary to subscribe to the correct mode of relationship. The PDM illustrates this diagramatically.

In Chapter 7, field survey is discussed which was used to validate the PDM. Statistical analyses were used to reinforce and support the model.

8.3 Product Life History

Figure 8-1 illustrates the history of a product diagramatically. It consists of the various phases and stages.

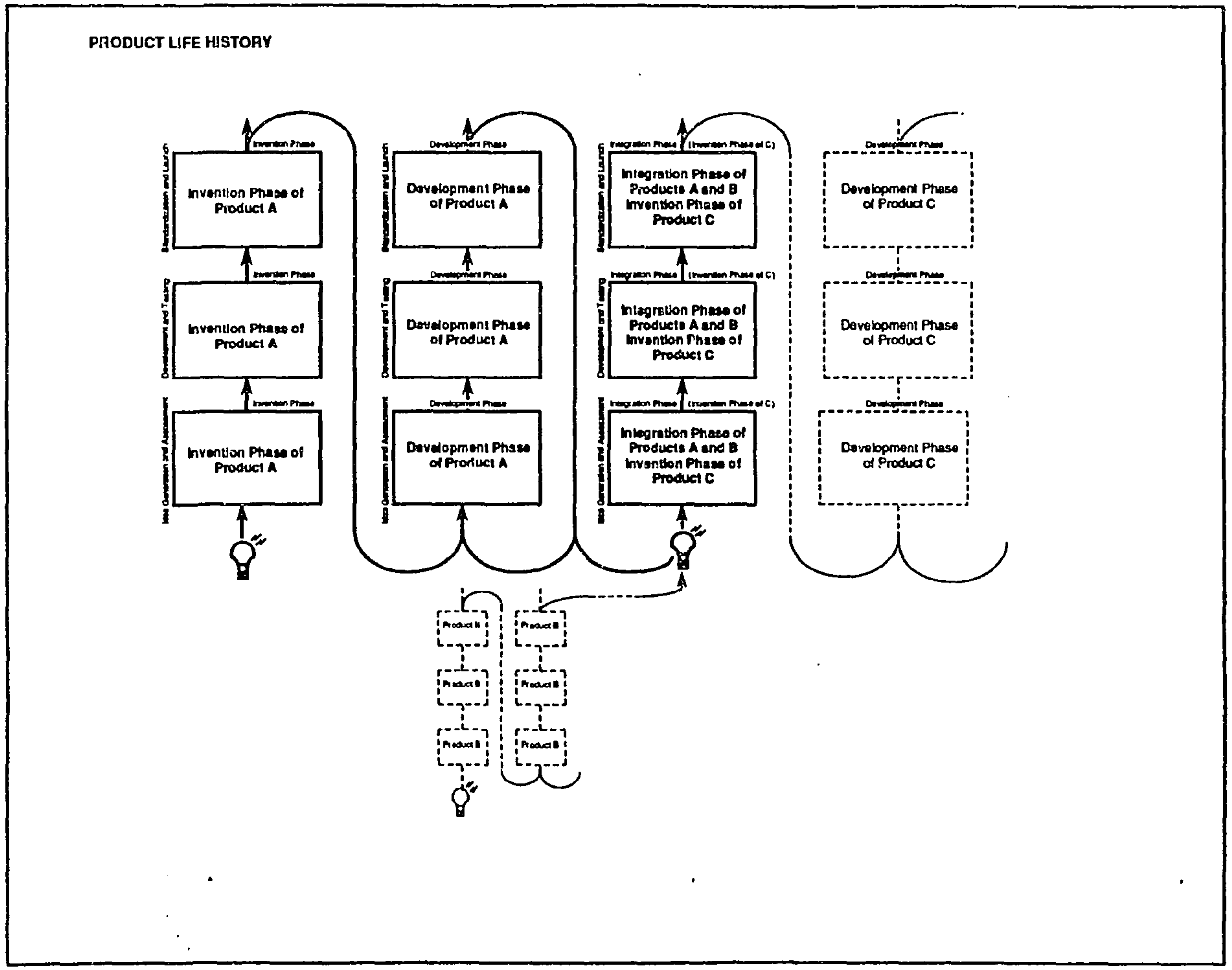

FIGURE 8-1 PRODUCT LIFE HISTORY

The figure consists of boxes arranged in columns and rows forming a matrix. The first three columns (with solid boxes) are associated with Product 'A.' The first, second, and third columns of boxes in the matrix represent the Phases, viz. Invention Phase, Development Phase, and Integration Phase, respectively. Rows one, two, and three (from bottom to top) of the matrix represent the Stages, viz. Idea Generation and Assessment Stage, Development and Testing Stage, and Standardization and Launch Stage, respectively.

The product development lifecycle of a product (in this case Product 'A') commences at the lower left corner of the box matrix, i.e., Invention Phase/Idea Generation and Assessment Stage. The commencement is indicated by a glowing light bulb. The product then proceeds along the direction indicated by the arrow. After the product passes through the upper box on the left corner, i.e., Invention Phase/Standardization and Launch Stage, it -- 1. follows the arrow pointing upwards (which indicates "entry into the market"), and/or 2. follows the arrow looping downwards to the middle box at the lower end, i.e., Development Phase/Idea Generation and Assessment Stage. The arrow that leads the product into entry to the market subjects the product to remain in its existing state, while the arrow that leads to Development Phase subjects the product to undergo enhancements. (Note: The product path decision need not be made synchronously. It is often possible for the product to follow the downward path to Development Phase after it has entered the market and remained there for some time, i.e., decision is made asynchronously). Similar to the Invention Phase, the arrow in the Development Phase directs the product through treatments as it traverses the various stages. The upward arrow after the Standardization and Launch Stage indicates entry into market. The other arrow however leads to another glowing light bulb. At this point another Product 'B' which has also undergone similar treatments as Product 'A' is brought together and integrated to form Product 'C.' This phase is the Integration Phase for both Product 'A' and Products 'B,' but simultaneously it is the Invention Phase for Product 'C,.' The dotted boxes at the right side indicate the product development lifecycle for Product 'C' which is undergoing similar treatments as Product 'A' and Product 'B.'

The above proceedings are possible only through the interactions of entities that are involved in the development of the product. The entities can be categorized into four groups -- manufacturers, research organizations, customers, and government agencies. The relationships of the entities at the various stages and phases therefore occupy an important position in the development of a product. In the course of subjecting the product through treatments the entities may either compete, cooperate, or remain neutral. In this study it was discovered that the relationship changes at each point of the matrix. It commences with competition between all entities (Invention Phase/Idea Generation and Assessment Stage) and concludes with cooperation between all entities (Integration Phase/Standardization and Launch). While traversing through the stages, the relationships between entities change from competition to cooperation, while relationships among entities remain competition. However, as traversing through the phases, the relationships among entities change from competition to cooperation, while, the relationships between entities remain the same.

8.4 Implications of the Study

At the present, HDTV has occupied the center stage in the arena of high technology product development for well over a decade now. This has been mainly due to the grandeur of opportunities that it presents. Thus in this research, television was taken up as the product of study to analyze the scenario. The study was sparked off largely to understand the dynamics of a high technology product development. The idea was conceived initially by the observation of the delay noticed in its development. The United States, which had occupied the cradle of product development in recent years, was faltering behind in the HDTV race. It seemed that the U.S. was incompetent. Numerous delays were observed at every step and delay portrays inefficiency in allocation of resources. However, unexpectedly the U.S. has now taken up the lead, over-taking its competitors (Europeans and Japanese). The reasons for this outcome are evident through the findings of this study.

The Europeans and the Japanese dwelled on the premise of HDTV being a developed form of television, i.e., development over color television which in turn was a development over monochrome television. The U.S. however dwelled on the premise of HDTV being an integration of television with computers. But, the entities involved in the development of HDTV in the U.S. subscribed to the relationship mode of competition during the early period of HDTV development, with fragmented cooperation. However, later on the entities concurred with each other and adopted the relationship of cooperation by forming alliances (Grand Alliance). (Some of the alliances are formal while others are informal.

But the cooperative effort is a landmark in the history of technology development. It is a lesson learnt late, but it is a lesson well learned). It was only then that the possibility of U.S. companies being able to develop HDTV seemed visible at the horizon. In no time, its competitors had to yield and recognize the success of the U.S.

It can be observed from the discussion above that it is necessary to properly identify the Phase and Stage for a product in its development. (Note: This was the mistake that the Europeans and the Japanese committed). After proper identification it is necessary to subscribe to the proper mode of relationship between and among entities. (Note: This was the mistake that the U.S. committed in the early period). The Product Development Model developed in this study helps to guide entities in this process, as well as provide insights into product development.

Largely due to the integration of many products in recent years, entities have started forming alliances to remain competitive. It has been therefore been necessary to cooperate to remain competitive.

8.5 Utility of the Model

The PDM illustrates diagramatically the relationship that is necessary at the various stages and phases of a product development. The most common and obvious choice for is "competition," since it is still considered as the strongest, and most competitive weapon of capitalistic economy. However, as has been discussed and explained in this study, competition could be the wrong relationship and may lead to failure. This was evident in the development of HDTV.

It is therefore necessary to identify the particular stage and the particular phase and subscribe to the correct relationship to successfully develop a high technology product. The most common error occurs at the Integration Phase. During this phase, cooperation is supposed to be the necessary relationship. But, elements of the entities continue to subscribe to competition which results in delays, inefficient allocations of resources, and in most cases -- failure.

The development of global cellular radio is the drawing the central attention among high tech developers. MCI and AT&T are moving along fast to acquire and capture the market (Indepth, April 1994).

The PDM reveals the necessary relationship to successtully develop the global cellular system. According to the model, it is necessary to identify the correct stage and correct phase. Global cellular integrates -- telephone system, satellite system, mobile radio system, computer system, etc. Therefore, the phase in -- Integration Phase. During this phase cooperation needs to be fostered among entities. And that is what is exactly what is happening. It is due to this reason why Nextel, Motorola, British Telecom, Comsat, Northern Telecom, and MCI are joining together and fostering cooperation. On the other hand, McCaw, AT&T, and Viacom are fostering cooperation among themselves. Because of the cooperative efforts, global cellular system is already on the horizon. Had it not been for cooperation, it would not be possible to realize the dream of global cellular system.

8.6 Limitations of the Study

In this study, the analysis approach has been more holistic than fragmented and in doing so the effects due to small and minor fragments have not been taken into account. Some of them are -- the resources (the human resources, the financial capital, and the technological capabilities of the organization); the structure (size and the level); and, the culture (leadership, group dynamics, and employee behavior) of the individual elements of the entity set. It is beyond the scope of this study to take into account all of the above factors. To overcome the above constraints all of the elements in the entity sets have been assumed to be homogeneous.

This study has concentrated only in the product development lifecycle of one product -- television. It has been pointed out in this study that the product development lifecycle of a product is only one branch of the many branches. To understand the product development lifecycle (PDLC) it is necessary (at least) to consider the product development lifecycle (PDLC) that immediately precedes it as well as the one that immediately succeeds it. In this study, even though it would have been possible (to some extent) to consider the PDLC that immediately preceded the PDLC of television, it would be impossible to consider the PDLC that immediately succeeds it, since the PDLC doesn't yet exist.

8.7 Final Statement

The basic intent of this study has been to provide the various entities involved in the development of a product with a description of the various treatments that a product is subject to in the PDLC, as well as provide a guide to the mode of relationships. This work is by no means exhaustive, and is part of an ongoing process. It is therefore hoped that subscribers be aware of this fact while implementing the outcomes.

APPENDIX A
HIGH DEFINITION TELEVISION

A.1 HDTV: What is it?

High Definition Television (HDTV) is the next generation (third generation or sometimes called fourth generation) of television technology being developed by various organizations around the world. (Note: The first generation of television was monochrome television, the second generation was color television, and the third generation is HDTV. Sometimes HDTV is divided into two generations. The analog HDTV is referred to as third generation, and the digital HDTV is referred to fourth generation). HDTV promises to bring sharper images to the TV screen, as well as, superior digital stereo sound (similar to compact disc) and a wide screen picture to the audience. It is an attempt to create an electronic image equivalent to a 35 mm film production. High definition can be measured by the resolution of the picture or the number of active horizontal or vertical lines scanned on the television screen (generally referred to as the television raster). HDTV and Advanced television (ATV) are sometimes used synonymously. ATV refers to any system that results in improved television audio and video quality, whether the methods employed improve or enhance the existing National Television System Committee (NTSC) transmission system, or constitute an entirely new system (FCC Notice of Inquiry, 1987). The present TV standard being used in the United States is a 40 year old NTSC standard which has 525 horizontal scanning lines with field rate of 60 Hz. This corresponds to approximately 350 lines of vertical resolutions and 350 lines horizontal lines. With the increment of active lines on the raster HDTV will scan many more lines and provide a clarity, sharpness, and less distortions that is available only on films. HDTV provides better motion picture, i.e., the wagon wheels don't go backwards anymore. It is not possible to increase the size of displays in the conventional receivers because as the displays using non-HDTV technology gets larger, the viewer notices more defects and artifacts in the picture such as -- interline flicker, line crawl, vertical aliasing, static raster, and cross color. CD quality audio is available with the use of digital stereo sound system in the HDTV system.

Early research on visual perceptions discovered that the qualities advocated by HDTV could only be realized when viewers sat closer to the screen than they do with conventional televisions. This resulted in a wider field of view which in turn increased the sense of presence of the audience viewing the picture. But in doing so the viewers were able to see the scanning lines on the raster, which resulted in a very disturbing picture often causing vertigo. To overcome this effect, the number of lines scanned had to be almost doubled. To further increase the sense of presence, researcher discovered that the aspect ratio (width to height ratio) had to be increased. The following are five features that define the main areas of HDTV (Donow, K.R., & Sonne, M.L.De., 1988, Flaherty, J.A., 1987) --

1. High Resolution Display,
2. Wider Aspect Ratio,
3. Larger Viewing Angle,
4. Greater Color Rendition, and
5. Digital Sound.

A.1.1 High Resolution Display

HDTV will use at least twice the NTSC scanning rate (525 lines) resulting in a system with about at least 1,000 scanning lines. (Note: The FCC Advisory Committee of HDTV made the following point -- The HDTV system should provide an image quality equal to that of 35 mm film with no fewer than 1,000 active lines resolution (FCC Interim Report, 1988)). Combined with a wider screen, HDTV will deliver about five times as many picture elements (pixels) increasing resolution considerably as compared to the NTSC system. (See figure A-1).

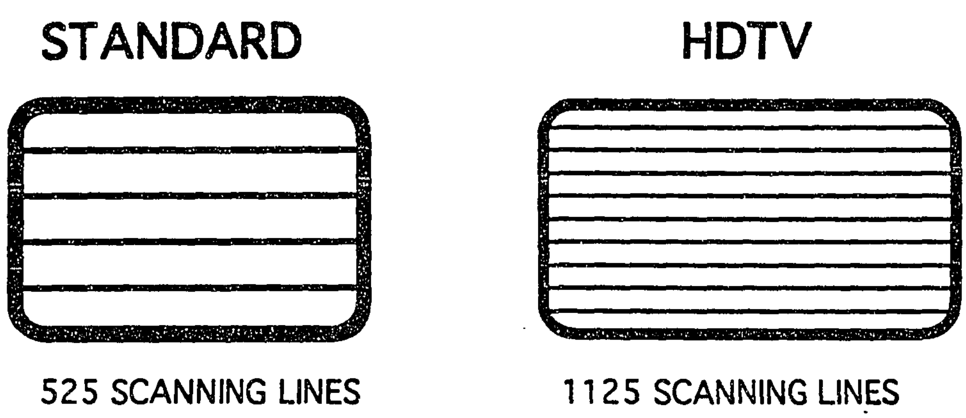

FIGURE A-1 RESOLUTION

A.1.2 Wider Aspect Ratio

The aspect ratio of NTSC standard is 4:3. HDTV will have an aspect ratio of 16:9. This will result in a wider screen which results in a perceptible increase in picture quality. Enlargement of the display screen would be the most effective technological method for creating psychological effect on feeling, reality and powerful impression (Fujio, T., 1978). (See Figure A-2).

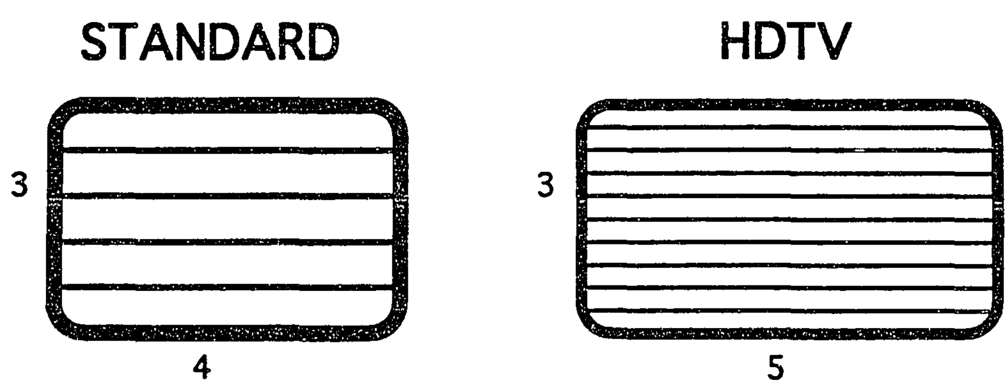

FIGURE A-2 ASPECT RATIO

A.1.3 Viewing Conditions

Research had concluded that the ideal viewing conditions for a NTSC-standard receiver with an aspect ratio 4:3 is a 10 degree field-of-vision, which is accomplished by seating the viewer at a distance of about seven screen-heights away from the TV receiver. When seated closer, the lines on the raster becomes visible. With HDTV (aspect ratio 16:9), the ideal condition is three screen-heights away from the TV receiver. This results in a 30 degrees field-of-vision. To take the maximum advantage of high definition, the HDTV screens will have significantly larger display screens (at least 40-50 inches diagonal). (See figure A-3).

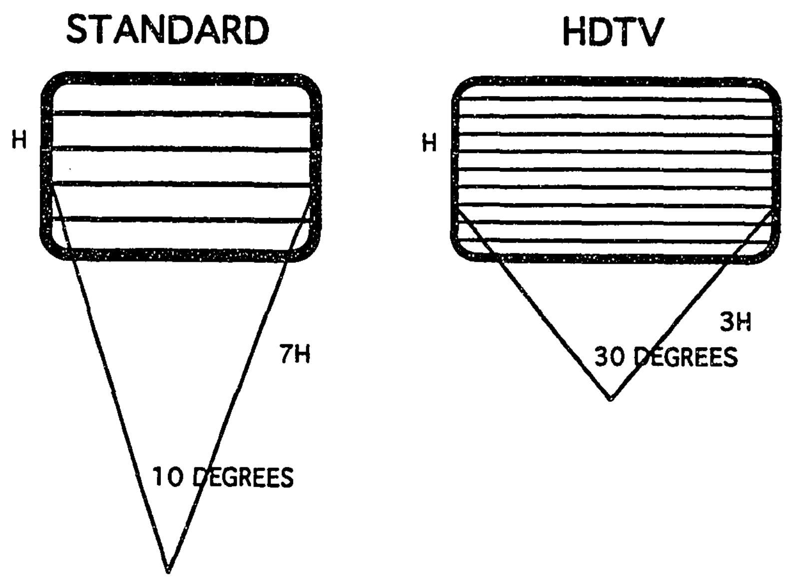

FIGURE A-3 VIEWING CONDITION

A.1.4 Color Rendition

HDTV system will provide an approximate 10-fold increase in color information as compared to the current NTSC system by using more bandwidth for color encoding. This will allow a more thorough resolution of hue and saturation on small details on video picture allowing more realistic reproduction of colors of the original scene. (See Figure A-4).

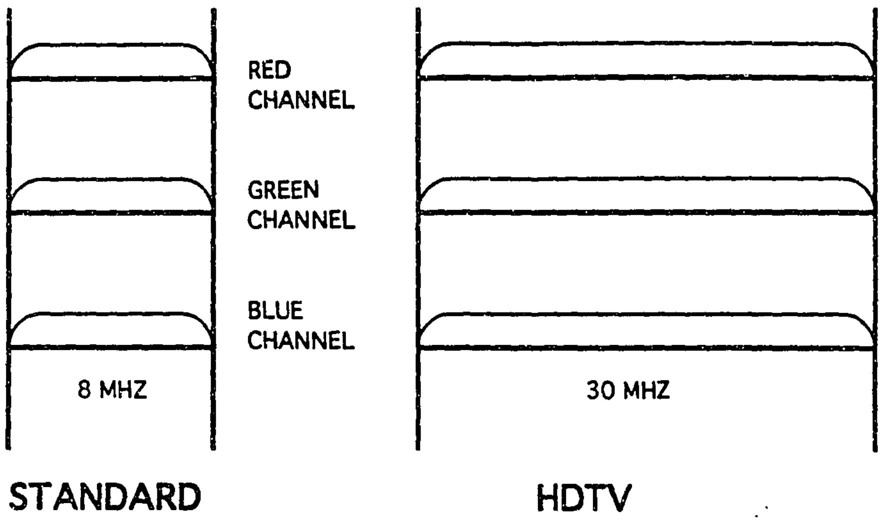

FIGURE A-4 COLOR RENDITION

A.1.5 Compact Disc Quality Sound

Since the audio component will be digital and stereophonic, the sound reproduction will be similar to CD quality. (See Figure A-5).

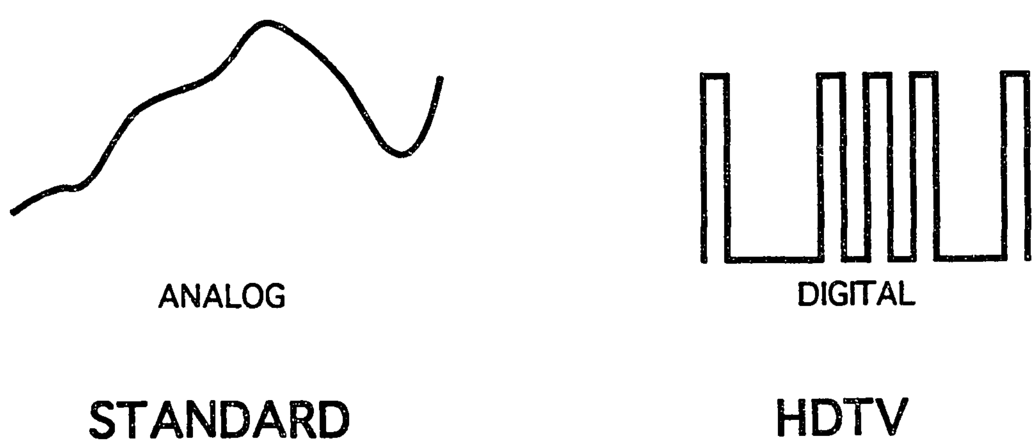

FIGURE A-5 SOUND

The development of high definition television (HDTV) or advanced television (ATV) represents the convergence of video, computer, and communications technologies (Note: See Appendix B). HDTV is a revolution that will eliminate the barriers between now-disparate technologies (Business Week, January 30, 1989). HDTV embraces both old and new technologies. Much of the potential for new video and advanced imaging products is drawn form developments in computer sciences -- components, software and systems (NTIA, U.S. DOC, 1989). Thus, some of the same technological developments that have made possible well-known and dramatic advances in telecommunications and data processing -- higher capacities, higher speeds and lower costs -- are being applied to creating, recording, processing, storing, distributing and displaying visual images. HDTVs must process huge quantities of information at speeds approaching those of today's supercomputers in order to display a real time, full-color, high definition video and audio signal, which would be only possible through the use of relatively low cost specialized task circuitry.

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APPENDIX B
ADVANCE TELEVISION SYSTEMS

High Definition Television (HDTV) is the most advanced forms of Advanced Television System (ATV), as defined by a classification scheme adopted by the Advanced Television Systems Committee (ATSC) (Darby, L., 1988, U.S. Congressional Budget Office, 1989). The ATSC taxonomy includes --

1. Improved Definition Television (IDTV),
2. Enhanced Definition Television (EDTV), and
3. High Definition Television (HDTV)

B.1 Improved Definition Television Systems (IDTV)

These are available in retail stores. By definition, these operate wholly within the current broadcast technical standards. Improvements are made possible by "combing" interspersed signals at both the transmitter and the receiver; by converting to progressive from interlaced scanning through the use of memory device in the receiver; and, by interspersing more video information throughout the normal six megahertz channel. In the receivers the signal is digitized, processed, stored in memories, and displayed to improve picture quality. The combined effect of these and numerous other technical improvements to double (roughly) the picture imperfections of traditional systems by embodying only internal modifications, involves no change in broadcasting equipment or radio spectrum allocation. These systems are generally compatible with both existing channel allocations and the embedded receiver base.

B.2 Enhanced Definition Television Systems (EDTV)

These systems could, theoretically at least, incorporate many of the techniques available for upgrading present systems. It involves further receiver improvements including wider screens, and perhaps more horizontal lines of resolution than is currently used. In addition, through a form of time divided, multiplexed packet transmission, signal quality and information quantity are appreciably enhanced. The transmission would remain within the 6 MHz per channel allocated to broadcasters and much of today's broadcasting equipment would be unaffected.

B.3 High Definition Television Systems (HDTV)

These systems involve an increase in the number of lines of resolution, to perhaps twice that available today, to achieve picture quality comparable to that of 35 mm film, along with CD quality digital sound. These improvements would require more complex receivers, new program production and broadcasting equipment, and more radio spectrum space.

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APPENDIX C
APPLICATION OF HDTV

C.1 Background

The development of HDTV or ATV represents the integration of video, computer, and communications technologies (Note: See Appendix B). HDTV is a revolution that will eliminate the barriers between now-disparate technologies (Business Week, January 30, 1989). HDTV embraces both old and new technologies. Much of the potential for new video and advanced imaging products is drawn form developments in computer sciences -- components, software and systems (NTIA, U.S. DOC, 1989). HDTVs must process huge quantities of information at speeds approaching those of today's supercomputers.

C.2 Applications of HDTV

HDTV connotes applications which initially are largely consumer oriented, principally, the delivery of entertainment television to homes. But despite this consumer product orientation, the nonentertainment applications of HDTV are both likely to be substantial and quite diverse. HDTV would drive the state-of-the-art in a number of technologies that would be very vital to some industries like future generation computers and communications equipments -- digital signal processors for real time video signals; high performance displays or HRS; fast, high density magnetic, optical data storage and semiconductor memories such as DRAM; technologies for packaging and interconnecting various electronics components; and improving manufacturing efficiencies. Some of the areas where HDTV could be applied are as follows (OTA, 1990):

C.2.1 Entertainment

Theater quality movies can be viewed in home thus creating a personal theater. It would be possible to take a video stroll through mountain resorts that the viewer is considering on vacation. It would be possible to watch a football game, where clarity and wide picture would enable the viewer to watch the entire game unfold. It would be possible to have close-ups of quarter back, defensive back, etc., on a window (subpicture) on the screen controlling what the viewer would like to see.

C.2.2 Telemedicine

Due to its high resolution and true rendition of color, HDTV could be used to transmit medical images such as x-rays, CAT scans, etc., to leading experts to avail critical advice thus creating interactive network serving medical community. This would provide benefit to areas where expertise may be non-existent (Kemezis, P., 1988), offering the highest quality video for remote diagnostic capability for more cost effective services (Newman Jr., L.S., & Jennings, T.B., 1987). Southwestern Bell Telephone Company demonstrated at a hospital in Texas the big role that could be played by HDTV in remote medical diagnosis and treatment (Bushaus, D., 1990).

C.2.3 Education

By manipulating digital video data, the viewer would be able to observe a painting in a museum, perform dissection, build models, or avail information as required. Great work of arts can be easily viewed from the home. Multidimensional libraries could be created where it would be possible to stroll through a stored record of an ancient city displaying the desired audio and video signals in response to the given direction. An electronic version of a newspaper edited according to particular choice could be easily availed (Valentine, T., 1991). This ability to interact makes HDTV far more important to education.

C.2.4 Simulation

Engineering simulation, including computer aided design (CAD) of structures, electronic circuits and a host of other things could be possible with the use of this new technology. Recent advances in computer generated images could extend simulations to enable viewers to walk through the image.

C.2.5 Photography

Pictures taken by electronics camera could be used in conjunction with editing to obtain pictures that cater to the taste of diverse audience. HDTV is already in use of motion picture production due to its efficiency and simplification in editing while saving production costs by about 15% (Investor's Daily, March 23, 1989).

C.2.6 Telecommunications

A host of new services, ranging from videophones and teleconferencing to telemarketing could be made available.

C.2.7 Publishing

Advanced video technologies would accelerate desk-top publishing by allowing the transmission and display of high quality video images. HDTV pictures have photographic quality and have the advantage of being electronically edited causing reduction of working time (Hatori, M, & Nakamura, Y., 1989). In the advertising industry, the electronic processing of HDTV signals is already replacing the editing of 35 mm film as a way to produce printed material because of the significant productivity improvements, even though such HDTV work stations costs hundreds of thousands of dollars (Bellision, J.A., 1989).

C.2.8 Defense

Use of electronic camera for reconnaissance would eliminate delay in processing films. High resolution maps and improved cockpit displays would enhance military efficiency. HDTV displays play a central role in the highest-payoff defense programs such as -- command and control, battle management, and training and simulation (Young, W.R., 1989). HDTV will enable the military to fully exploit the next generation of cockpit automation. HDTV can be used in tanks as well as command and control field equipment. HDTV could be used in shipboard command and control systems (SAC) and could be used for map displays in Army command and control centers where, for the first time, it will be possible to see legibly whole map sheets and battlefield overlays. (Note: HDTV systems will be installed for U.S. traffic control by the Federal Administration (FAA) in the very near future).

Figure C-1 illustrates a diagram describing the various applications of HDTV, which is excerpt from a Japanese promotional document of HDTV system.

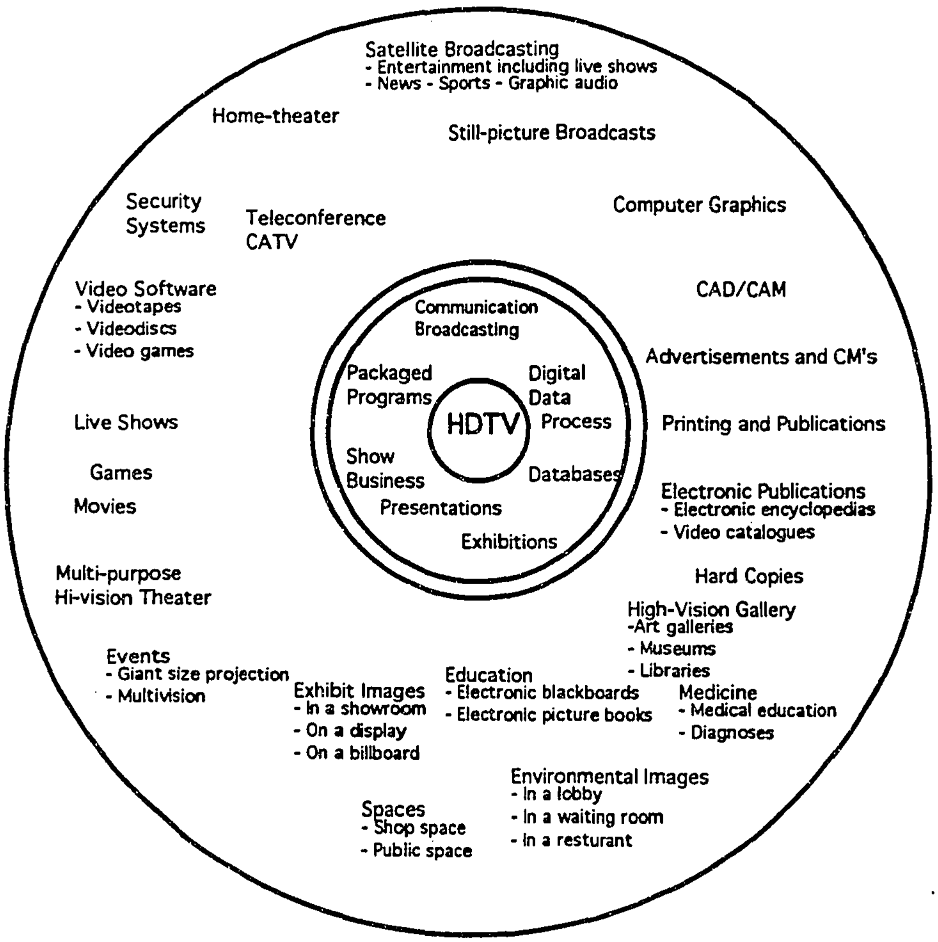

FIGURE C-1
HDTV APPLICATIONS MANDALA

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APPENDIX D
HDTV PROPOSALS IN THE UNITED STATES

D.1 Background

There have been number of proposals made for HDTV system in the United States. The primary reason for this has been the huge market that has been predicted by various analysts (Note: See Appendix E). A brief review of the major proposals is provided in this chapter. While some of the efforts are indigenous to the United States, others have been offshore.

D.2 Proposals

The proposals can be divided into four groupings --
1. 6 MHz NTSC-Compatible Systems;
2. 6 MHz NTSC-Incompatible Systems;
3. NTSC-Compatible Systems using the existing 6 MHz television channel, plus a separate channel of 6 MHz or less (augmentation channel), to carry the extra information needed to provide high definition pictures; and,
4. NTSC-Incompatible Systems using more than 6 MHz bandwidth.

D.2.1 6 MHz NTSC-Compatible Systems

These systems permit HDTV operation on existing VHF and UHF spectrum allocated to television without disruption to existing services. Since these are compatible with existing receivers, it will not be necessary to replace the color TV receivers. The only question is -- Do these systems provide picture improvements comparable to full high definition television systems?

The advantages of this system are as follows --
1. All existing broadcasters would be able to upgrade to HDTV;
2. FCC involvement and other regulatory constraints would be minimized;
3. There would be no significant disruptions; and,

4. There would be continual support by the delivery system (Over-air transmission, VCRs, etc.)

D.2.1.1 ACTV I (Advanced Compatible Television)

The proponents of this system was a consortium comprising of David Sarnoff Research Center (formerly known as RCA) located in Princeton, New Jersey, NBC (National Broadcasting Center), and RCA (Radio Corporation of America) which is now a part of GE (General Electric) (The New York Times, 1990).

The ACTV I enhanced picture is delivered within the existing 6 MHz broadcast channel. Existing NTSC receivers with an aspect ratio of 4:3 will be able to display the Advanced Compatible Television I signal. ACTV I is a 1,050 lines per frame, single channel NTSC compatible system. Its luminance resolution is 410 horizontal lines and 480 vertical lines and is chrominance resolution is the same as NTSC. The aspect ratio is 16:9. Figure D-1 provides a schematic block diagram of ACTV I.

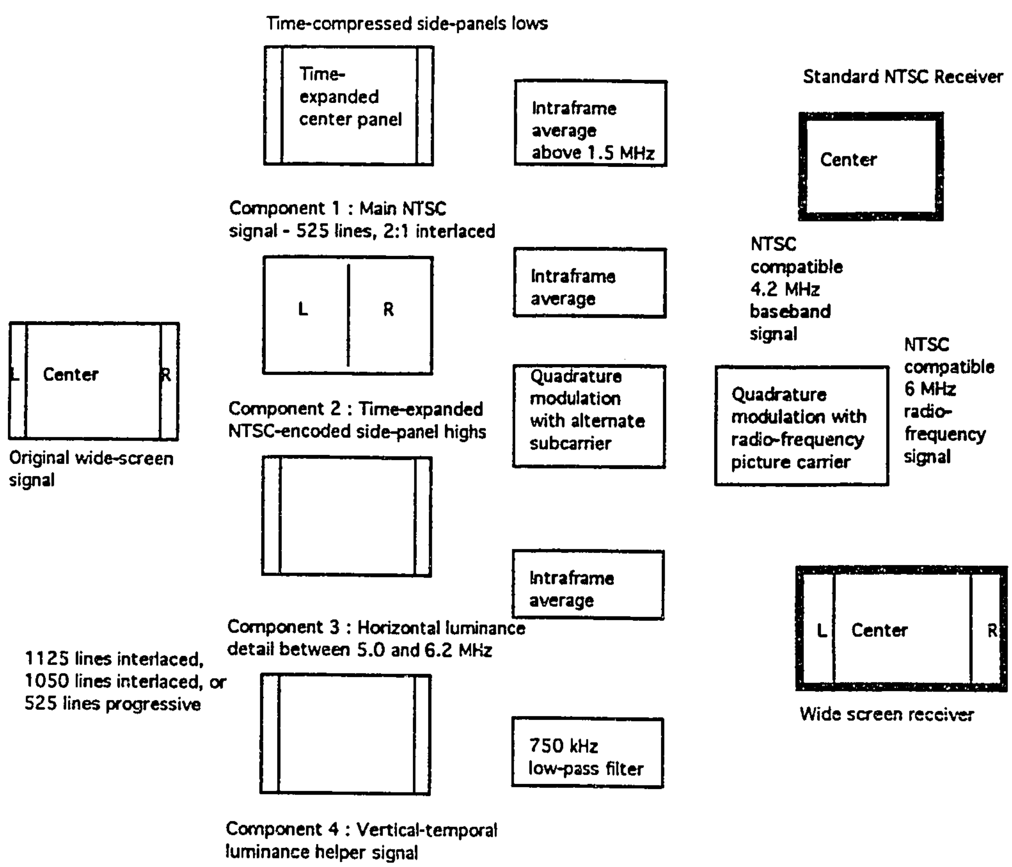


FIGURE D-1 ADVANCED COMPATIBLE TELEVISION BLOCK DIAGRAM

Source: Jurgen, R.K., 1988

The ACTV was initially proposed by NBC on October 1, 1987 (Broadcasting, October 5, 1987). In the following week, a computer simulation was presented in the Ottawa Canadian HDTV conference (Broadcasting, October 26, 1987). The general impression was that the picture was better than NTSC. In April, 1989, an over the air demonstration of AVTC was carried out on WNBC-TV in New York (Television Digest, April 24, 1989). Even though regular TVs could receive the signal, only David Sarnoff Center could receive the enhanced television picture.

D.2.1.2 EDTV System I

This system was proposed by Broadcast Technology Association. The EDTV System I was intended to improve picture quality of the present NTSC system by introducing progressive scan (in place of interlaced scan) display with three dimensional Y/C separation, higher resolution signal sources, and modifying the signal parameters. The improvement in picture quality was expected to be about +1.5 grade compared with conventional NTSC pictures (EIA HDTV Information Center). The aspect ratio was the same. Since no changes to the present NTSC system were made on the aspect ratio, the frequency spectrum and bandwidth, and sound channel, the system was fully compatible with the current NTSC receivers, broadcasting networks, and CATV system, implementation could be easily done. Laboratory tests and field tests showed promising results (Multichannel News, March 13, 1989).

D.2.1.3 GENESYS

This system was proposed by Production Services, Inc. The GENESYS Transmission System was a single 6 MHz system that was fully compatible with the current NTSC system. It was capable of delivering the SMPTE 240M 1,125/10/2:1 interlace standard, as well as the 1,050/59.94 format (EIA HDTV Information Center). GENESYS consisted of four different consecutive processes. The first process applied modified delta modulation techniques for analog to digital conversion of HDTV signal. The second process used a type of waveform modulation which modified the digitized HDTV signal, not as FM (Frequency Modulation), AM (Amplitude Modulation), or PCM (Pulse Code Modulation), but as the shape of the carrier (Tobing, E.H.C., 1989). The same carrier was used to transmit vestigial side band (VSB) NTSC signal. Finally, the signal was demodulated and the digital signal was converted into analog form (Hopkins, R., & Davies, K.P., 1989). The audio was transmitted as four discrete channels with 60 KHz sampling rate. The equipment requirement at the TV station were minimal and a single IC (Integrated Circuit) chip with no memory was all that was required for the TV receiver.

D.2.1.4 HD-NTSC (High Definition NTSC)

This system was proposed by Del Rey Group, a small company located in California of Richard Del Rey.

The Del-Rey Group proposed a system which was based on the introduction of a subsampling technique called TriScan. TriScan took a high definition monochrome signal and compressed it down to NTSC format (SMPTE Journal, March 1988).

This system was NTSC compatible and could be accommodated in the present 6 MHz broadcast channel. The resolution was adjustable up to a limit of 700 horizontal lines and 700 vertical lines. It was able to accept 900, 1,050, 1,125 or 1,500 line studio standard. It had an aspect ration of 16:9. It was compatible with consumer VCRs and most station equipment. The system would provide a very large, sharp, and wide picture which was free from current conventional artifacts. It would be accompanied with a CD quality audio. The most interesting characteristics of this system was that performance could be gradually increased over time to full HDTV level without additional spectrum and receiver upgrades. Figure D-2 provides a picture of HD-NTSC process.

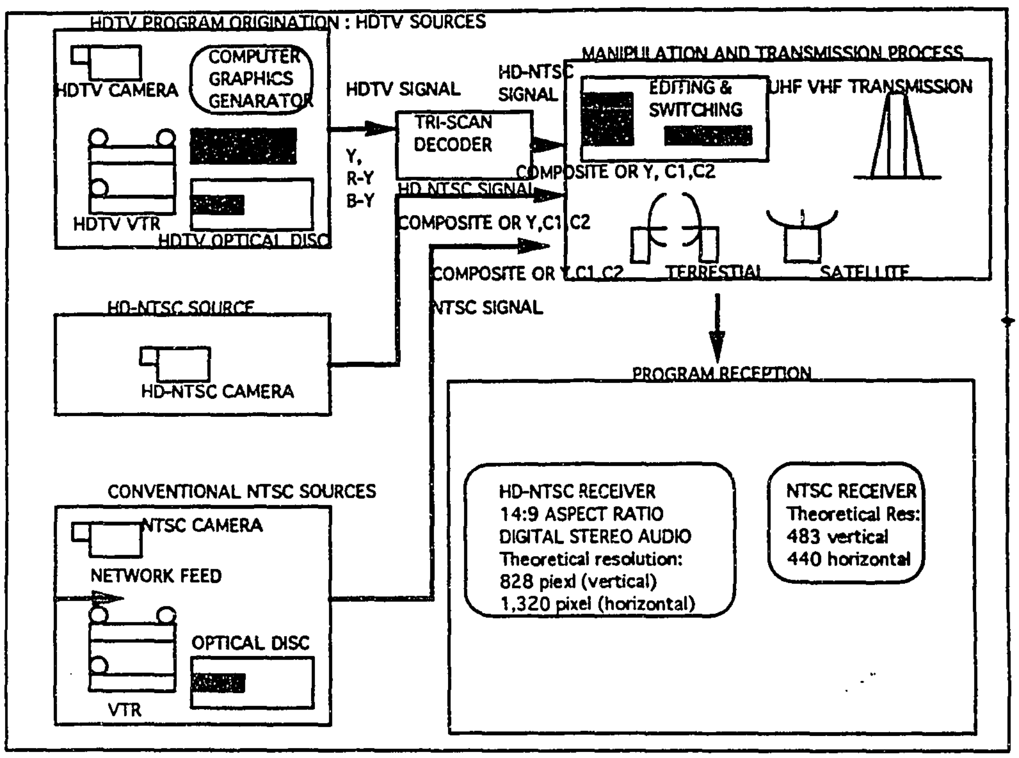


FIGURE D-2 THE HD-NTSC PROCESS -- A CONCEPTUAL VIEW

Source: Iredale, R.L., 1987.

A limited partnership under the name Compatible Video Consortium (CVC) was formed between Cox Enterprises Inc., Atlanta, Tribune Broadcasting Co., Chicago, Marina Del Rey, California, Cox Cable and Group W (Broadcasting, February 29, 1988).

HD-NTSC was tested through two thresholds. First, HD-NTSC was simulated on a VAX 8600 using monochrome images. Second, in December 1987, tests were with color images. The group reported that they have been encoding high definition color images into composite HD-NTSC and back again (NAB, 1988).

D.2.1.5 High Definition & High Frame Rate Compatible NTSC Broadcast Television System

This system was proposed by Avelex. This was a method of terrestrial broadcast and cable transmission of HDTV with high frame rate in the basic NTSC format using a single 6 MHz. channel. Sub-Nyquist sampling was used with an eight field sequence (Aoki, K., 1990). The transmitted signal was appropriate for display on present NTSC receivers and would generate a wide screen display on new high definition receivers with 1,500 pixels horizontally on each of the 966 lines in a 16:9 or 5:3 aspect ratio format (EIA HDTV Information Center). The transmitted signal permitted display at 60 frames per second at a receiver, each virtually independent of one another, and thus permitted smooth high speed motion without studder or jerkiness. None of the NTSC active frame area was required to be given up to accommodate the new expanded video and audio data. The system provided a method of motion compensation with receiver verification of motion vector data for the high resolution and a method for transmitting new side "wings" video data on a quadrature component of the visual RF carrier.

D.2.1.6 MIT-RC

This system was proposed by Massachusetts Institute of Technology. MIT-RC was compatible with 6 MHz channel and was receiver compatible. It was an enhanced-definition (EDTV) system featuring improved resolution on special receivers. It provided satisfactory reception on existing receivers. It had freedom from NTSC cross-effects and had digital audio. This system masked the top and bottom of the picture by a process known as "letter box" processing (Hopkins, R., & Davies, K.P., 1989). The luminance information was carried by the top and bottom bars. To double the horizontal resolution, the chrominance frame rate was decreased to 15 frames per second.

D.2.1.7 NTSC MUSE 6

The MUSE-6 system was announced by NHK in early 1987 as a suggested transitional system in the movement from NTSC to a full-fledged HDTV MUSE system (NAB, 1988). This system was compatible with existing channel and television sets. It was an enhanced definition transmission system. MUSE 6 used conversion of scanning lines by converting 1,125 lines to 750 lines at the transmitter and changing it back to 1,125 at the receiver. Two of the MUSE-6 systems compressed picture for NTSC sets, displaying a 16:9 picture with black strips across the top and bottom of the screen. The other MUSE 6 system croped the sides of the picture on NTSC screens (EIA Information Center). The resolution of the picture was 750 lines by 600 lines. High resolution data was inserted into the 4.2 MHz TV video baseband using MUSE compression techniques. Higher compression to the 6 MHz required complex technology. The system also incorporated two digital audio channels (Hopkins, R., & Davies, K.P., 1989).

D.2.1.8 SuperNTSC

This system was proposed by Faroudja Laboratories, which was owned by the French born inventor Yves Charles Faroudja (Tobing, E.H.C., 1989).

This system combined pre-processing at the transmitter and post-processing at the receiver (TV set). It ran on a single 6 MHz channel and was fully compatible with the current NTSC receivers. According to Faroudja, all that was needed to receive the improved picture was a "comb" filter in the receiver, which was already included on most present high quality televisions (Tilles, A.S., & Weisman, D.E., October 1988). SuperNTSC was a system that doubled the number of scanning lines to 1,050 and the frame rate was 59.94 per second. The system expanded the capability of NTSC almost to its theoretical limits, rendering full-color images indistinguishable from source images after transmission over a standard NTSC 6 MHz channel (NAB, 1988). This was accomplished by use of filters that do not allow the luminance signals to interfere with the color signal (Donahue, H.C., 1989). Faroudja Labs introduced its SuperNTSC system at the November 1987 SMPTE Conference in Los Angeles (NAB, 1988).

D.2.2 6 MHz NTSC-Incompatible Systems

The 6 MHz NTSC-Incompatible Systems approach was based on the idea that it would make more short-term and long-term sense to reject the NTSC constraints, and design and entirely new 6 MHz system (NAB, 1988).

D.2.2.1 MIT-CC

This system was proposed by MIT (Massachusetts Institute of Technology). It was a one channel (6 MHz) incompatible system featuring resolution and digital audio/data capabilities comparable to the Japanese HDTV transmission systems, but on special receivers only (EIA Information Center). The coding technique used in this system was the sub-band coding (Tobing, E.H.C., 1990). It was developed specially for cable use, but was also applicable to the eventual incompatible broadcasting system. In that application, it also featured reliable performances in degraded channels, by means of suppressing ghosts, random noise, and mutual interference between TV transmissions.

(Note: Both the MIT-RC and MIT-CC systems were fully compatible with terrestrial, satellite, and cable channels and could achieve higher performances with additional spectrum, either in contiguous or noncontiguous bands. A concept being studies in connection with the MIT TV systems was the "Open-Architecture Receiver" since MIT believed in the probability that multiple TV standards would prevail in the future. Using digital signal processing and modern solid-state components, all kinds of input signals would be converted in low-level digital hardware and displayed at a single high-definition standard. The architecture was bus-oriented to facilitate interconnection with a large variety of other devices and communication lines. MIT believed that such an approach would permit evolutionary improvement in performances by adding software and/or hardware modules at a later date (EIA Information Center).

D.2.2.2 Narrow MUSE

NHK proposed this 6 MHz NTSC-incompatible system. Narrow-MUSE used identical bandwidth compression algorithms as the standard MUSE format to compress the base-bandwidth to 5 MHz rather than 8.1 MHz (NAB, 1989). Narrow-MUSE used a converter for use with existing TV sets and allowed transmission of 4-channel digital sound signals. Narrow-MUSE was itself a transitional system on the way to a full MUSE implementation. Narrow-MUSE offered picture qualities that were two grades better than present NTSC video, but still one grade level less than full MUSE.

D.2.2.3 SC-HDTV (Spectrum-Compatible HDTV System)

This system was proposed by Zenith. SC-HDTV used simulcast transmission system which eliminated most interference with NTSC by employing double sideband suppressed carrier modulation for analog video components and digitized low frequency video and audio. The more than 90 percent power reduction realized by the transmission system and the inter-leaving of NTSC and HDTV spectrum resulting from encoding enabled the use of otherwise unusable taboo channels of UHF and VHF broadcast spectrum for simulcast HDTV (EIA Information Center). Although the transmitted HDTV component encoded signal would resemble NTSC 525-line interlaced transmission for spectrum compatibility, the HDTV display on home receivers would be a 787.5 line, progressively scanned 59.94 Hz display comparable to 1,000 plus-lines interlaced display (Broadcasting, September 5, 1988). As a source for these 787.5-line HDTV transmissions, broadcasters could use either a 787.5 line, 59.94 Hz format in a 30 MHz RGB signal, or a 1,050 line, 59.94 Hz progressively scanned format which was then electronically compressed to be compatible with the 787.5 line display. The system was capable of providing TV images with aspect ratios such as 16:9, 5:3, or 4:3.

D.2.3 NTSC-Compatible Systems using an existing 6 MHz television channel, plus a separate channel of 6 MHz or less, to carry the extra information needed to provide a high definition picture

D.2.3.1 MUSE-9

This system was proposed by NHK. It had 3 variations, but all required 9 MHz of channel bandwidth and therefore could be transmitted only via satellite, cable, or an expanded broadcast television channel. MUSE-9 was compatible with the existing NTSC sets using a 3 MHz augmentation channel. It provided an aspect ratio of 16:9, twice the static resolution of the NTSC system and allowed transmission of 4-channel digital sound signals.

D.2.3.2 Philips HDS-NA (High Definition System for North America)

This system was proposed by Philips Laboratories. HDS-NA was designed to be comparable in quality to HDTV systems which would be adopted elsewhere in the world and would be usable on an equal basis by all modes of television delivery -- terrestrial broadcasting, cable television, direct broadcast satellite (DBS) and fibre optics cables. HDS-NA was characterized by --

1. A wide screen (an aspect ratio of 16:9 rather than the conventional 4:3);
2. HDTV resolution and picture quality free from motion artifacts, flicker, and line structure (more than 400,000 picture elements rather than the 145,000 associated with conventional NTSC receivers); and,
3. Multichannel compact disc (CD) quality digital sound.

The system was compatible with the existing NTSC receivers and did not cause degradation in quality (EIA Information Center). There were two type of HDS-NA systems being proposed. These were as follows --

1. HDMAC-60, and

2, HDNTSC.

D.2.3.2.1 HDMAC

HDMAC-60 was a 60 Hz adaptation of its 50 Hz European MAC system designed for HDTV satellite transmission which carried information from the program source to a terrestrial broadcast system, a cable headend, or directly to the viewer's home.

D.2.3.2.2 HDNTSC

HDNTSC was a terrestrial distribution system derived from HDMAC-60 with a transcoder that would carry information from a terrestrial broadcast system or a cable headend to a viewer.

HDMAC-60 was a 1,050/59.94/2:1 interlace scan system with aspect ratio of 16:9. The signal had a base bandwidth of approximately 9.5 MHz. Upon reception of the HDMAC-60 signal, it was demodulated and divided into two signals, each which fitted into a 6 MHz band. The first was the traditional NTSC signal in all ways. The augmentation channel contained all of the extra information needed to deliver HDTV including the side panels necessary for widening the picture, the extra

HDTV resolution, the improved color rendition, and the data necessary to achieve CD quality digital stereo (NAB, 1988). This system was demonstrated in April 1987 (Hecht, J., 1989). The most important feature of this system was that it made the most out of the "taboo" channels (Hopkins, R., & Davies, K.P., 1989). Philips presented the first demonstration of HDTV hardware for U.S. satellite transmission in December 1988 (Television Digest, 1988).

D.2.3.3 VISTA

This system VISTA (Visual System Transmission Algorithm) was proposed by New York Institute of Technology (Glenn, W., & Glenn, 1988). This system was developed under the guidance of William Glenn. This system was compatible with the NTSC receiver. It was based on the use of the existing 6 MHz channel, plus a second 3 MHz "detail" augmentation channel. The resolution of static images in this system was extremely high. To squeeze high picture information into a 3 MHz augmentation channel, fine details were transmitted at a slower rate of 7.5 frames per second. The technique for NTSC was to break the signal into low spatial and high temporal resolution components, while for the augmentation signal its was the opposite, high spatial and low temporal resolution components. This system employed temporal filters and diagonal filters (Glenn, W.E., & Glenn, K.G., 1988). The system was given a closed-circuit tests at the 1986 and 1987 NAB conventions NAB, 1988). Figure A-3 illustrates the block diagram of the NYIT Compatible System.

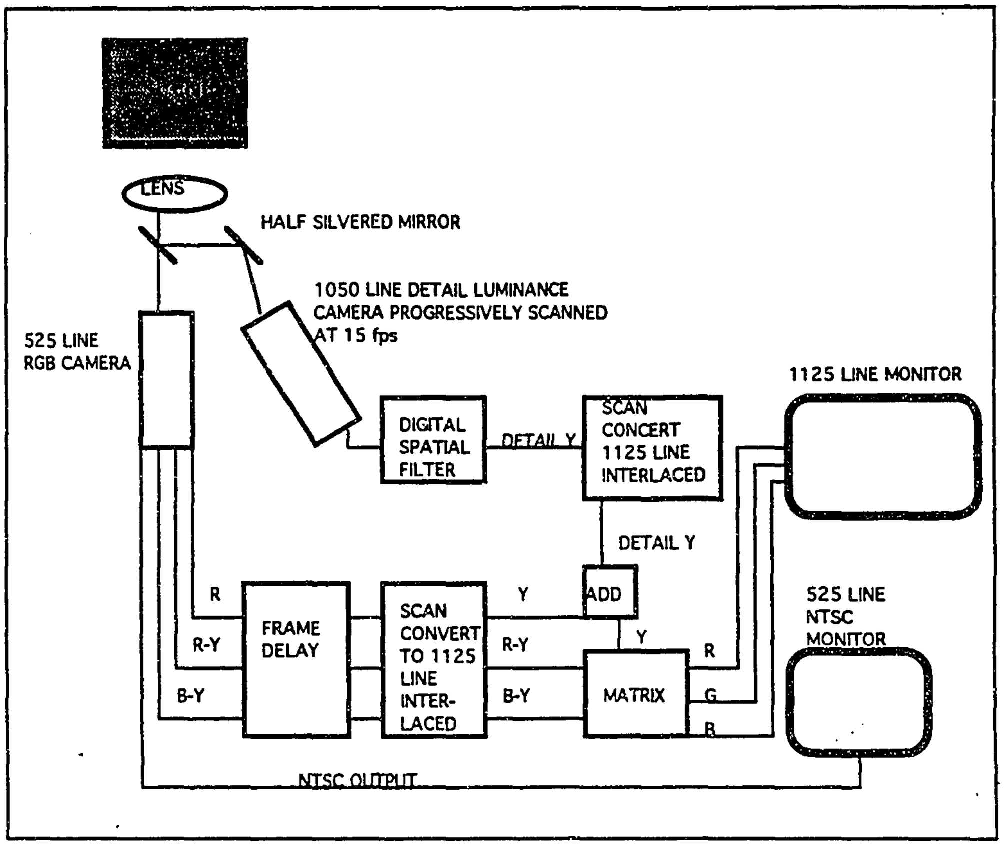


FIGURE D-3 NYIT COMPATIBLE SYSTEM BLOCK DIAGRAM

Source: Glenn, W., & Glenn, K., 1987.

D.2.3.4 ACTV II (Advanced Compatible Television)

The proponents of this system was a consortium comprising of David Sarnoff Research Center (formerly known as RCA) located in Princeton, New Jersey, NBC (national Broadcasting Center), and RCA (Radio Corporation of America) which is now a part of GE (General Electric). (Note: See ACTV I above).

ACTV II was meant to augment ACTV I, elevating the resolution of ACTV I to true high definition with the use of an additional channel. It was a 1,050 lines per frame system which was compatible with both NTSC and ACTV I. It used two channels with a total bandwidth of 12 MHz. The luminance resolution was 650 horizontal lines (in contrast to 410 for ACTV I) and 800 vertical lines (in contrast to 480 for ACTV I). The chrominance resolution was double that of NTSC (it was the same for ACTV I). The aspect ratio was 16:9.

This system was first demonstrated at the NAB convention in April, 1988. The ACTV II would be the second phase of implementation of HDTV after adopting ACTV I, according to the consortium (Broadcasting, April 18, 1988). ACTV-E (entry level) was also introduced by the consortium to enable broadcasters to have a smooth progression at minimal cost (Television Digest, October 24, 1988).

D.2.4 Systems That Are Incompatible with NTSC-Standards and Using More Than 6 MHz Bandwidth

D.2.4.1 HDB-MAC

This system was proposed by Scientific Atlanta. HDB-Mac was intended for satellite distribution to broadcast stations and cable head ends, as well as satellite broadcasting direct to homes. The signal would pass through cable systems using two contiguous 6 MHz channels. The signal was not directly compatible with NTSC receivers, and required a MAC decoder to generate NTSC signals. To display HDB-MAC signal on an NTSC receiver, it was necessary to use a set-top converter with an NTSC output (EIA Information Center). A progressive scanning process was applied and the system used a diagonal filter. The system occupied a bandwidth of 10.7 MHz. The aspect ratio were 4:3 and 16:9. These could be achieved by using pan and scan technique. The system had six digital audio channels (Hopkins, R., & Davies, K.P., 1989). A spectrum folding technique was used to achieve horizontal resolution of 950 lines with a 525 lines progressive scan.

D.3 HDTV Systems Submitted For Final Evaluation to the FCC

There were six proposals under consideration by the ATTC by March 1, 1991 (ATTC, March 1, 1991) which is illustrated in Table D-1.

TABLE D-1
PROPOSED ADVANCED TELEVISION TRANSMISSION SYSTEMS
BEFORE THE FCC ADVISORY COMMITTEE
(MARCH 1, 1991)*

	ATV SYSTEM NAME & PROPONENTS (in alphabetical order of system)	**TYPE**	**DECLARED SCANNING FORMAT**	**SIGNAL FORMAT**
1	**ACTV** David Sarnoff Research Center/ATRC (Advanced Television Research Consortium)	Enhanced NTSC	525/59.94, 1:1	Analog
2	**ADTV** North American Philips/ATRC	Simulcast HDTV	1050/59.94 , 2:1	Digital
3	**ATVA Progressive** System MIT/ATVA (Advanced Television Alliance)	Simulcast HDTV	787/59.94, 1:1	Digital
4	**Digicipher** GI/ATVA	Simulcast	1050/59.94 . 2:1	Digital
5	**Narrow MUSE** NHK	Simulcast	1125/60, 2:1	Analog
6	**DSC-HDTV** Zenith/AT&T	Simulcast	787.59.94, 1:1	Digital

*(Note: The scanning format is number of scanning lines per second/frames per second, interlaced (2:1) or progressive (1:1)). Source: Advanced Television Testing Committee, March 1, 1991.

D.4 Selection Criteria

Ten selection criteria and associated target values were set by the FCC Advisory Committee SS/WP4 (Systems Sub-committee/Working Party 4) (ATTC, March 1, 1991). They are as follows --

1. Coverage area -- Comparable to NTSC.

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

3. Audio/video quality -- The CCIR has defined HDTV in terms of current television systems. That definition, applied to NTSC, leads to the following target value. The resolution should be twice that of NTSC in both vertical and horizontal directions, the temporal resolution should not be less than NTSC, the color rendition should be superior to NTSC, any artifacts should be less objectionable than are NTSC artifacts, the aspect ratio should be 16:9, and the subjective sound quality should be comparable to compact disc.

4. Transmission robustness -- Better than NTSC within the defined coverage area.

5. Scope of services and features -- When compared with NTSC, increased capability and flexibility in the ability to provide audio, captioning, data services, etc.

6. Extensibility -- A new service must provide long life, just as NTSC has provided a long life, by supporting future enhancements and future technology advances.

7. Interoperability -- A new service should be "friendly" to alternate delivery media. Interoperability with Cable TV is mandatory. Interoperability with VCRs, satellite, computer, data communications, telecommunications applications with simple interfacing hardware is also an objective.

8. Cost to broadcasters.

9. Cost to alternative media.

10. Cost to consumers.

It is difficult to establish target values for cost issues. Furthermore, cost is a function of market conditions and production volume. Key issues for broadcasters and cable operators would be cost to "pass" programming. Key issues for consumers would be cost of a receiver and a VCR after five years of production.

(Note: In a last minute decision ATRC dropped out their analog ACTV (Advanced Compatible Television) from the race. Thus only five proposals remained with the FCC). The proposals are discussed below.

D.5 Final Proposals Description

Many of the features and elements are common to all of the proposed systems with a some variations. Table D-2 compares the final four proposals that are in the race.

TABLE D-2
FINAL HDTV COMPETITORS*

SYSTEM	DIGI-CIPHER	DCS	ADTV	CCDC
SCAN LINES/FRAME	1050	787.5	1050	787.5
FRAMES/SECOND	29.97	59.94	29.97	59.94
SCAN FORMAT	2:1 Inter	Prog	2:1 Inter	Prog
HOR. LUM PIXELS	1408	1280	1440	1280
VERT LUM PIXELS	960	720	960	720
HOR. CHROM PIXELS	352	640	720	640
VERT. LUM PIXELS	480	360	480	360
LUM BW MHz	21.5	34	23.6	34
CHROM BW	5.4	17	11.8	17
VID SAM FREQ. MHZ	53.65	75.3	56.64	75.5
VIDEO DATA RATE Mbps	17.47/ 12.59	17.1/ 8.6	17.73	18.88/ 13.60
AUD SAMP FREQ.kHz	48	47.203	48	48
AUD DATA RATE Mbps	0.503	0.5	0.512	0.755
AUDIO DYN RANGE dB	85	96	96	94
ERROR CORRECTION OVERHEAD Mbps	6.17	1.3/2.4	5.64	6.54
TRANS DATA RATE	24.39/ 19.51	21.0/ 11.1	24.0/ 4.8	26.43/ 21.25
PROPONENTS	GI.MIT	ZENITH, AT&T, SCIENTIFC ATLANTA	THOMSON, PHILIPS, NBC, DAVID SARNOFF RESEARCH CENTER, COMPR. LABS.	GI, MIT

*Source: Harris, A., May 1993.

The section below discusses each of the proposed systems in detail.

D.5.1 AD-HDTV (Advanced Digital High Definition Television)

(Note: For a detailed description of this proposal please see -- "Advanced Digital High Definition Television: System Description," January 20, 1992. The description that is to follow has been taken from that report.)

ADTV (Advanced Digital High Definition Television) has been developed by the ATRC (Advanced Television Research Consortium) at David

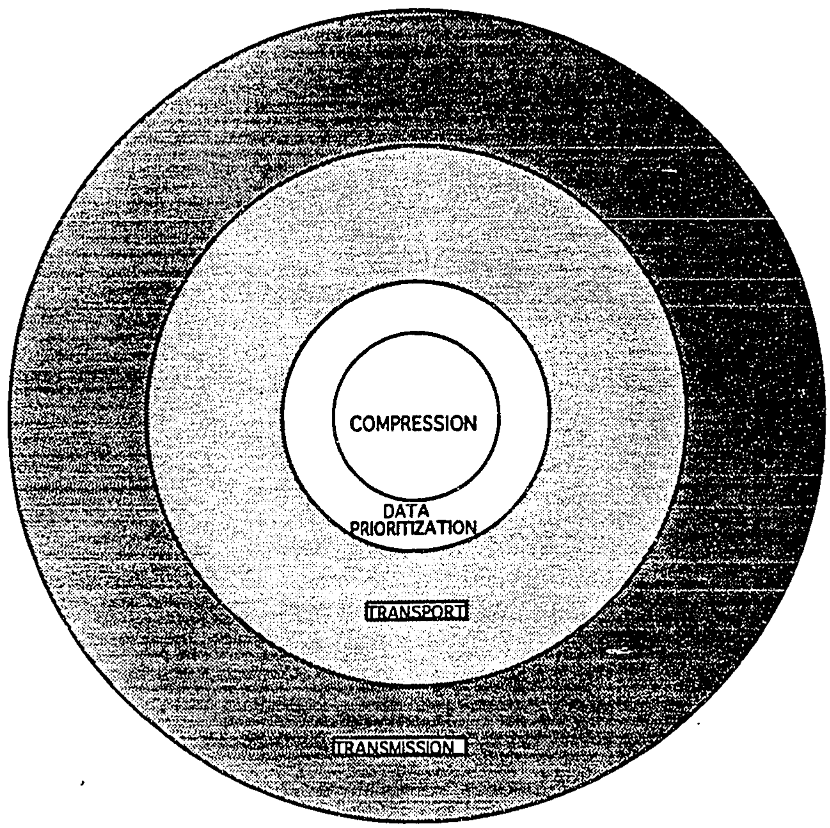
Sarnoff Research Center, Princeton, New Jersey and Philips Laboratories, Briarcliff Manor, New York. AD-HDTV has several unique attributes that contribute to its superior performance, flexibility and cost characteristics --

1. MPEG (Motion Picture Experts Group) video and audio compression;
2. Flexible video formats that provide choices of interlaced or progressive scan with rectangular or square pixels;
3. Separate video, audio and data packaging, that allow flexible mix of services;
4. A data format that is well-suited for both broadcast and data networks;
5. Receivers that disregard unorganized types of data;
6. Two separate data carriers with different power levels;
7. A spectrally-shaped signal that avoids NTSC interference; and,
8. A high 24 MBPS (Mega bits per second) total data rate.

These unique attributes combine in a powerful way to give AD-HDTV important advantages in many important dimensions in which an HDTV system must be evaluated --

1. Superior HDTV picture and sound quality;
2. Highly reliable and robust performance for broadcasting;
3. Lowest interference with existing NTSC service;
4. Coverage better than or equal to NTSC and high accommodation;
5. Most flexible scope of service;
6. Greater interoperability and extensibility for future growth; and,
7. Lower cost for broadcasters, alternative media and consumers.

AD-HDTV consists of MPEG++ video compression, MUSICAM (Masking-pattern-adapted Universal Subband Integrated Coding and Multiplexing) audio compression, PDT (Prioritized Data Transport) format and SS-QAM (Spectrally-Shaped Quadrature Amplitude Modulation), integrated to operate in unison as an effective simulcast system. Figure D-4 illustrates an architectural view of AD-HDTV, which has been designed as a system with multiple layers, each having a clearly defined function and interface.



COMPRESSION LAYER
- Input/Output Pre-/post-processing
- Data Compression/Decompression

TRANSPORT LAYER
- Service multiplexing/demultiplexing
- Error control
Video-specific adaptation control

PRIORITIZATION LAYER
- Separation (merging) of data to (from) standard and high priority

TRANSMISSION LAYER
- Physical level modulation
- Adaptive equalizing
- Frequency translation to/from r.f.

FIGURE D-4 CONCEPTUAL VIEW OF AD-HDTV SYSTEM ARCHITECTURE

Source: ATRC, 1992.

The compression layer performs the tasks of video pre/post-processing and the MPEG compression/decompression. The prioritization layer has the task of assigning priorities to video data at the encoder, and combining the data elements of different priority into coherent data streams for decompression at the decoder. The data transport layer is layer is responsible for service-independent data multiplexing, cell formatting, error detection, error correction, as well as service-specific logical error recovery. The transmission layer performs the tasks of modulation, channel equalization, and frequency translation. A high level block diagram of the AD-HDTV systems is shown in Figure D-5 below.

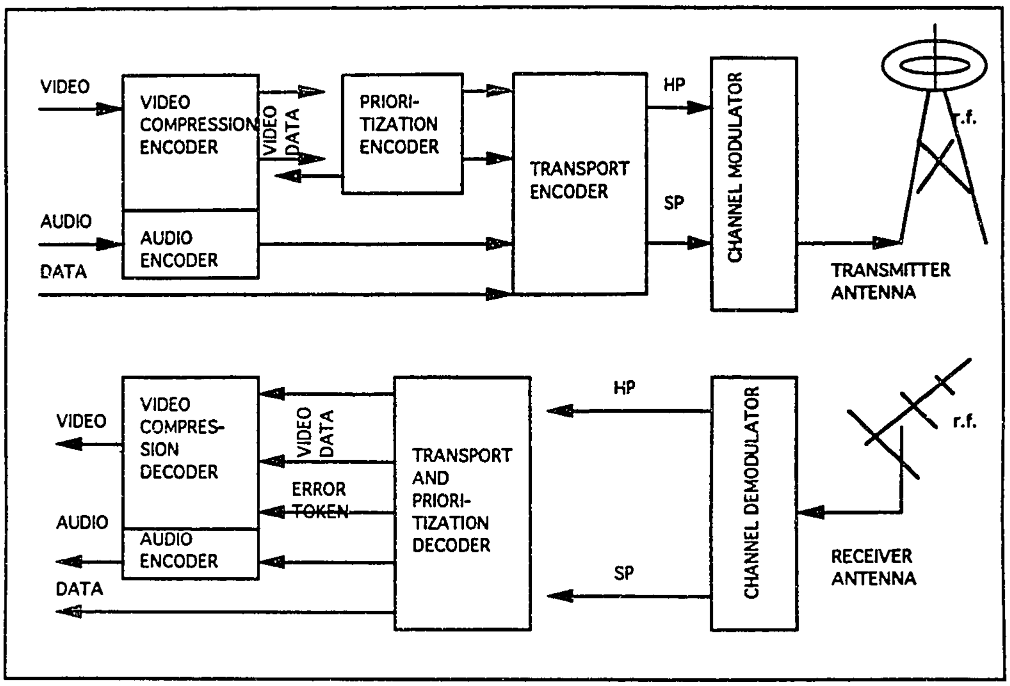


FIGURE D-5 AD-HDTV HIGH-LEVEL BLOCK DIAGRAM

Source: ATRC, 1992.

TABLE D-3
AD-HDTV SYSTEM SPECIFICATION

SERVICES	NOMINAL MODE	ADDITIONAL MODE
Video	1 HDTV video signal	video cap. may be traded for aditional audio and data cap.
Raster format	1050 scan lines	1050 scan lines
	2:1 interlaced	1:1 prog. scan
	16:9 aspect ratio	16:9 aspect ratio
Field/Frame rate	59.94 fields/s	29.97 frames/s or
		24 frames/s
Pixel format	1440X960 lum	1440X960 lum/
	720X480 chroma	207X480 chroma
Sampling rate	54 MHz (27 MHz chroma)	
Video bandwidth	24.4 MHz(12.25 chroma)	Up to 27 MHz
Resolution	730 TVL/PH	Up to 810 TVL/PH
	365 TVL/PH chroma	
Compression technique	MPEG++	
Compressed video bit rate	17.73 Mbps	
Audio	2 stereo pairs	Up to 72 stereo pairs
Sampling rate	48 kHZ, 16 bits/sample	
Audio bandwidth	23 kHz	
Compression technique	MUSICAM	
Compressed audio bit rate	256 kbps per stereo pair	
Auxiliary data	256 kbps	Up to 18.5 Mbps

D.5.2 CCDC-HDTV (Channel Compatible DigiCipher HDTV System)

(Note: For a detailed description of this system please see -- "Channel Compatible DigiCipher HDTV System" submitted by Massachusetts Institute of Technology on behalf of American Television Alliance, May 14, 1992. The description below has been taken from that report).

The CCDC-HDTV (Channel-Compatible DigiCipher HDTV) system is an all-digital HDTV system developed by Massachusetts Institute of Technology and General Instrument Corporation. The CCDC-HDTV system is an all digital system which has a number of important features. The system is channel compatible and will fit within the channels currently being used for terrestrial broadcast transmission. A high resolution progressively scanned baseline video signal of 1280 X 720 picture elements, 59.94 fps, and 16:9 aspect ratio, and four channels of compact disc quality audio can be transmitted within a single 6 MHz channel.

The system is source adaptive. The system can recognize and adapt itself to the particular characteristics of the source format so that the highest video quality can be reconstructed. The system is also extensible and scalable, so that future improvements can be accommodated and receivers of different price/complexity/per-formance classes can be accommodated.

The system is resistant to channel impairments. Very high quality video can be delivered to the home despite substantial channel degradations. Because of this resistance to noise, high picture quality can be achieved with the same coverage area as the current NTSC service at substantially lower power, thereby making the use of taboo channels possible.

The system has been designed to be modular. Video processing, audio processing, and transmission systems are separated and largely independent of each other. This has the advantage that the video and audio processing systems can be used for other applications and will not require significant changes when other media are used for transmission. Modularity also leads to reduced hardware complexity which will lead to significant reduction in development and production cost of VLSI chips.

The system uses motion compensated transform coding for video processing, adaptive transform coding for audio processing and quadrature amplitude modulation with Reed-Solomon coding, trellis coding and adaptive equalizer for transmission. Figure D-6 illustrates the CCDC-HDTV high level systems block diagram.

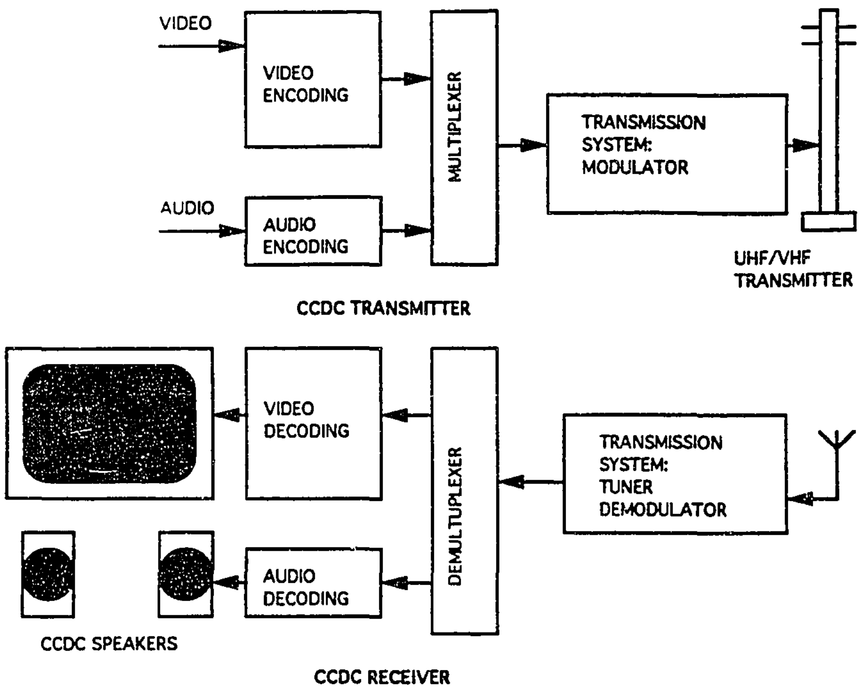


FIGURE D-6 CCDC HIGH-LEVEL BLOCK DIAGRAM

Source: American Television Alliance, 1992.

TABLE D-4
CCDC-HDTV SYSTEMS PARAMETER

OPERATING MODE	32-QAM	16-QAM
VIDEO		
Scanning	Prog	Prog
Aspect Ratio	16:9	16:9
Frame rate	59.94 Hz	59.94 Hz
Bandwidth		
Luminance	34 MHz	34 MHz
Chrominance	17 MHz	17 MHz
Active pixels		
Luminance	1280(H)X720(V)	1280(H)X720(V)
Chrominance	640(H)X360(V)	640(H)X360(V)
Sampling frequency	75.5 MHz	75.5 MHz
Colorimetry	SMPTE 240M	SMPTE 240M
Horizontal line time	21.18 micro sec.	21.18 micro sec.
AUDIO		
Number of channels	4/6	4/6
Bandwidth	24 kHz	24 kHz
Sampling frequency	48 kHz	48 kHz
Compression technique	MIT-AC	MIT-AC
DATA		
Video data	18.88 Mbps	13.60 Mbps
Audio data	755 kbps	755 kbps
Async data and text	126 kbps	126 kbps
Control channel data	126 kbps	126 kbps
Total data rate	19.89 Mbps	14.60 Mbps
TRANSMISSION		
FEC data	6.54 Mbps	6.54 Mbps
Data transmission rate	26.43 Mbps	21.15 Mbps
QAM symbol rate	5.287 MHz	5.287 MHz

D.5.3 DigiCipher HDTV System

(Note: For a detailed description of this system please see -- "DigiCipher HDTV System Description," submitted by General Instrument Corporation on behalf of American Television Alliance, August 22, 1991).

The DigiCipher HDTV system has been developed by General Instrument Corporation and Massachusetts Institute of Technology. It is an all digital system that can be transmitted over a single 6 MHz VHF or UHF channel. It provides full HDTV performance with virtually no visible transmission impairments due to noise, multipath, and interference. It offers high quality, while the complexity of the decoder is low. The low transmitting power is ideal for simulcast using the unused taboo channels. The system can also be used for cable and satellite transmission.

To achieve full HDTV performance in a single 6 MHz bandwidth, a highly efficient, unique compression algorithm based on DCT (Discrete Cosine Transform) coding is used. For error free transmission of the digital data, powerful error correction coding combined with adaptive equalization is used. The system provide two distinct modes, 32-QAM and 16-QAM. At a carrier-to-noise ratio above 16.5 dB, essentially error free transmission can be achieved. Figure D-7 shows the overall system block diagram.

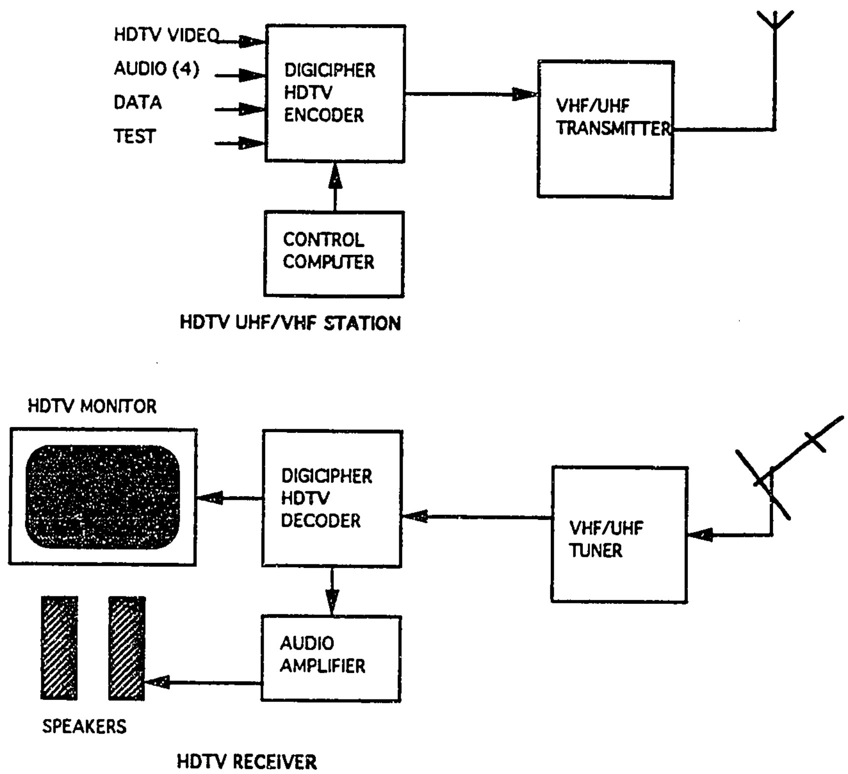


FIGURE D-7 DIGICIPHER BLOCK DIAGRAM

Source: American Television Alliance, 1992.

Figure D-8 shows the block diagram of the encoder. The digital video encoder accepts YUV inputs with 16:9 aspect ratio and 1050 line interlace at 59.94 field rate. The digital video encoder implements the compression algorithm and generates a video data stream.

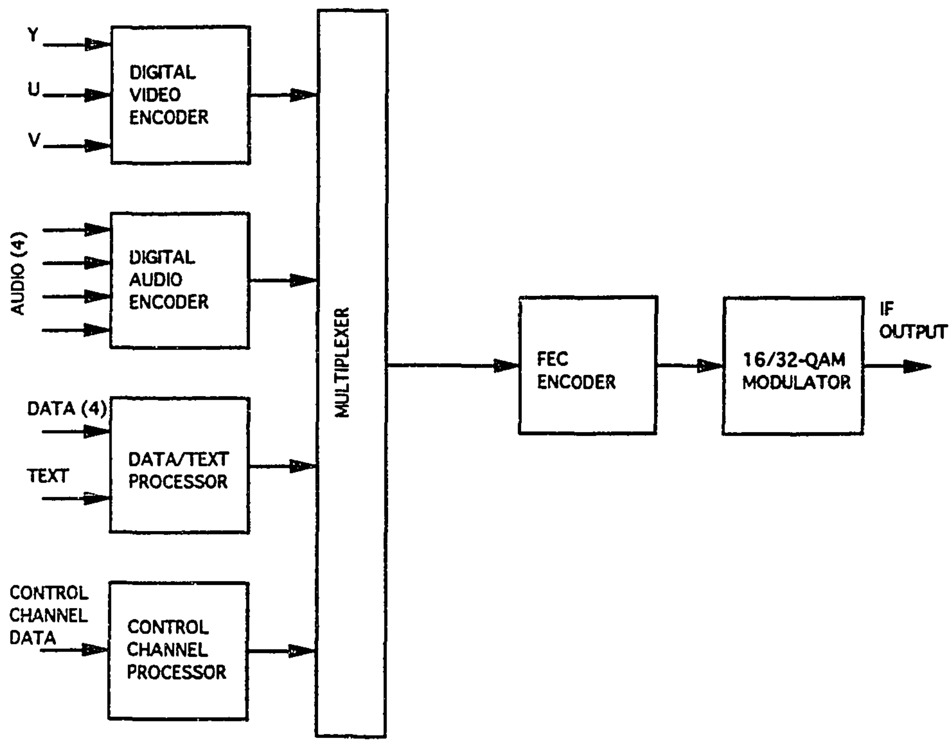


FIGURE D-8 DIGICIPHER SYSTEM ENCODER BLOCK DIAGRAM

Source: American Television Alliance, 1992.

Figure D-9 shows the block diagram of the decoder. The 32-QAM demodulator receives an IF signal from the tuner and provides the demodulated data at 24.39 Mbps.

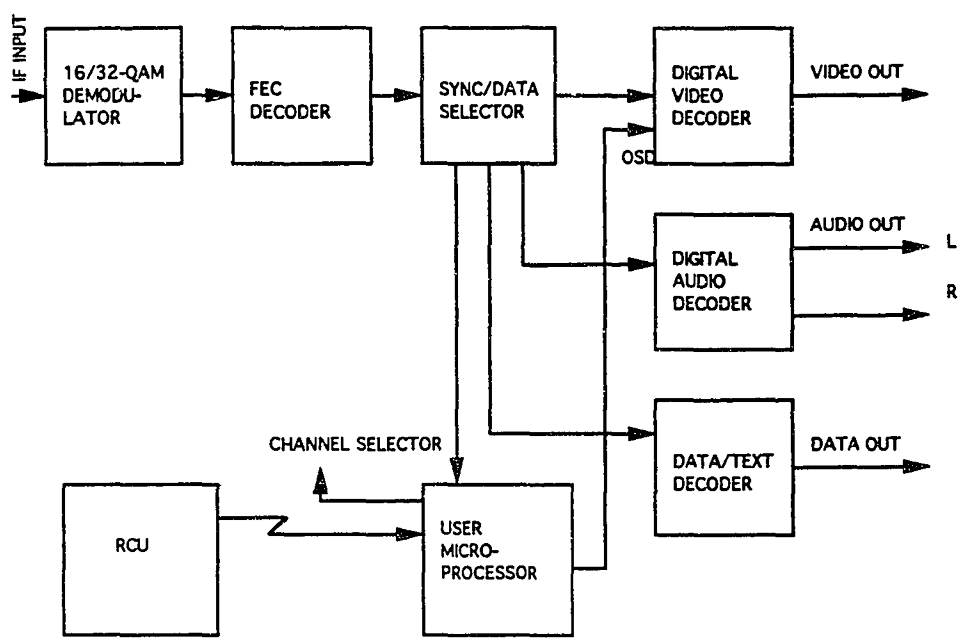


FIGURE D-9 DIGICIPHER SYSTEM DECODER BLOCK DIAGRAM

Source: American Television Alliance, 1992.

TABLE D-5
DigiCipher SYSTEM PARAMETER

OPERATING MODE	16-QAM	32-QAM
VIDEO		
Raster format	1050/2:1 interlaced	1050/2:1 interlaced
Aspect Ratio	16:9	16:9
Frame Rate	29.97 Hz	29.97 Hz
Bandwidth		
Luminance	21.5 MHz	21.5 MHz
Chrominance	5.4 MHz	5.4 MHz
Active Pixels		
Luminance	960(V)X1408(H)	960(V)X1408(H)
Chrominance	480(V)X352(H)	480(V)X352(H)
Horizontal resolution		
Static	660 line/picture height	660 l/p height
Dynamic	660 "	660 "
Sampling frequency	53.65 MHz	53.65 MHz
Colorimetry	SMPTE 240M	SMPTE 240M
Horizontal line time		
Active	26.24 micro sec	26.24 micro sec
Blanking	5.54 micro sec	5.54 micro sec
AUDIO		
Number of channels	4	4
Bandwidth	20 kHz	20 kHz
Sampling frequency	47.2 kHz	47.2 kHz
Dynamic range	90 dB	90 dB
DATA		
Video data	12.59 Mbps	17.47 Mbps
Audio data	503 kbps	503 kbps
Async data and text	126 kbps	126 kbps
Control channel data	126 kbps	126 kbps
Total data rate	13.34 Mbps	18.22 Mbps
TRANSMISSION		
FEC data	6.17 Mbps	6.17 Mbps
Data transmission rate	19.51 Mbps	24.39 Mbps
QAM symbol rate	4.88 MHz	4.88 MHz

D.5.4 Narrow MUSE (Narrow Multiple Sub-Nyquist Sampling Encoding)

(Note: For a detailed description of this system please see -- "Narrow-MUSE System Description," NHK Japan Broadcasting Corporation, April 22, 1991)

Narrow-MUSE is a simulcast system that can transmit a full HDTV picture and four digital audio signals within a 6 MHz channel. It employs Multiple Sub-Nyquist Sampling Encoding (MUSE) scheme for video and Near-Instantaneous Companded DPCM (DANCE) scheme for audio signals. Digital audio signals and ancillary data are multiplexed during the vertical blanking interval using ternary code. In order to transmit the Narrow-MUSE signal through terrestrial channel without causing interference, a new modulation scheme is used.

Narrow-MUSE employs advanced digital technology for the baseband encoding and decoding, and also for signal processing in the modulator and demodulator.

Narrow-MUSE uses the same coding scheme as the full-band MUSE signal, which is designed for satellite HDTV broadcasting and has a bandwidth of 8.1 MHz.

(Note: This system will not be discussed further because it is analog system and was dropped out of the race).

TABLE D-6
SPECIFICATIONS OF NARROW-MUSE

VIDEO	
Scanning rate	Source: 1125/60/2:1
	Transmission: 750/60/2:1
	Display: 1125/60/2:1
Aspect ratio	16:9
RF bandwidth	6 MHz
Baseband width	4.86 MHz (-6 dB)
NTSC compatibility	Simulcast
Colorimetry	SMPTE 240M
Temporal effects	The spatial resolution of moving portions becomes one half of stationary portions.
AUDIO	
Number of channels	Mode A: 4 channels
	Mode B: 2 channels
Signal bandwidth	Mode A: 15 kHz
	Mode B: 20 kHz
Dynamic range	Mode A: 90 dB or over
	Mode B: 96 dB or over
Coding scheme	DPCM, Near-instantaneous companding with 8 ranges for Mode A, 6 ranges for Mode B.
Modulation scheme	Encoded signals are multiplexed in the vertical blanking interval of the video signal.

D.5.5 Digital Spectrum Compatible HDTV

(Note: For a detailed description of this system please see -- "Technical Details : Digital Spectrum Compatible HDTV," submitted by Zenith Corporation and AT&T, September 23, 1991).

Zenith and AT&T have developed this all digital HDTV simulcast system that combines powerful video compression technology and a unique simulcast transmission system. It provides full high definition resolution -- perceived to be equal to studio original -- even after compressing the wide bandwidth signal into a 6 MHz channel. The system digitally transmits the compressed signal on currently unusable taboo channels with only minimal interference to or from NTSC channels. Figure D-10 and Figure D-11 shows a block diagram of this system's transmitter and receiver respectively.

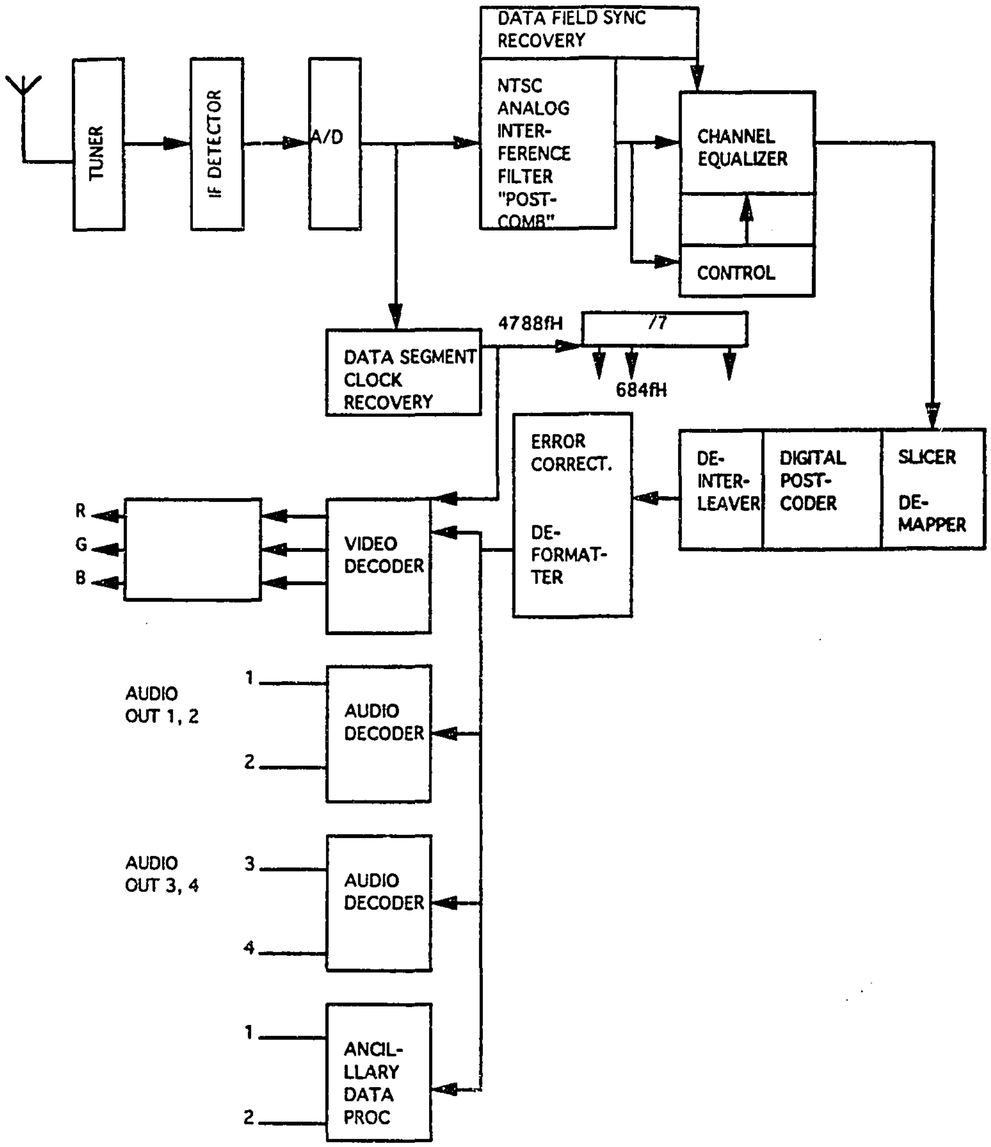


FIGURE D-10 DSC-HDTV RECEIVER BLOCK DIAGRAM

Source: Zenith & AT&T, 1991.

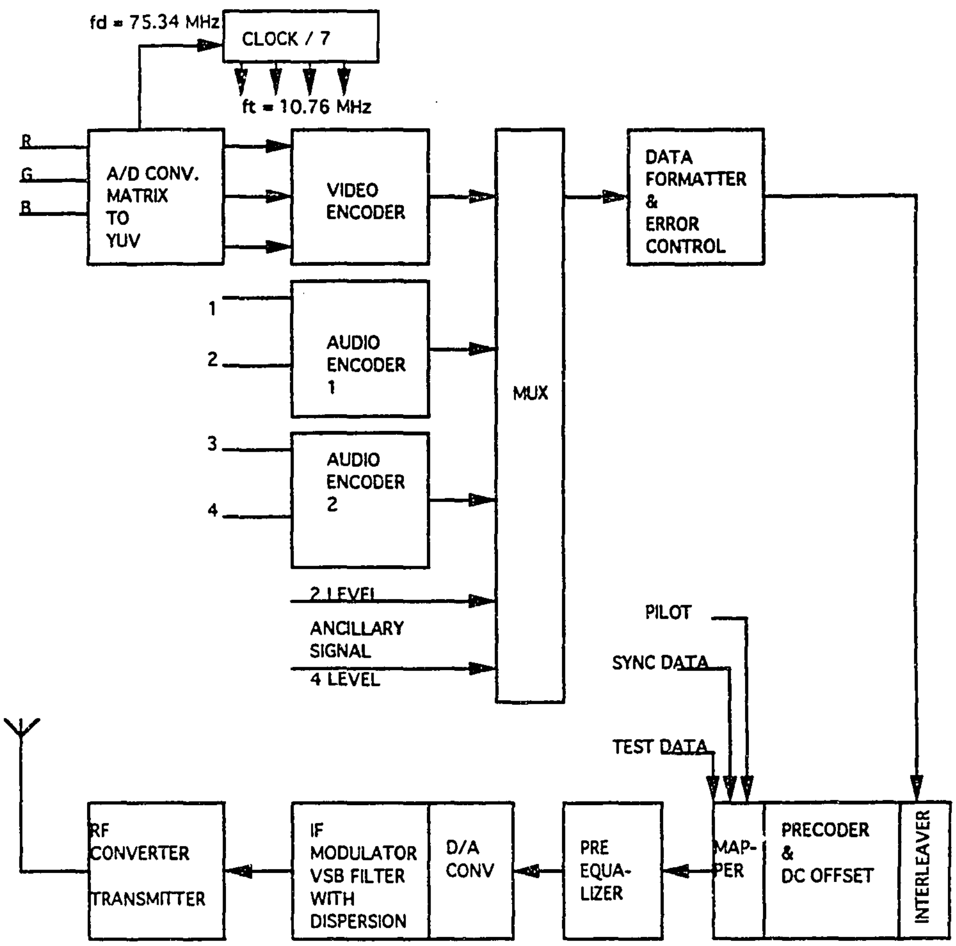


FIGURE D-11 DSC-HDTV TRANSMITTER BLOCK DIAGRAM

Source: Zenith & AT&T, 1991.

The DSC-HDTV system's high performance compression and RF transmission technologies provide transparent picture quality utilizing a maximum video data rate (up to 17 Mbps) and provide noise-free and ghost-free terrestrial broadcast reception throughout a broad service area. DSC-HDTV is compatible with other media, including cable, satellite, studio VTRs, home VCRs, video disc, fibre, etc. The system's 787.5-line progressive scanning format eliminates artifacts of interlaced systems, provides full motion rendition and promotes HDTV compatibility with current and future computer and digital communications technologies.

TABLE D-7
DSC-HDTV SYSTEM PARAMETERS

PARAMETERS	VALUE
VIDEO	
Aspect ratio	16:9
Raster format	787.5/1:1 progressive
Frame rate	59.94
Bandwidth	
Luminance	34 MHz
Chrominance	17 MHz
Active Video pixel	
Luminance	1280(H)X720(V)
Chrominance	640(H)X360(V)
Sampling frequency	53.65 MHz
Colorimetry	SMPTE 240M
AUDIO	
Number of channels	4
Sampling frequency	75.3 kHz
Bandwidth	20 kHz
Dynamic range	96 dB
DATA	
Video data	Automatically varies from 8.6 to 17.1 Mbps
Audio data	.5 Mbps
Control data	40 kbps
Total data rate	11.1 to 21 Mbps

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APPENDIX E
HDTV MARKET

E.1 Background

The future growth and the ultimate size of various HDTV related markets are unknown. As with most products that are yet to be introduced in the market, HDTV markets also depends on many complicated and unpredictable factors. No one knows how the HDTV market will develop. On one hand, it could be very possible for HDTV to become irresistible to the consumers and the market might grow at unprecedented rate, while on the other hand, HDTV market might grow slowly -- growing only after much larger and improved display technologies are available -- after consumers are sensitized to the value of its higher picture quality and after quality programming is available (FCC, 1989). It is also very possible for less advanced version of ATV like IDTV or EDTV to prove to be more favorite to the consumer, limiting HDTV to a small market.

HDTV market research has been very ambiguous and contradictory. Despite the lack of concrete audience based HDTV market research, a number of analysts have projected HDTV markets in the United States. Their forecasts have been made by analogy modeling HDTV penetration rates after black and white TV, color TV, VCR etc. These models implicitly assume that HDTV will eventually be successful. There have been numerous products such as videodisks, quadraphonic sounds, stereo AM radio etc. that have been marketing disasters (Schnaars, S.P., 1988). The HDTV models project market penetration rates which follow the traditional S-shaped curve and neglect the inverted U-shaped curve for unsuccessful products (OTA, 1990). All of them assume that the high-end markets will provide economies of scale to reach the middle level and lower level income consumers. They ignore substitutes such as IDTVs and EDTVs. Some have suggested that HDTV markets will be a big flop (Davis, B., 1989), emphasizing the high initial price of HDTVs and questioning whether consumers see enough additional value over their current sets to justifying paying the difference. Among the important analysis that has been performed is the "American Electronics Association Report" prepared by Advanced Television Task Force Economics Impact Team (November, 1988), "Electronics Industries Association Report" prepared by Robert R. Nathan Associates Inc. (February, 1989), and "National Telecommunications and Information Administration Report" prepared by Darby Associates (April, 1988).

E.2 American Electronics Association

(Note: This report was prepared by ATV Task Force Economic Impact Team for the American Electronic Association in November, 1988. The title of the report was "High Definition Television (HDTV): Economic Analysis of Impact.").

The reports objectives were --

1. To identify trends in potential worldwide and U.S. markets for HDTV and related products by 2010;
2. To give a perspective on the impact of HDTV on U.S. economy; and,
3. To give some idea of the cost of new entrant.

The report recognized that economic competitiveness has become the national security issue. Further, it mentions that ATV is a fundamental new imaging technology with enormous capability to effect not only most electronics industry segments but the balance in end-use markets between cable, broadcasters, etc. It is therefore, vital for the U.S. to participate actively in HDTV.

The sources of information for the report were leading U.S. research companies (Dataquest, Semiconductor Industry Association (SIA), Larry Darby Associates, and BIS Machintosh), the U.S. Department of Commerce (DOC), the Office of U.S. Trade Representative, Berkeley Roundtable on International Economics, top executives from former U.S. manufacturing firms, etc. The worldwide sales of HDTV projected, according to the report, is listed in Table E-1 and Table E-2.

TABLE E-1
HDTV RECEIVERS
WORLDWIDE SALES FORECAST*
(IN THOUSANDS OF UNITS)

DATE	U.S.	EUROPE	JAPAN	R.O.W.	TOTAL	CUMUL.
1990	1	1	20	1	23	23
1991	5	2	80	3	90	113
1992	7	2	150	3	162	275
1993	10	3	260	5	278	553
1994	20	5	350	6	381	934
1995	30	5	450	10	495	1429
1996	80	10	620	15	725	2154
1997	100	50	800	20	970	3124
1998	250	150	1000	30	1430	4554
1999	500	300	1200	100	2100	6654
2000	1000	1000	1600	700	4300	10954
2001	1600	1500	2000	1200	6300	17254
2002	2600	2400	3000	1900	9900	27154
2003	4900	3000	3500	2500	13900	41054
2004	6500	4500	4500	3400	18900	59954
2005	6700	5000	5000	4000	20700	80654
2006	6800	5500	5000	4700	22000	102654
2007	6900	6500	4800	5300	23500	126154
2008	7900	7000	4000	5500	24400	150554
2009	8900	8000	4500	5800	27200	177754
2010	11000	8500	4500	6000	30000	207754

*Source: American Electronic Association, November 1988.

TABLE E-2
HDTV RECEIVERS
WORLDWIDE SALES FORECAST*
(IN MILLIONS OF U.S. DOLLARS)

DATE	U.S.	EUROPE	JAPAN	R.O.W.	TOTAL	CUMUL
1990	4	4	80	4	92	92
1991	18	4	280	10	314	406
1992	25	7	480	10	522	928
1993	29	9	754	15	806	1734
1994	54	14	945	16	1028	2762
1995	75	14	1125	25	1238	4001
1996	176	22	1364	32	1594	5595
1997	200	100	1600	40	1940	7535
1998	450	270	1800	54	2574	10109
1999	800	480	1920	160	3360	13469
2000	1500	1500	2400	1050	6450	19919
2001	2080	1950	2600	1560	8190	28909
2002	2860	2640	3300	2090	10890	38999
2003	4900	3000	3500	2500	13900	52899
2004	5850	4050	4050	3060	17010	69909
2005	5360	4000	4000	3200	16560	86469
2006	5100	4125	3750	3525	16500	102969
2007	4830	4550	3360	3710	16450 119418	119418
2008	5135	4550	2600	3575	15860	135279
2009	5563	5000	2713	3625	17000	152279
2010	6600	5100	2700	3600	18000	170279

*Source: American Electronic Association, November 1988.

The figures of Table E-1 and Table E-2 do not include EDTV or IDTV. The projections are very close to the historical take-up rates for color TV. The pricing was estimated to start at $4,000 in 1990 for the early units, dropping to $2,500 in the year 1995, $1,500 in the year 2000, $800 in the year 2005, and $600 in the year 2010. (Note: Due to the delay in the decision of the FCC, it is expected that HDTV will be introduced only around 1995. Thus the projections made above will be shifted).

The conclusions that were reached in the report were as follows -- For the United States to re-enter the consumer electronics market via

HDTV -- a new technology with a huge market opportunity -- it will need the following --

1. A legislative agenda that supports/encourages reentry into consumer electronics by U.S. corporations;

2. Investment of capital that measures success as growth of marketshare;

3. Development of a new licensing of a proven receiver technology that is equal or superior to that of foreign manufacturers;

4. Establishment of U.S. manufacturing capability for production of TV displays and for assembly of receiver components;

5. Implementation of a creative marketing strategy that convinces consumers to buy HDTV and the value of buying American product, along with a pricing strategy that recognizes the Japanese "staying power" when it comes to buying marketshare;

6. Adaptation of a distribution strategy based on capturing shelf space currently dominated by foreign manufacturers and underpinned by competitive pricing, better product performance and features, and a reliable service; and,

7. U.S. enforcement of anti-dumping laws.

E.3 Electronic Industries Associates

(Note: This report was prepared by Robert R. Nathan Associates, Inc., Economic and Management Consultants, Industry Research and Analysis Group, Washington, D.C. for the Electronics Industries Association in February 1989. The title of the report was " Television Manufacturing in the United States: Economic Contributions -- Past, Present, and Future.").

The report mentions that the development of HDTV will affect the nature of U.S. color television manufacturing industry significantly. The new technology will have an effect on virtually all segments of the television industry: television program and software production, transmission system, the reception and display equipment.

The purpose of the report was to estimate the tangible contributions of color television manufacturing in the United States since 1980. Secondly, the purpose of the report was to determine the likely future of HDTV and its impact on the domestic color television manufacturing industry and its contribution to the U.S. economy.

There were three methods that was employed to achieve these purposes. First, a mail and a telephone survey of industry experts and current manufacturers of color televisions in the United States was conducted to determine historical production volumes, factory value of production, prices, major television components, and, for each component, the percentage sourced overseas. Next, the Multi-Regional Policy Impact Simulation (MRPIS) model, which was developed at the Social Welfare Research Institute (SWRI) at Boston College, was used to estimate the direct, indirect, and induced impacts on the economy of color television manufacturing. Lastly, an economic forecasting model developed by RRNA was used to predict HDTV production and sales.

The findings of the report was as follows --

The production and sale of high definition television will have substantial effects on color TV manufacturing in the United States. In the year 2003, 13 million HDTV units will be sold, a fraction less than the number of color TVs produced and sold in the United States in 1987; more than 12 million of the 13 million HDTVs will be manufactured in the United States. Sales of U.S.-made HDTV will generate more than 3.6 times retail value of U.S. production in 1987, and about 3.3 times the industry's contribution to GNP. Household penetration will reach 25 percent by the beginning of 21st century.

The HDTV forecast results are given in Table E-3. It illustrates the number of units, as well as the dollar value.

TABLE E-3
FORECAST OF HDTV*
(UNITS IN MILLIONS AND DOLLARS IN BILLIONS)

YEAR	TOTAL UNITS	TOTAL DOLLARS
1989	21.3	9.9
1990	22.4	10.6
1991	23.6	11.3
1992	24.6	12.0
1993	26.0	13.9
1994	27.3	15.7
1995	28.6	18.1
1996	29.9	19.8
1997	31.3	21.6
1998	32.7	23.6
1999	34.1	24.8
2000	35.6	26.2
2001	37.1	26.0
2002	38.6	26.0
2003	40.2	27.7

*Source: Electronics Industries Association, February 1989.

E.4 National Telecommunications and Information Administration

(Note: This report was prepared by Larry Darby, Darby Associates for National Telecommunications and Information Administration in April 7, 1988. The report title was "Economic Potential of Advanced Television Products.").

The purpose of the report was to analyze some potential economic impacts of the introduction of new video and related products into the U.S. market and to assess in a preliminary way the implications for the U.S. economic development and other national goals. The overriding purpose was to set forth reasonable views of the market implications of advanced television (ATV) technologies, systems and products.

The methodology used in the report was the traditional method of inference of a potential growth path indirectly from the history of other product innovations and applying it to the diagonal S-curve growth path. The products analyzed were (CTV) Color Television Receivers, (VCR) Video Cassette Recorders, (TVRO) Television Receive-Only Earth Stations, Projection Television Receivers, Home Computers, and Audio Stereo Component Systems. The Stages of Growth were identified as Stage 1 -- The Innovation Stage, Stage 2 -- Growth and Imitation Stage, and Stage 3 -- Maturity Stage. Two scenarios "Scenario 1" -- Sluggish Diffusion and "Scenario 2" -- Rapid Product Diffusion were created.

The conditions for "Scenario 1" -- Sluggish Economy is as follows --

1. Continuing uncertainty of spectrum constraints and receiver standards;
2. Delay in R&D programs directed to competing technologies, systems and products;
3. Periodic and prolonged domestic macroeconomic conditions involving some combination of slow growth, substantial government deficit reduction programs, flattening or declining real consumer spending and unfavorable employment conditions;
4. High and rigid ATV product prices; and,
5. Weak revealed household preferences for ATV products.

The conditions for "Scenario 2" -- Rapid Product Diffusion is as follows --

1. Timely and decisive regulatory action respecting receiver standards and spectrum limitations;
2. Accelerated R&D programs leading to product diversity and active price competition;
3. Sufficient sales in the first ten years to avail producers the opportunity to exploit scale and learning economies; and,
4. Rapid development of high quality, moderately priced, compatible supply sources.

"Scenario 1" Forecasts -- If the conditions for "Scenario 1" prevails, the report concludes that it is quite conceivable that one percent household penetration threshold would not be realized until well after the year 2000, replicating the historic growth of projection TV sets. Depending upon the pattern of product prices over that period cumulative value of sales could be in the $3 to $5 billion range.

"Scenario 2" Forecasts -- If the conditions for Scenario 2 prevails, the report concludes the market value to be as in Table E-4. Table E-4 combines the result of receivers and VCRs and values unit sales by applying a range of hypothetical product prices.

TABLE E-4
FORECAST OF ATV PRODUCTS
(UNITS IN MILLIONS AND DOLLARS IN BILLIONS)*

YEAR		CUM. SALE TV			CUM SALE VCR		TOT	
	NUM.	VAL.	VAL.	NUM.	VAL.	VAL.	VAL.	
		HIGH	LOW		HIGH	LOW	HIGH	LOW
1997	1.0	.8	.4	1.0	.6	.3	1.4	.7
1998	2.6	2.0	1.0	2.6	1.5	.75	3.5	1.75
1999	5.2	4.2	2.1	5.2	3.1	1.5	7.3	3.6
2000	9.3	7.4	3.7	9.3	5.6	2.8	13.0	6.5
2001	15.9	12.7	6.4	15.9	9.5	4.8	22.2	11.1
2002	26.4	21.0	11.5	26.4	15.8	7.9	36.8	19.4
2003	37.9	30.3	15.6	35.6	21.4	10.7	51.7	25.3
2004	50.6	40.5	20.2	45.8	27.4	13.7	67.9	33.9
2005	64.6	51.6	25.8	57.0	34.2	17.1	85.8	42.9
2006	80.0	64.0	32.0	66.2	39.7	19.8	103	51.8
2007	96.9	77.5	38.6	76.3	45.8	22.9	123	66.6
2008	115	92.4	46.2	87.5	52.5	26.2	144	72.4

Source: National Telecommunications and Information Administration, April 7, 1988.

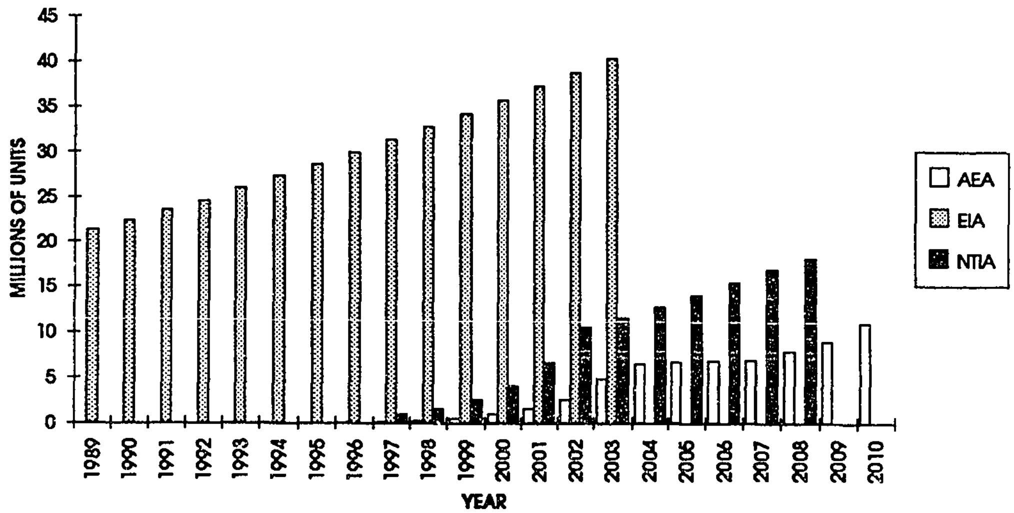
The conclusions that was reached by the report was as such -- The potential wealth that may be generated in world markets for ATV over the next twenty years is astounding. The future development of this technology may offer both enormous opportunity and significant risk to U.S. interests.

E.5 Analysis of the Reports

The forecasts have been made by analogy, i.e., modeling HDTV penetration rates after successful consumer products like monochrome TV, color TV, VCRs, etc. The forecasts therefore needs to be taken with a grain of salt because there are many products that were marketing blunders like videodisk, AM stereo radio etc. (Schnaars, S.P., 1988). Further, the projections rely on the high-end markets driving the cost reduction from economies of scale to reach lower levels. Without a strong audience-based HDTV market research this logic seems quite vulnerable to wide criticism. The projections have inherently assumed that HDTV will be a great success. Substitute products such as EDTV or IDTV could dampen the HDTV markets significantly. Further several factors will combine to determine the rate of diffusion of HDTV related products (NTIA, 1989). Key elements underlying consumer demand include prices, quality and introductory timeliness of new HDTV product lines; consumer income and their general acceptance of new HDTV products; the availability, quality, and pricing of complimentary products/services (software, programming, distribution media, and the like); and, very importantly, the content and timing of equipment and spectrum standards adopted by the relevant government entities.

The traditional inclined S-curve growth rate seems to be the locus of product development that the projections have relied on. This method which is non-contradictory relies on three general variables -- 1. the Take-off point, 2. the Rate of Take-off, and 3. the Tapering rate. The projections have determined these variables quite indiscriminately by using similar products as their benchmarks. All three projections have a different take-off point. The Electronics Industries Association (EIA) assumes the year 1994, the National Telecommunications and Information Agency (NTIA) assumes 1997, and the American Electronic

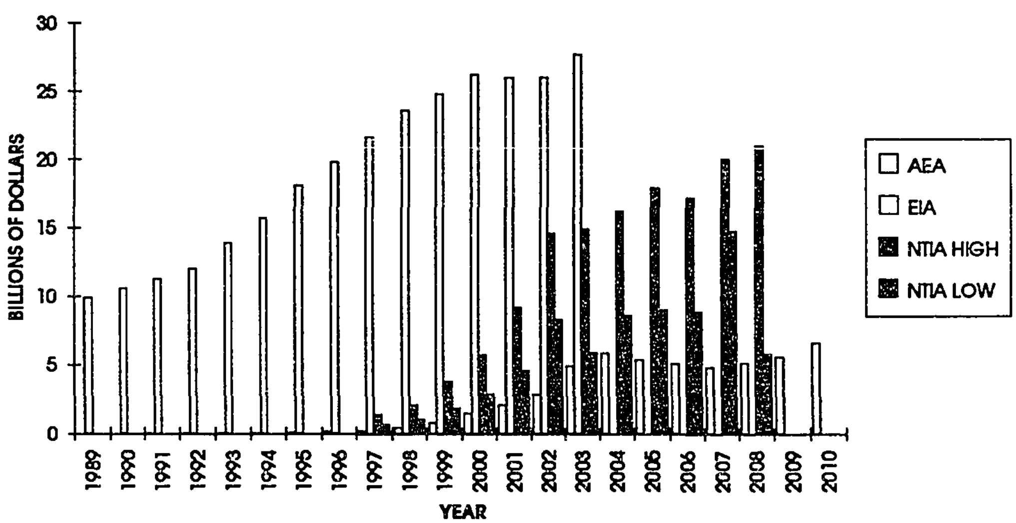
Association (AEA) assumes 2000. (Note: These projection were made during the end of eighties, when HDTV was expected to be introduced around 1992. Due to the delay in the decision making of FCC, the introduction of HDTV may not begin even as early as 1994. In such a case, the projections will have to be relatively displaced to take into consideration the delay factor). However, all three have similar take-off rates (See Graph E-1). The variable "tapering rate" has not been taken into consideration by any of the projections. There have been some products who have had rapid take-off rates, but have tapered off rapidly also (Schnaars, S.P., 1988).



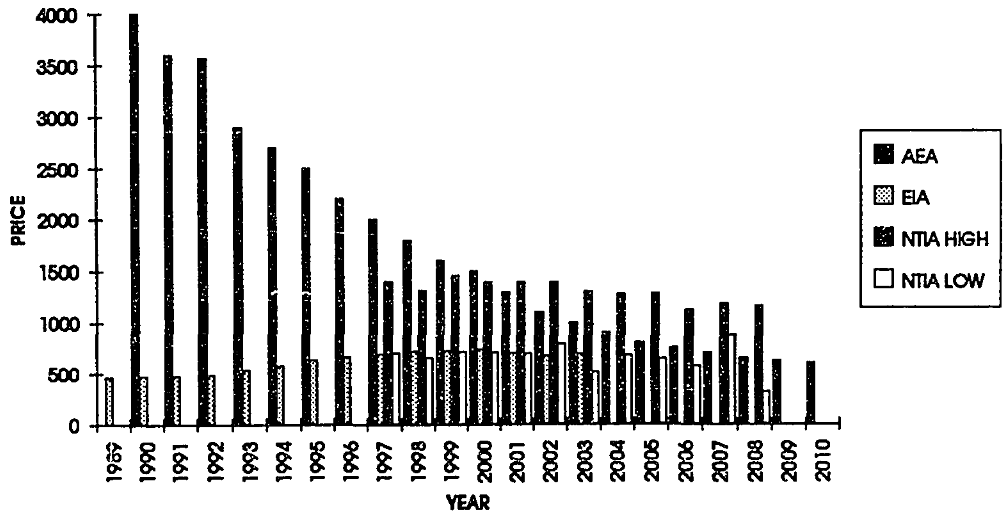
GRAPH E-1 PROJECTED ANNUAL U.S. UNIT SALES OF HDTV RECEIVERS

The HDTV market potential projected by the three reports are very large, but they do not cohere with one another. In 2003 EIA estimates the market to be $12 billion, NTIA estimates between $8 to $16 billion, and AEA estimates $8 billion in the United States and $32 billion worldwide.

The reports (Graph E-2) provide a wide range of market size and timing. Darby's high-growth and EIA forecast predict the market size to become comparable to the market size of color television in 1980 within 15 years. EIA and AEA predict a market size for HDTV to be as large as current VCRs market within the next 15 to 20 years. Darby's high growth scenario rises almost continuously, while others tend to peak off at the 1987 VCR and TV market size ($11.5 billion in 1987 (EIA Market Data Book, 1988). Graph E-3 shows the price assumption of each report. Darby's low-growth scenario's prices remain at about fairly constant at $2,500 and high growth remains fairly constant at about $600. The EIA and AEA prices continuously tend to decrease.



GRAPH E-2 PROJECTED ANNUAL U.S. MARKET VALUE OF HDTV PRODUCTS



GRAPH E-3 PROJECTED PRICE OF HDTV RECEIVERS

The forecasters in the report have compared the relative importance of the HDTV market by --

1. projecting constant growth rates into the future,
2. comparing the component demands for assumed market sizes, and
3. comparing ultimate market penetration and corresponding needs per user (OTA, 1990).

E.5.1 Extrapolating Current Growth Rates

Extrapolating current or expected growth trends at the same compound annual rate far into the future for making projections can lead to highly exaggerated claims. The introduction of high technology consumer products is usually followed by a lengthy trial period in which consumers, producers, and providers of ancillary services group toward a definition of the product (Reischauer, R.D., 1989). These projections ignore the simple point that sales cannot grow exponentially forever because markets eventually saturates and the take-off rates begin to taper.

E.5.2 Comparing the Component Demands for Assumed Market Sizes

This technique compounds the uncertainties of market growth rates with a lack of regard for relative importance of various type of components. For example, the memory chips in HDTV are widely used in other products, so the contribution is fairly complicated to predict.

E.5.3 Comparing Ultimate Market Penetration Rates and Corresponding Needs per User

With the technological progress the total volume of HDTV will slow down to only replacement levels. At that time the number of such devices used per person will determine the importance of the industry.

The market for HDTV, as envisioned may or may not develop at all. HDTV might see unforeseen success or it may prove to be a big flop. However, the importance of technology should not be understated. With the embracement of digital technology important technological spillovers can be envisioned. Technological linkages between components and market segments are undeniably important and not easily quantifiable. Linkages are usually more subtle and their impact on other industries and markets is often slow to develop. In spite of significant uncertainty about how might this market develop, most analyses indicate that the potential market is quite large and that, given the right conditions, market penetrations might be noticeably rapid.

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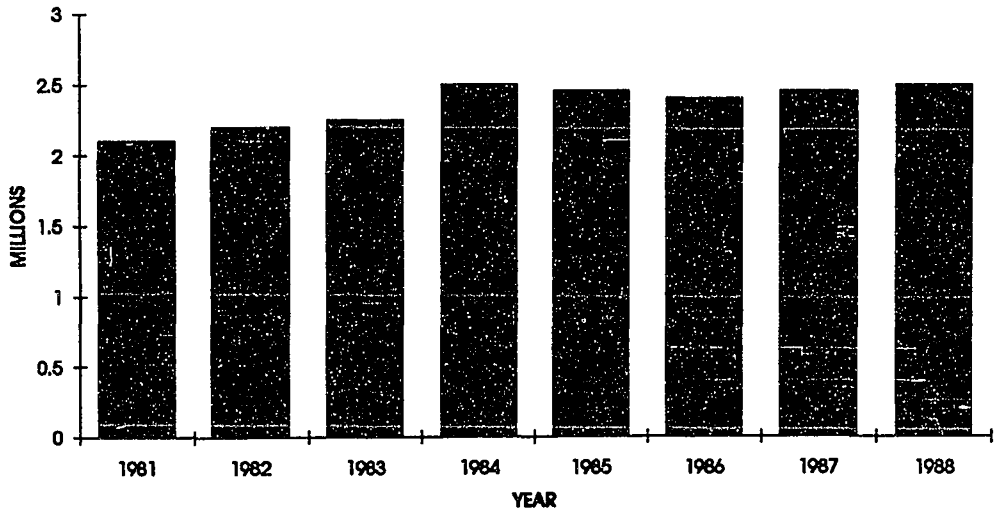
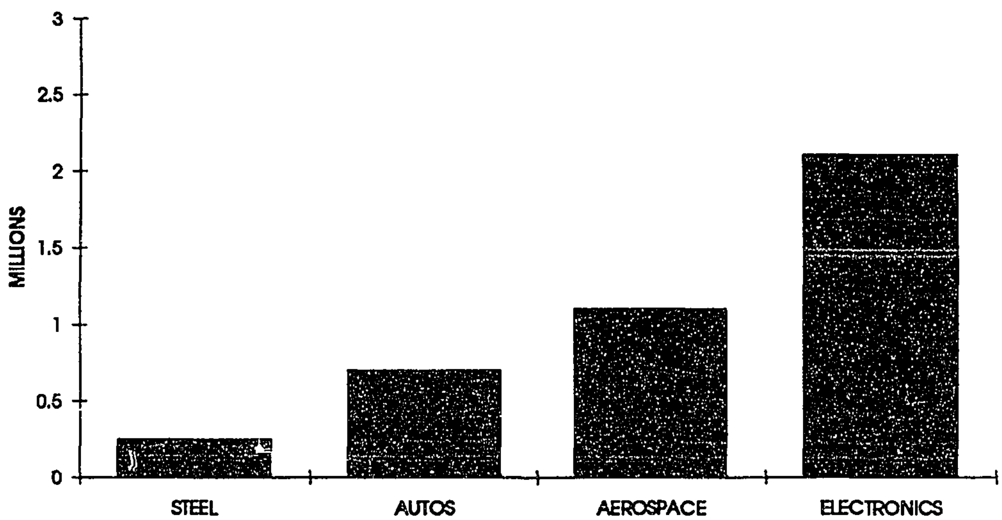
APPENDIX F
IMPORTANCE OF HDTV

HDTV means more to the U.S. electronics industry and in turn to the U.S. economy than just re-entering the consumer market. HDTV will drive leading edge technologies, such as advanced semiconductors. Some experts have forecasted that HDTV will be the consumer electronics product of the 1990s, much as the video cassette recorder (VCR) and the compact disc (CD) were the products of the 1980s (Sikes, A.C., 1989). Unless the U.S. industry can get a lion's share of the domestic HDTV market, the U.S. will not only miss the coming HDTV wave, but even risk losing the present share of the highly prized telecommunications and computer market (Lankford, D.S., 1989). Access to and significant involvement in the development of critical technologies involving HDTV products has the potential to confer significant advantages in a broad range of upstream, downstream and collateral product and service lines (NTIA, 1989). It is very important for the U.S. to get actively involved in the core technology (Jussawalla, M., & Rana, S., 1994). HDTV poses both critical challenge to the U.S. economy as well as opportunity. HDTV is more than a single new consumer electronics breakthrough, it is more than a single technology. The markets of HDTV will bring with it new wealth for the U.S. and directly impact its national economy, international trade, competitiveness, and national security. Today, the U.S. consumer electronics marketplace is heavily dependent on imports. However, changes in manufacturing technology, improvements in productivity, and a low dollar exchange rate give rise to the possibility of a "second chance" for U.S. manufacturing in the HDTV era (FCC Interim Report, 1988).

Electronics is now the largest durable goods manufacturing industry in the United States and is growing three times faster than all other manufacturing (Elkus, R., Jr., 1988). Over 2.6 million American Workers are directly employed in electronic manufacturing. This is more than three times the size of the auto industry, and nine times the size of steel fabrication industry (Rosenzweig, R., 1989)(See Graph F-1 and Graph F-2). The U.S. electronics industry accounts for more than one million jobs since 1976 (Hubbard, P.H., 1989). The electronics industry's nearly $250 billion in annual domestic sales translates into one U.S. job for every $100,000 in sales.



GRAPH F-1 LARGEST U.S. MANUFACTURING EMPLOYER



GRAPH F-2 ELECTRONICS JOBS COMPARED TO OTHER INDUSTRIES

Worldwide, the electronics market enjoys a compound growth rate of nearly 9 percent. Over the last decade electronics industries in the aggregate posted compounded annual growth rate (CAGR) in excess of 13 percent. Consumer electronics surpassed even that rate (NTIA, 1989). The United States accounts for 40 percent or more of the total demand for consumer electronics (Sikes, A.C., 1989). In 1987, $235 billion dollars of electronics goods were sold in the United States. In 1988, the United States incurred a consumer electronics trade deficit of about $10.2 billion, or about 8 percent of its total 1988 international deficit of $129 billion for manufactured goods (NTIA, 1989). Overall, the U.S. market share of consumer electronics manufacturing has declined from 100 percent in 1970 to less than 5 percent today. Between 1984 and 1987, the United States' share of world electronics production slipped from 50.4 percent to 39.7 percent (EIA, 1989). (Note: During that same period, Japan's share of world production increased from 21.3 percent to 27.1 percent, Western Europe's output share grew from 23.5 percent to 26.4 percent, and the so-called "Four Tigers" -- Hong Kong, South Korea, Singapore, and Taiwan -- rose from 4.9 percent to 6.8 percent of the world production (Sikes, A.C., 1989)). Consumer electronics has been a major contributor to the trade deficit problems. (Note: The U.S. could face an annual trade deficit of more than $225 billion in electronics and lose more than two million jobs a year by 2010 if it fails to develop HDTV (Cohen, R.B., & Donow, K., 1989)). Losses in the consumer electronics have had a pervasive impact throughout the electronic industry and economy as a whole. Unlike most other industries, the electronics industry is composed of interdependent segments which cross-sell within a complex, interrelated organizational matrix. This technological chain is much like the biological food chain. The survival of each unit in the chain -- materials, manufacturing equipment, semiconductors, circuit boards, computers, systems, software, etc. -- is critical to all of the other elements in the chain. Weakening or destruction of one link causes injury to all other parts of the chain (See Figure F-1). If the U.S. fails to research, develop, design, engineer and manufacture HDTV products and services, U.S. as a whole is likely to experience a continuing decline in world marketshare of automated manufacturing equipment, personal computers, and semiconductors. In addition, telecommunications and other significantly critical industries would follow (Rosenzweig, R., 1989).

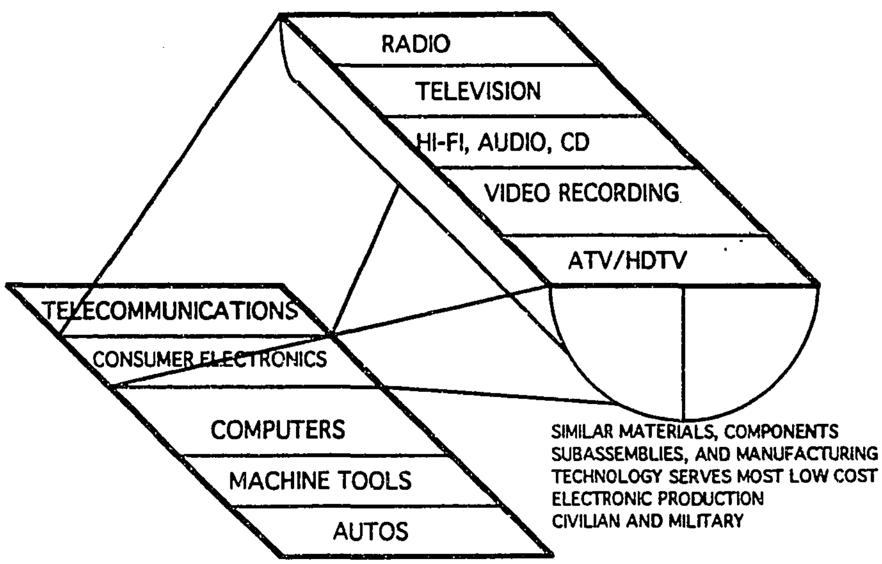


FIGURE F-1 TECHNOLOGY LINKAGES

HDTV has a tremendous potential of economic enhancement due to its "ripple effect" on non-consumer electronics segment such as semiconductor manufacturing, software, telecommunications, computers, etc. Access to and significant involvement in the development of critical technologies involving HDTV products has the potential to confer significant advantages in a broad range of upstream, downstream and collateral product and service lines (NTIA, 1989). HDTV R&D expenses could be leveraged across broad range of products. HDTV will absorb numerous quantities of semiconductors. The typical home HDTV set may contain some 30 time the memory chip capacity of today's personal computer (Sikes, A.C., 1989). Huge profits generated through the sales of HDTV products and licenses would allow unprecedented amounts of R&D dollars to be spent in furthering the electronics technologies. Finally, HDTV will drive information and knowledge technology; information is the key to a bright future -- it is a capital asset and the currency of national progress (Staelin, D.H., 1991).

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APPENDIX G
IMPACT OF HDTV

G.1 Background

The impacts of HDTV can be categorized along four divisions --

1. Potential Commercial and Industrial Impacts,
2. Potential Impact on International Trade,
3. Potential Impact on National Security, and
4. Potential Impact on employment (NTIA, 1989).

G.2 Potential Commercial and Industrial Impacts

G.2.1 Impact on the Semiconductor Industry

The technologies now being developed and applied to HDTV products are semiconductors intensive and will consume large quantities of semiconductors. HDTV will create a huge demand for a new generation of sophisticated semiconductors, including DRAMs (dynamic random access memory chips), specialized video chips or VRAMs (video random access memory chips) (Markey, E.J., 1989) and specialized digital signal processors (DSPs)(Eebre, P.C., 1989). ((Note: The NEC prototype HDTV receiver contains five chips for analog and digital signals conversion; six processing chips; and, eighteen memory chips (NTIA, 1989)). (Note: Dr. Craig I. Fields, Director of DARPA, said in his testimony to the "Hearing Before The Research and Development Subcommittee and The Investigations Subcommittee of the Committee on Armed Services House of Representatives," One Hundred First Congress, First Session, May 10, 1989, that report from the Electronics Industry Association of Japan, a Statement on Semiconductors dated 21 November, 1988 mentioned "Japanese investment plans (for DRAM production facilities) in the near future have sharply increased. This does not reflect predatory intent but rather a conviction that demand -- especially for memory chips -- will grow and stabilize with the introduction of new end use products using much larger quantities of DRAMs)". HDTV market dominance, or even large scale participation, will confer significant advantages in the production of current and future generations of semiconductors. These indicators are significant because there are a variety of important synergies between the level of HDTV-related products manufacturing, upstream scales of semiconductors and, further upstream, semiconductor materials and manufacturing processes. The following relationships can be documented (NTIA, 1989) --

1. Scale economies in semiconductor production are more readily attainable in the presence of high volume demand from the consumer electronics sector;

2. To the extent that common production processes are used, the cost of semiconductors for other uses will be lower as a result of the high volume demand from the consumer product sector;

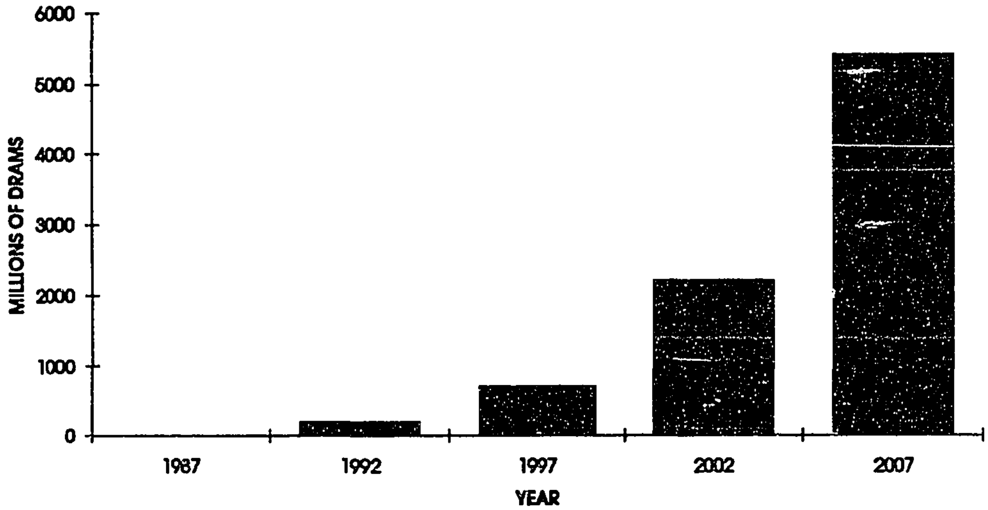
3. The cost of R&D for a wide range of commercial, industrial and governmental applications can be amortized across the consumer-electronics driven base;

4. The fairly stable demand for consumer electronics products can provide insulation from the more volatile demand of semiconductors from other sectors;

5. Cost advantages will accrue to favorably positioned suppliers by virtue of both economies of vertical integration and economies of scope;

6. Horizontally diversified and vertically integrated firms can use revenues from the consumer products and semiconductor lines to contribute to the development of new processes and new products both upstream and downstream;

7. High volume production of semiconductors gives rise to "learning" economies which increase the proportion of circuits that function, thereby driving down the average cost and price of salable output.



GRAPH G-1 WORLD-WIDE DRAM USAGE IN HDTV
Source: Fields, C.I., 1989.

G.2.2 Impact on the Computer Industry

The U.S. enjoys significant world-wide advantage in computer hardware and software, but all these companies, even IBM, depend on foreign competitors, especially Japanese firms, for the supply of substantial number of key components such as DRAMs which threatens the independence and competitiveness of the U.S. computer industry. (Note: The DRAM shortages in 1988 forced computer production cuts and substantial price increases (NTIA, 1989). Lack of U.S. participation in the HDTV markets will exacerbate the problems of U.S. computer industry and threaten its hardware because dependency in key components such as integrated circuits, analog to digital converters, microprocessors and low-noise, fast gallium arsenide logic devices, etc. will only continue to increase eroding the foundations of U.S. semiconductor industry.

G.3 Potential Impact on International Trade

The potential size of HDTV product market in the U.S. makes it potentially a very substantial entry into future trade accounts. The tremendous strategic importance of HDTV market has been recognized by U.S.'s closets trading allies the European Economic Community (EEC) and the government of Japan. Both these entities are competing vigorously in order to gain advantage in the enormous and pivotal U.S. HDTV marketplace. The extent to which ATV products are produced in the U.S., rather than offshore and imported, could have a significant influence on the size and composition of the trade balance.

G.4 Potential Impact on National Security

There are several specific defense applications of HDTV technologies, including: intelligence images and high quality dynamic displays; high fidelity simulator displays; large command center displays; multimedia systems including television as a data type; and, a variety of classified display systems whose supply dependence on foreign firms could prove detrimental to the national security. The Department of Defense (DOD) and Defense Advanced Research Projects Agency (DARPA) is well aware that dependency on foreign sources for state-of-the-art electronics technology is completely an unacceptable situation -- national security would require an adequate supply of the highest technology (Fields, C.I., 1989). U.S. national security is currently driven by the quest for qualitative rather than quantitative superiority in the defense system (Rosenzweig, R., 1989). The food chain analogy is specially important when considering the impact of HDTV upon national defense. Technological leadership in all of the interconnected segments of the electronics industry is critical if the U.S. is to maintain its qualitative edge, particularly in an era of declining budgets (Young, W.R., 1989). If the civilian industrial base moves offshore, the risks for defense and national security sharply increases. It is hard to separate national security from national economy (Fields, C.I., 1989). Technological leadership of all the elements of the electronics industry food chain is critical if the U.S. is to maintain its qualitative edge.

G.5 Potential Impact on Employment

The Darby Report submitted to NTIA contains an analysis of potential impact on employment utilizing multipliers for domestic production of consumer electronics products taken from a study conducted by Arthur D. Little for the "Consumer Electronics Group" of the Electronics Industries Association. According to the report, if HDTV does achieve a high consumer acceptance rate in the U.S., the extent or pattern of utilizing U.S. labor force is assured to change. Between 10,000 and 25,000 jobs will be created by HDTV-related industries for every $1 billion in final sales of HDTV products, according to Department of Commerce estimates (NTIA, 1989). The EIA report suggests that 130,000 jobs will be created through direct employment, while another 103,000 will be created through secondary effects. Darby's high-growth scenario presents a similar increase of 240,000 jobs. Cohen, R.B. and Donow, K. of the Economic Policy Institute mention "The U.S. could face an annual trade deficit of more than $225 billion in electronics and lose more than two million jobs a year by 2010 if it fails to develop HDTV (Cohen, R.B., & Donow, K., 1989)."

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APPENDIX H
GOVERNMENT RELATIONSHIP

H.1 Background

The letter dated October 9, 1989, from business, labor, and congressional leaders warned the President and Congress that "HDTV has become a symbol of our national willingness to compete in the strategic industries and technologies of the 1990s, and our failure to develop it could have alarming implications for our economic future (Rebuild America, October 9, 1989)." It is thus evident that HDTV has been fostering numerous support among government circles and affiliated agencies. However, the camp is distinctly divided into two distinct groups. One that advocates support from the government (the activists), and the other, advocates laissez faire solution (the skepticists).

H.2 Activists

Activists have argued that United States cannot afford to remain passive, particularly in the high-paced high-tech sector, where the initial advantage is believed to have enduring commercial importance and when other governments are targeting industries such as HDTV for promotion (Beltz, C.A., 1991). They press their arguments further by mentioning that U.S. policies must be geared up for the coming century and must be matched to that of foreign competitors. They mention that the issue is not whether, but rather how the government will be involved. Skepticists have argued that the government has a role to play but disagree on the form that this support should take, they believe more on the market mechanism. They believe the primary reason for this is the difficulty in picking up the right industry and determining the type of support (Note: This is quite a valid argument).

Technically, HDTV represents the next generation of television and economically, HDTV represents "To miss out on HDTV is to miss out on the 21st century (Ritter, D., July 10-16, 1989)." HDTV activist in the U.S. have argued that "America cannot afford to sit on the sidelines and let other nations develop an HDTV industry without our participation." These activist have rightly pointed out the lead of foreign competitors like Japan and Europe and have made the lack of U.S. competitiveness clear by pointing to the only remaining TV manufacturing company Zenith. They have contended that the U.S. is falling further and further behind and time is not in favor of U.S. but its competitors (Japan and Europe). They have made it clear that -- the market for HDTV and related products is enormous, and development of HDTV will foster productivity development which will help strengthen national economy and security. The competitiveness of the whole of the electronic food chain will be strengthened. HDTV will enable the U.S. economy to breathe a new life (Gore, A., August 1, 1989). They further their argument by saying that HDTV should be viewed not as a single industry, but an essential link in the electronic food chain that will help a wide range of U.S. firms capture productivity-enhancing benefits that would not otherwise be captured from the development of advanced digital technologies and components (Beltz, C.A., 1991). They contend that HDTV is a rare market opportunity to stimulate consumer electronics production in the U.S. and thereby generate improvements in the pool of manufacturing knowledge (Hart, J., & Tyson, L., Summer, 1989). The greater the U.S.

participation in HDTV, the greater will be the upstream, downstream, and manufacturing benefits for the rest of U.S. economy. HDTV will function as a pump that will speed the unraveling of network design problems and the creation of the electronic highway for information industries of the future. HDTV means new markets for the components industry such as, semiconductors, fiber optics, flat screen displays, etc. These markets will bring with them new wealth for the United States and directly impact our national economy, international trade, competitiveness and national security (Roe, R.A., March 22, 1989). Due these special reasons for importance of HDTV, compounded by strengthened aggressive targeting programs for abroad, it seems necessary that the U.S. support for HDTV should have to be different and especial. HDTV should be the model for developing all other key strategic industries of the future (Branfman, F., 1989). The suggestions made by the activist include grants, guaranteed loans, special taxes, infant industry nurturing, procurement contracts, etc. There have been numerous HDTV related legislations that have been introduced.

H.3 Skepticists

The above position of the activists have been countered by skepticists. They argue that the strategic importance of HDTV has been overstated and the threat from foreign competitors have been exaggerated. They maintain that the market predictions made by various experts is flawed in that the predictions take into consideration that HDTV will be a big success. MIT research suggest that the success of HDTV will depend on the relative size of the viewing screens and also on the content of the programs (Solomon, R.J., August 1, 1989). Skepticists also suggest that the linkages or interdependencies between HDTV and other related technologies have fostered inconsistent opinions among experts and there is no consensus as yet (Beltz, C.A., 1991). Vigorous competition between rivals in the television industry and between those in computers has generated vast improvements surprising even experts. Among the prominent skepticist was the OTA. It argued that "it is often impossible to be certain which application is ahead, or will remain ahead, as the driver of many technologies.. and that.. technological spillovers among different branches of electronics cannot be pinned down or forecasted with precision (Office of Technology Assessment, February 1990)." They argue that the threat from foreign competitors is negligent. The analog based HDTV manufactured abroad will have no effect on the digital HDTV manufactured in the U.S. Gilder, a prominent advocate, suggests that "Rather than industrial targeting, the government's role should be limited to setting the parameters, such as eliminating unnecessary regulations that discourage firms from tying high technologies together (Gilder, G., May 28, 1989)."

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APPENDIX I
STANDARDS

I.1 Background

The existence of product standards (or the lack of them) can greatly affect consumer behavior and the efficiency within which economy operates (Bensen, S. M., & Johnson, L.L., 1986). Standards allow compatibility among different equipment manufactured by same or different manufacturers, which leads mass production, economies of scale in manufacturing and marketing, VLSI implementations, and other benefits that decrease price and further increase acceptance. For manufacturers, standards provides guidelines for designing products that meet industry and market needs. For consumers, standards provides convenience in the procurement and use of equipment. Lack of standards renders costly inconveniences to both the manufacturer and the consumer. With standards, however, costs and uncertainty could easily be avoided, while compatibility and services could be readily assured (Cohen, E.J., & Wilkens, W.B., 1985). Standards assure the following -- interoperability, extensibility, scalability, and harmonization (Liebold, M., May 21, 1991). As for HDTV it would mean the following --

Interoperability -- The capability of operations between different video and image formats.

Extensibility -- Ability of a video standard to incorporate extended functions over time.

Scalability -- The degree video and image formats can be combined in systematic proportions for distribution over communication channels of varying capacities.

Harmonization -- The organization of different standards into order.

CCIR provides a definition of the term compatibility, since the term is widely used and could carry different meaning (CCIR, July 1987). The proposed definition of "compatibility" is as follows:

> Broadcasting service A or its signal are said to be compatible with broadcasting service B, when signals of service A can be received and used by receivers designed for service B; without the use of adapters, the performance of receiver B shall be essentially equivalent to that resulting when receiving a normal service signal B signal.

The CCIR documents mentions "Six Levels of Compatibility." They are as follows --

LEVEL 5 -- This level is represented by a system whereby HDTV transmission are received on a receiver which displays the picture in high definition.

LEVEL 4 -- This level represents a system whereby a receiver accepts HDTV transmission and displays the picture with same quality as it displays a normal transmission.

LEVEL 3 -- This level is represented by a system whereby a receiver accepts HDTV transmissions and displays the picture with somewhat reduced performance compared with a normal transmission.

LEVEL 2 -- This level is represented by a system whereby a current receiver requires an inexpensive adapter box to display HDTV transmission in the current standard format.

LEVEL 1 -- This level is represented by a system whereby the adapter box is expensive.

LEVEL 0 -- This level is a non-compatible system.

Standards fall into two distinct categories -- de facto and de jure. De facto standards are those that have just happened, without any formal plan (Tannenbaum, A. S., 1989). (Note: IBM PC and its successors are de facto standards because dozens of manufacturers have chosen to copy IBM's machine very closely). De jure standards are formal, legal standards adopted by some authorized body.

There are three types of process through which standards may be developed and adopted (Bensen, S.M., & Johnson, L.L., 1986). They are -- Noncooperative, Cooperative, and Government imposed.

Noncooperative -- This is the marketplace approach in which the marketplace decides which standard to adhere to. There is no binding agreement between the various players, and therefore, they adapt to the environment in which they are operating. In this method the actions of various players are plagued by uncertainty. Uncertainty is reduced and avoided by big players by flooding the market which their proprietary standards.

Cooperative -- In this approach formal procedures are established by the various players. Representatives from the various organizations get together for committee meeting, voting, developing, recommending, and finally adopting a uniform standard. Various organizations are available to set a uniform platform. The standards that is set is voluntary, i.e., any of the players, if it so desires, may agree not to adhere to the adopted standard. Doing so increases the risk to the player due to uncertainty of market acceptance of its standards, and the player does so at its own discretion.

Government Imposed -- Government agencies sometimes mandate the adoption of particular standard, due to safety, environmental, defense, or other reasons. These standards are protected by law, and each player must abide with it or face dire consequences of legal prosecution.

The time at which standard is established is absolutely critical for its success. David Clark of M.I.T. has a theory of standards that he calls the apocalypse of two elephants (Tannenbaum, A.S., 1989) (See Figure I-1).

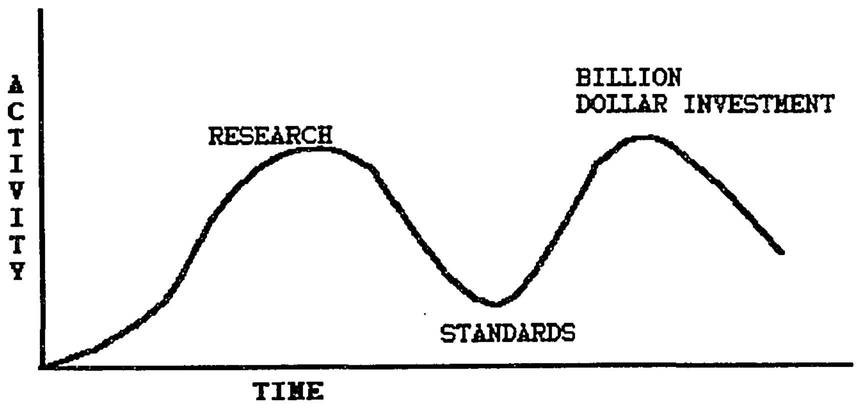

FIGURE I-1 APOCALYPSE OF TWO ELEPHANTS
Source: Tannenbaum, A.S., 1989.

The figure illustrates the amount of activity surrounding a new subject. At its discovery, lot of research activity is present. Soon it subsides, and the activity centers around investment. It is essential that the standards be written in the trough because if written to early, the subject may be underdeveloped leading to bad standards. On the other hand, if written to late, heavy investments already committed may lead to the standard being ineffective.

I.2 HDTV Standard

HDTV standard can be divided into three categories (Landau, S., March 1989) --

1. Production standard,
2. Transmission standard, and
3. Display standard.

I.2.1 Production Standard

This is related to the number of scanning lines, field rate, and other specifications related to program production. The value of HDTV has been recognized by the program production industry. They have advocated uniform standard throughout the world. The need for international agreement on production standard is very important, since it affects international trade (Schreiber, W.F., 1989). However, it is expected that most of the future systems will be entirely digital and programmable and therefore will be able to deal with a wide variety of input sources.

I.2.2 Transmission Standard

This standard is related to the bandwidth of the signal, modulation method etc. The Japanese system uses MUSE, the European uses MAC, etc. Transmission standard is technically the most difficult. Different medias have their own constraints and own benefits with regards to this issue.

I.2.3 Display standard

This standard is related to aspect ratio, number of pixels, etc. According to Professor Schreiber, this should be let to the industry to decide. He makes this argument saying, "The sharper the image, the better the picture. Freezing this would greatly inhibit the growth of ATVs" (Schreiber, W.F., 1989).

The issue of single standard is extremely important for the U.S. The new HDTV has the potential of replacing the current 35 mm film de facto standard. This would have a potential impact on the $2.8 billion trade surplus in export of movies and television which the U.S. currently enjoys (Landau, S., 1989). Worldwide HDTV standard would facilitate lower costs due to economies of scale, and would enable U.S. industries to enter the markets, which would otherwise be impossible.

I.3 Standard-Making Organizations

There are a handful of standard-making organizations. Some only make recommendations, while others have legislative powers to enforce standards. Standards-making organizations can be divided into -- International Standard-Making Organizations and National Standard-Making Organizations.

I.3.1 International Standard-Making Organization

I.3.1.1 International Organization for Standardization (ISO)

International standards are produced by ISO, a voluntary, nontreaty organization founded in 1946. Its members are the national standards organizations of the 89 member countries such as ANSI (U.S.), BSI (Great Britain), AFNOR (France), DIN (West Germany), etc. (Tannenbaum, A.S., 1989). Its primary objective is to deal with the development of standards for the facilitation of goods and services. It issues standards on a vast number of subjects, ranging from nuts and bolts to telephone pole coating organizations. It has almost 200 Technical Committees numbered according to the order of creation. The real work of OSI is however, done by over 100,000 volunteers worldwide, who come from diverse backgrounds.

OSI is comprised of two tiers. One is the tier consisting of active group of members, while the second, consists of correspondent members. Active members have a great representation in the organization, have a voting right in any technical committee, and have seats in the General Assembly. Correspondent members do not directly participate in any of the activities of OSI, but are informed of the proceedings. The U.S. representative in OSI is ANSI (American National Standards Institute), which is a private, nongovernmental, nonprofit organization.

The procedure for standard-making in the OSI is designed to achieve as broad a consensus as possible while working in preparing the standard. The process is initiated when one of the members feel the need for standard. A working paper is prepared and distributed to the technical committees. After maturity, the WP (Working Paper) becomes a DP (Draft Proposal). The DP is circulated to all member bodies who get six months to criticize it. The revised document called DIS (Draft International Standard) is circulated for comments and voting. If 75% approval is received during the voting the DIS is turned to final text of IS (International Standard).

I.3.1.2 International Telecommunication Union (ITU)

The ITU, which is an organ of the UN (United Nations), is an intergovernmental organization headquartered in Geneva, Switzerland and was founded in Paris in 1865. During its founding it was called the European Telegraph Union. In 1936, it was renamed International Telegraph Union. Finally, in 1947, the Atlantic City ITU conference thoroughly reorganized the ITU's structure and function and brought it into the UN system (Coding, G.A., 1980).

The functions of the ITU are - making regulations regarding telecommunications, setting standards regarding telecommunications, frequency management, and development assistance. Its members (which total 175 States (ITU, 1993))are drawn from the telecommunications administrative organizations and recognized private companies of respective countries. The State Department has designated International Division of FCC to represents the United States in the ITU.

The branches of ITU include -- the Plenipotentiary Conferences, the Administrative Conferences, the Administrative Council, the General Secretariat, the International Radio Consultative Committee (CCIR), the

International Telegraph and Telephone Consultative Committee (CCITT), the International Frequency Registration Board (IFRB), and the Telecommunications Development Bureau (BDT).

The CCIR is responsible for HDTV, and therefore will be discussed in some detail.

I.3.1.2.1 The International Radio Consultative Committee (CCIR)

(Note: The ITU has restructured after the Additional Plenipotentiary Conference of the ITU held in Geneva from December 7-12, 1992. See the note below. During the early period of HDTV development, the ITU structure below was responsible, and thus a discussion is carried about it).

The CCIR, which is a permanent organ of the ITU, is designed to study technical and operating questing regarding radio communications and issue recommendations, which are non mandatory. The CCIR recommendations and reports provide the main technical basis for ITU administrative radio conferences which allocate and regulate the frequency spectrum usage. The results are used further for the international coordination and planning of frequency assignments, and for national planning (Kirby, R.C., January 1985).

The CCIR has several working groups which include --

1. Spectrum utilization and monitoring;
2. Space research and radio astronomy;
3. Fixed service at frequency below 30 MHz;
4. Fixed-satellite service;
5. Propagation of non-ionized media;
6. Propagation in ionized media;
7. Standard frequencies and time signals;
8. Mobile, radiodetermination and amateur services;
9. Fixed service using radio-relay systems;

10.Broadcasting services -- sound; and,
11.Broadcast services -- television; Joint Study Group CCIR/CCITT for television and sound transmission (ITU, 1993).

The involvement of CCIR in the development of HDTV standards began in early 1970s. HDTV had been the prominent issue in the CCIR since 1983 when the Study Group 11 (Broadcast services (television)) established a specialist group to undertake the task to develop a recommendation on HDTV standard. It was agreed, during that time, that a draft proposal of single worldwide HDTV standard would be brought forward in the 1986 plenary assembly in Dubrovnik, Yugoslavia, and transmission and display standard would be finalized in the work cycle 1986-1990. In September 1984, the U.S. supported the CCIR recommendation of 1125/60 production standard, which was overwhelming supported by U.S. industries. In October, 1985 Study Group 11 meeting, the Europeans blocked the effort of passage of the 1125/60 production standard. The May 1986, CCIIR Plenary Assembly in Dubrovnik failed to get the passage of the 1125/60 production standard. Realizing, that one standard would not be adopted worldwide, the U.S. also withdrew its support for the 1125/60 standard. The CCIR Extraordinary Meeting (May 10-16, 1989) resulted in the following outcomes (McKinney, J.C., May 31, 1989) --

1. No selection of any single worldwide HDTV production standard;
2. No selection of regional standards (e.g. -- 1250/50 in Europe, 1125/60 in Japan);
3. Approval of 18 of 34 basic video parameters for the future HDTV production standard;
4. Establishment of a study program for the concept of "Common Image Format" and "Common Data Rate" as a means for transferring programs in the event that more than one HDTV production standard is eventually approved; and,

5. Technical documentation of both 1250/50 and 1125/60 as "candidates" for a future single worldwide HDTV production standard without adoption of a recommendation for either system.

The global approach of the CCIR Study Group 11 was oriented towards determining the role of HDTV in the Information Society of the 21st century, and included the harmonization of standards and operating practices for HDTV production, emission and transmission, as well as for no broadcast HDTV equipment intended for consumer applications (Nickelson, R.L., September 1989).

(Note: The Additional Plenipotentiary Conference of the ITU, held in Geneva from December 7-22, 1992 made revolutionary changes in the structure of the ITU which was construed by the following events: the marriage of telecommunication and computer technologies; the appearance of a multitude of new telecommunication services and a willing market for those services; the deregulation and privatization of many PTTs; the appearance of regional standardization organizations; and, the developing country taking advantage of its superior voting power in the ITU (Coding, Jr., G.A., February, 1994).

The new structure consists of three sectors and the General Secretrait. The three sectors are --

1. The Telecommunication Standardization Sector comprising of fifteen study groups;
2. The Radio Communication Sector; and,
3. The Telecommunication Development Sector).

I.3.2 National Standard-Making Organizations

I.3.2.1 The American National Standards Institute

ANSI (American National Standards Institute) is a private, nongovernmental, nonprofit organization. It was first established in 1918 as the American Engineering Standards Committee. Ten years later, in 1928, it was reorganized and named the American Standards Association. It underwent another reorganization in 1966, after which it was named the U.S. Standards Institute. Finally in 1969, it got its present name - the American National Standards Institute (ANSI).

The members of ANSI comes from other standards organizations, trade associations, Federal and State government agencies, professional people, business people, etc.

The jobs of ANSI includes -- coordination of private sector activities in the development of national standards; provide rules on the eligibility of standards; and, manage, coordinate and provide financial and administrative support for U.S. participation in nongoverment international standard bodies. U.S. is represented by ANSI in ISO.

I.3.2.2 The Federal Communications Commission (FCC)

Founded in July 1934, the FCC is an independent regulatory agency of the Federal government responsible for the communications activities in the U.S.

The FCC is made up of three bureaus (Office of Federal Register, 1989/90) --

1. the Mass Media Bureau;
2. the Common Carrier Bureau; and,
3. the Private Radio Bureau.

The standards put forward by the FCC is enforceable by law. The decisions to be taken by FCC regarding HDTV is very crucial because it will determine the course of HDTV industry.

The FCC began its activities in HDTV on February 13, 1987, when the commission received a petition "Petition for NOI (Notice of Inquiry)" by 58 broadcast organizations and companies (Jurgen, R.K., October, 1989). On November 17, 1987, the FCC initiated an Advisory Committee on Advanced Television Services with the following objectives (Wiley, R.E., September 7, 1989) --

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

The advisory committee was made up of three subcommittees --

1. Planning Subcommittee;
2. Systems Subcommittee; and,
3. Implementation Subcommittee.

The Planning Subcommittee consisted of several working parties (Wiley, R.E., September 7, 1989).

Working Party 1 -- ATV Attributes: This party was assigned the task of defining the attributes which characterize all ATV systems and which will permit a comparison of proposed systems.

Working Party 2 -- ATV Testing and Evaluation Specifications: This party was asked to establish specifications for the testing and evaluation of proposed ATV systems and to develop a draft schedule for the actual testing and evaluation of the systems.

Working Party 3 -- Spectrum Utilization and Alternatives: This party was assigned the task of investigating the availability of spectrum for broadcast of ATV.

Working Party 4 -- Alternative Media Technology and Broadcast Interference: This party was given the task of developing a point of reference or baseline for designers of broadcast ATV systems so that user friendly interface would be achieved whenever broadcast signals interface with alternative distribution media.

Working Party 5 -- Economic Factors and Market Penetration: The objectives of this party was to look into and analyze economic and business aspects of ATV.

Working Party 6 -- Subjective Assessment of ATV Systems: The task of this party was to recommend test methods to be used in the subjective assessment of the proposed ATV distribution systems.

I.3.2.3 The Advanced Television Systems Committee (ATSC)

In late 1982, the Joint Committee on inter-Society Coordination (JCIC) established the ATSC to coordinate and develop voluntary national technical standards for advanced television systems (McKinney, J.C., May 31, 1989). The ATSC is a group made up of broadcasters, cable operators, satellite operators, consumer electronics manufacturers, professional equipment manufacturers, motion picture industry and other professionals. The JCIC members are -- Electronics Industries Association (EIA), the Institute of Electrical and Electronics Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Television Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE) are charter members of the ATSC.

The ATSC is also charged with making recommendations for presentation to the U.S. Department of State for its use in developing the U.S.'s positions on various standards issues that are considered from time to time by CCIR and other international organizations. The other areas of responsibility include (McKinney, J.C., May 31, 1989) --

1. development of HDTV standards,
2. coordination of HDTV standards with other organizations, encouragement of private sector participation by U.S. government agencies in the work of the ATSC,
3. technical review of proposed voluntary standards, and
4. recommendations of standards to the appropriate agencies or organizations.

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APPENDIX J
HDTV DISPLAY TECHNOLOGIES

To date most of the display were big and bulky. Five new display technologies are competing for success. They are Active Matrix Liquid-Crystal Display, Plasma Technology, Electroluminescence (EL), Vacuum Microelectronics, and Deformable Electronics (Business Week, February 26, 1990).

Active Matrix Liquid-Crystal Displays -- These are being developed at Sharp, Hitachi, Matsushita, Sarnoff Research, Toshiba, IBM, MagnaScreen, and Ovonic Imaging. The principle used is: When a transistor at each dot (or pixel) on the screen is turned on, it causes a liquid crystal to twist, allowing light to pass through.

Plasma Technology -- These are being developed by Photonics Technology, NHK, Matsushita, Sharp, Toshiba, and Hitachi. The principle used is: An electric current to each pixel causes a gas to glow and the light beam then stimulates a phosphor coating on the screen to produce the image.

Electroluminscence (EL) -- These are being developed by Planar Systems, Sharp, and Hitachi. The principle used is: An electric current causes the phosphor coating at each pixel to glow.

Vacuum Microelectronics -- These are being developed by Coloray Display, and Thomson. The principle used is: Unlike a conventional TV, in which a single beam sweeps back and forth, this technology uses a microscopic electronic source, or cathode, for each pixel.

Deformable Mirrors -- These are being developed by Texas Instruments. The principle used is: This relies on tiny movable mirrors on a sheet of silicon whose angle of reflection controls each pixel.

APPENDIX K
HYPOTHESES
TABLE K-1
NULL AND ALTERNATE HYPOTHESES

		CHANGES IN STAGE
1	Ho	Relationship value among manufacturers in Stage 3 == Relationship value among manufacturers in Stage 2 == Relationship value among manufacturers in Stage 1
	Ha	Relationship value among manufacturers in Stage 3 =/= Relationship value among manufacturers in Stage 2 =/= Relationship value among manufacturers in Stage 1
2	Ho	Relationship value among research organizations in Stage 3 == Relationship value among research organizations in Stage 2 == Relationship value among research organizations in Stage 1
	Ha	Relationship value among research organizations in Stage 3 =/= Relationship value among research organizations in Stage 2 =/= Relationship value among research organizations in Stage 1
3	Ho	Relationship value among customers in Stage 3 == Relationship value among customers in Stage 2 == Relationship value among customers in Stage 1
	Ha	Relationship value among customers in Stage 3 =/= Relationship value among customers in Stage 2 =/= Relationship value among customers in Stage 1
4	Ho	Relationship value among government agencies in Stage 3 == Relationship value among government agencies in Stage 2 == Relationship value among government agencies in Stage 1
	Ha	Relationship value among government agencies in Stage 3 =/= Relationship value among government agencies in Stage 2 =/= Relationship value among government agencies in Stage 1
5	Ho	Relationship value between manufacturers and research organization in Stage 3 == Relationship value between manufacturers and research organization in Stage 2 == Relationship value between manufacturers and research organization in Stage 1
	Ha	Relationship value between manufacturers and research organization in Stage 3 > Relationship value between manufacturers and research organization in Stage 2 > Relationship value between manufacturers and research organization in Stage 1
6	Ho	Relationship value between research organization and customers in Stage 3 == Relationship value between research organization and customers in Stage 2 == Relationship value between research organization and customers in Stage 1
	Ha	Relationship value between research organization and customers in Stage 3 > Relationship value between research organization and customers in Stage 2 > Relationship value between research organization and customers in Stage 1

TABLE K-1 (CONTINUED)
NULL AND ALTERNATE HYPOTHESES

7	Ho	Relationship value between customers and government agencies in Stage 3 == Relationship value between customers and government agencies in Stage 2 == Relationship value between customers and government agencies in Stage 1
	Ha	Relationship value between customers and government agencies in Stage 3 > Relationship value between customers and government agencies in Stage 2 > Relationship value between customers and government agencies in Stage 1
8	Ho	Relationship value between government agencies and manufacturers in Stage 3 == Relationship value between government agencies and manufacturers in Stage 2 == Relationship value between government agencies and manufacturers in Stage 1
	Ha	Relationship value between government agencies and manufacturers in Stage 3 > Relationship value between government agencies and manufacturers in Stage 2 > Relationship value between government agencies and manufacturers in Stage 1
9	Ho	Relationship value between manufacturers and customers in Stage 3 == Relationship value between manufacturers and customers in Stage 2 == Relationship value between manufacturers and customers in Stage 1
	Ha	Relationship value between manufacturers and customers in Stage 3 > Relationship value between manufacturers and customers in Stage 2 > Relationship value between manufacturers and customers in Stage 1
10	Ho	Relationship value between research organizations and government agencies in Stage 3 == Relationship value between research organizations and government agencies in Stage 2 == Relationship value between research organizations and government agencies in Stage 1
	Ha	Relationship value between research organizations and government agencies in Stage 3 > Relationship value between research organizations and government agencies in Stage 2 > Relationship value between research organizations and government agencies in Stage 1
		CHANGES IN PHASE
11	Ho	Relationship value among manufacturers in Phase 3 == Relationship value among manufacturers in Phase 2 == Relationship value among manufacturers in Phase 1
	Ha	Relationship value among manufacturers in Phase 3 > Relationship value among manufacturers in Phase 2 > Relationship value among manufacturers in Phase 1
12	Ho	Relationship value among research organizations in Phase 3 == Relationship value among research organizations in Phase 2 == Relationship value among research organizations in Phase 1
	Ha	Relationship value among research organizations in Phase 3 > Relationship value among research organizations in Phase 2 > Relationship value among research organizations in Phase 1

TABLE K-1 (CONTINUED)
NULL AND ALTERNATE HYPOTHESES

13	Ho	Relationship value among customers in Phase 3 == Relationship value among customers in Phase 2 == Relationship value among customers in Phase 2
	Ha	Relationship value among customers in Phase 3 > Relationship value among customers in Phase 2 > Relationship value among customers in Phase 2
14	Ho	Relationship value among government agencies in Phase 3 == Relationship value among government agencies in Phase 2 == Relationship value among government agencies in Phase 1
	Ha	Relationship value among government agencies in Phase 3 > Relationship value among government agencies in Phase 2 > Relationship value among government agencies in Phase 1
15	Ho	Relationship value between manufacturers and research organization in Phase 3 == Relationship value between manufacturers and research organization in Phase 2 == Relationship value between manufacturers and research organization in Phase 1
	Ha	Relationship value between manufacturers and research organization in Phase 3 =/= Relationship value between manufacturers and research organization in Phase 2 =/= Relationship value between manufacturers and research organization in Phase 1
16	Ho	Relationship value between research organization and customers in Phase 3 == Relationship value between research organization and customers in Phase 2 == Relationship value between research organization and customers in Phase 1
	Ha	Relationship value between research organization and customers in Phase 3 =/= Relationship value between research organization and customers in Phase 2 =/= Relationship value between research organization and customers in Phase 1
17	Ho	Relationship value between customers and government agencies in Phase 3 == Relationship value between customers and government agencies in Phase 2 == Relationship value between customers and government agencies in Phase 1
	Ha	Relationship value between customers and government agencies in Phase 3 =/= Relationship value between customers and government agencies in Phase 2 =/= Relationship value between customers and government agencies in Phase 1
18	Ho	Relationship value between government agencies and manufacturers in Phase 3 == Relationship value between government agencies and manufacturers in Phase 2 == Relationship value between government agencies and manufacturers in Phase 1
	Ha	Relationship value between government agencies and manufacturers in Phase 3 =/= Relationship value between government agencies and manufacturers in Phase 2 =/= Relationship value between government agencies and manufacturers in Phase 1

TABLE K-1 (CONTINUED)
NULL AND ALTERNATE HYPOTHESES

19	Ho	Relationship value between manufacturers and customers in Phase 3 == Relationship value between manufacturers and customers in Phase 2 == Relationship value between manufacturers and customers in Phase 1
	Ha	Relationship value between manufacturers and customers in Phase 3 =/= Relationship value between manufacturers and customers in Phase 2 =/= Relationship value between manufacturers and customers in Phase 1
20	Ho	Relationship value between research organizations and government agencies in Phase 3 == Relationship value between research organizations and government agencies in Phase 2 == Relationship value between research organizations and government agencies in Phase 1
	Ha	Relationship value between research organizations and government agencies in Phase 3 =/= Relationship value between research organizations and government agencies in Phase 2 =/= Relationship value between research organizations and government agencies in Phase 1
		RELATIONAL VALUE: 1 -- FULL COMPETITION, 2 -- MORE COMPETITION THAN COMPETITION, 3 -- NEUTRAL, 4 -- MORE COOPERATION THAN COMPETITION, 5 -- FULL COOPERATION.

APPENDIX L
LIST OF SUBJECTS FOR THE OPEN ENDED QUESTIONNAIRE SURVEY

1. Aoki, Kumiko.
2. Burke, Kelly.
3. Busch, Mathias.
4. Garrett, Leann.
5. Halverson, Richard.
6. Nahl-Jakobovits, Diane.
7. Ono, Ryota.
8. Pai, Sunyeen

APPENDIX M
QUESTION FOR ISOLATION OF FACTORS

There are three distinct phases in the development of a product - the *Invention Phase,* as associated with monochrome television, the *Development Phase,* as associated with color television, the *Integration Phase,* as associated with high definition television.

In your opinion, **what questions are most relevant and what factors are most critical during those phases?**

APPENDIX N
CONTENT ANALYSIS
TABLE N-1
CONTENT ANALYSIS FOR COMPETITION AND COOPERATION

		1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
1	COMPETITION				3			2	4	COOPERATION							2	2
2	Adversary									Accord								
3	Advertising				1			1		Affiliation								
4	Antagonism									Agreement		2	1	2		2		3
5	Bid									Alliance								
6	Bout									Arrangement		1	2		2			
7	Clash									Association							2	
8	Combat									Bloc								
9	Conflict									Brotherhood								
10	Contention									Cartel								
11	Contest									Co-op								
12	Discord									Coalition								
13	Differ		3			2	3			Collaboration								
14	Disputant									Company								
15	Effort									Concert								
16	Enemyship									Concord								
17	Exertion									Consortium		2						
18	Foeism									Contract								
19	Game									Corporation								
20	Hostility									Coterie								
21	Marketing	3	3	5	2	3	4	1	2	Deal		2						
22	Match									Fellowship								
23	Opposition									Fraternity								
24	Price	1	4		4	5	6	2	3	Group	3			2		3		
25	Race									Harmony			1	2	2			
26	Rivalry									Merger								
27	Sport									Organization		3						
28	Standard	3	4	2	1	3		1	2	Pact								
29	Strife									Partnership								
30	Struggle									Settlement								
31	Trial									Syndicate								2
32	Vying									Teamwork		4	2					
33										Understanding		1						
34										Union								
35										Unity								
		7	14	7	11	13	13	7	11		3	15	6	6	4	5	4	7
	TOTAL WORDS SPOKEN	48	164	44	241	83	72	57	210		48	164	44	241	83	72	57	210
	PERCENTAGE	15	8.5	16	4.6	16	18	12	5.2		6.3	9.1	14	2.5	4.8	6.9	7	3.3

APPENDIX O
NAME, AND ADDRESS OF SUBJECTS FOR FACTOR CONFIRMATION

1.	Badley, Kim	Facility Manager, DYNCORP, 233 Keawa Street, Honolulu, HI 96813.
2.	Bass, William M.	Executive Director, High Technology Development Corporation, 300 Kahelu Ave., Suite 35, Millilani, HI 96789.
3.	Gouveia, Mike	Vice President, Adetch Inc., 1814 Algaroba, Honolulu, HI 96826.
4.	Ikehara, Curtis	President, Applied Computer Electronics, PO Box 665, Aiea, HI 96701.
5.	McCord,Carol	Vice President, SETS, INC., Millilani Technology Park, 300 Kahelu Ave., Suite 10, Millilani, HI 96789.
6.	Nakamura, Lance	Verifone, Inc., Millilani Technology Park, 100 Kahelu Ave., Millilani, HI 96789.
7.	Platz, Judi A.	Site Manager, Computer Dynamics, Inc., 680 Iwilei Road, Suite 400, Honolulu, HI 96817.
8.	Rustik, Randy	Vice President, Computer Training Institute, 820 Millilani Street, Suite 123, Honolulu, HI 96813.

APPENDIX P
QUESTION FOR THE CLOSED ENDED QUESTION SURVEY TO CONFIRM FACTORS

Dear Sir/Madam,

Please could you spare some of your invaluable time and answer the following question.

QUESTION

Literature has suggested that **COMPETITION** and **COOPERATION** (which are antithetical approaches) are the two most important types of relational dynamics involved between entities developing a high technology product.

_____ AGREE _____ DISAGREE

Do you have any other suggestions.

1. ____________________

2. ____________________

Name:

Title:

Company:

Thank you very much for your kind cooperation.

Sincerely yours,
Shakti S. Rana
CIS Ph.D. Candidate
University of Hawaii
FAX - (808)955-0979

APPENDIX Q
LIST OF SUBJECTS FOR PILOT STUDY

1. Aoki, Kumiko,
   Ph.D. CIS.
   University of Hawaii at Manoa.

2. Garrett, Leann,
   Ph.D. CIS.
   University of Hawaii at Manoa.

3. Hope, Beverly,
   Ph.D. CIS.
   University of Hawaii at Manoa.

4. Makkad, Satwinder,
   Ph.D. Engineering.
   University of Hawaii at Manoa.

5. Nahl-Jakobovits, Diane,
   Ph.D. CIS.
   University of Hawaii at Manoa.

6. Ono, Ryota,
   Ph.D. CIS.
   University of Hawaii at Manoa.

7. Pai, Sunny,
   Ph.D. CIS.
   University of Hawaii at Manoa.

8. Spencer, Mark,
   Ph.D. Engineering
   University of Hawaii at Manoa.

9. Varahasamy, Murali,
   Ph.D. Engineering.
   University of Hawaii at Manoa.

APPENDIX R
QUESTIONNAIRE FOR THE PILOT SURVEY

PILOT STUDY

NAME ____________________________

MAJOR ____________________________

ADDRESS ____________________________

____

____

PHONE ______________ (RES)

______________ (BUS)

COMMENTS (IF ANY)

____

____

____

____

____

THANK YOU VERY MUCH FOR YOUR KIND COOPERATION.

SHAKTI S. RANA
(PHONE - 9550979)

Dear Sir or Madam:

Thank you very much for agreeing to participate in this study. It should take no longer than about one-half of an hour to complete.

In this study we are attempting to model the dynamics of *competition* and *cooperation* between (a) the *research organizations* (e.g., Bell Labs), (b) *government agencies* (e.g., FCC), (c) *manufacturers* and (d) *customers* for the successful development of high technology products. In our model, a "product", refers to a "type" of product (e.g., "cellular telephones"), not a particular model or brand (e.g., "Nokia PT612").

Our model considers three different "phases" of a product's life. The *invention* phase is the period when the type of product is first introduced. The *development* phase is the period when improvements are being made to the product. The *integration* phase is the period when the product is being integrated with other products to create new types of products.

For example, when the cellular telephone was first introduced (i.e., when in its invention phase), they were large, marginally portable and users experienced high disconnect rates. During the development phase, we witnessed improvements such as miniaturization, improved reception and enhanced services. In the integration phase we can expect to see cellular technology combined with other products to offer new types of products that were previously unavailable. Notice that the cellular telephone in its invention phase represented the *integration* of conventional telephone and cellular radio technology.

Also in this study, we are interested only in the stages (within a phase) which take place *before* a product is first available to customers. In our three stage model, the *idea generation and preliminary assessment stage* refers to the period when the idea of a product occurs and its feasibility analyzed. In the *conceptualization, development, testing and trial* stage, the product features are defined, implemented and tested. In the *standardization, launch and commercialization* stage, the product is prepared for production and introduced to the customers.

In the following pages you will find three separate pages; one for each of the three phases. Each page shows the three different stages for that respective phase. In each of the stages you will find the pairing between the entities. For each relationship pair in each stage for each phase, please mark what you believe is best: ☐ full competition, ☐ more competition than cooperation, ☐ neutral, ☐ more cooperation than competition, or ☐ full cooperation. For example, if you believe for a particular stage in a particular product phase that the relationship between government agencies and research organizations should be more cooperative than competitive, you would mark an X in the fourth box. If you believe that for a particular stage in a particular phase that manufacturers should compete fully, you would mark an X in the first box.

Between Government Agencies and Research Organizations

Competition [ ] [ ] [ ] [X] [ ] *Cooperation*

Between Manufacturers

Competition [X] [ ] [ ] [ ] [ ] *Cooperation*

INVENTION PHASE

Idea Generation and Preliminary Assessment Stage	Conceptualization, Development, Testing and Trial Stage	Standardization, Launch and Commercialization Stage
Between Manufacturers and Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Government Agencies and Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers and Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Government Agencies *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*
Between Manufacturers and Government Agencies *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers and Government Agencies *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*
Between Manufacturers *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers and Manufacturers *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers** *Competition* ☐☐☐☐☐ *Cooperation*

DEVELOPMENT PHASE

Idea Generation and Preliminary Assessment Stage	Conceptualization, Development, Testing and Trial Stage	Standardization, Launch and Commercialization Stage
Between Manufacturers and Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Government Agencies and Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers and Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Research Organizations *Competition* ☐☐☐☐☐ *Cooperation*	**Between Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Research Organizations** *Competition* ☐☐☐☐☐ *Cooperation*
Between Government Agencies *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*
Between Manufacturers and Government Agencies *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers and Government Agencies *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Government Agencies** *Competition* ☐☐☐☐☐ *Cooperation*
Between Manufacturers *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers and Manufacturers *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers and Manufacturers** *Competition* ☐☐☐☐☐ *Cooperation*
Between Customers *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers** *Competition* ☐☐☐☐☐ *Cooperation*	**Between Customers** *Competition* ☐☐☐☐☐ *Cooperation*

INTEGRATION PHASE

Idea Generation and Preliminary Assessment Stage	Conceptualization, Development, Testing and Trial Stage	Standardization, Launch and Commercialization Stage
Between Manufacturers and Research Organizations *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Manufacturers and Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Manufacturers and Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Government Agencies and Research Organizations *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Government Agencies and Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Government Agencies and Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Customers and Research Organizations *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers and Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers and Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Research Organizations *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Research Organizations** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Government Agencies *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Government Agencies** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Government Agencies** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Manufacturers and Government Agencies *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Manufacturers and Government Agencies** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Manufacturers and Government Agencies** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Customers and Government Agencies *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers and Government Agencies** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers and Government Agencies** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Manufacturers *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Manufacturers** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Manufacturers** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Customers and Manufacturers *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers and Manufacturers** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers and Manufacturers** *Competition* [ ][ ][ ][ ][ ] *Cooperation*
Between Customers *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers** *Competition* [ ][ ][ ][ ][ ] *Cooperation*	**Between Customers** *Competition* [ ][ ][ ][ ][ ] *Cooperation*

APPENDIX S
DATA ANALYSIS FOR THE PILOT SURVEY
TABLE S-1
IDEA GENERATION AND PRELIMINARY ASSESSMENT STAGE*

	S1										ME	MO	MD	TH	%ME	%MO	%MD	%TH
	M-M													VL				VL
1	P1	1	1	1	3	5	4	2	2	3	2	1	2	1	-19	-67	-33	-80
2	P2	1	1	2	3	5	5	2	2	3	3	2	2	3	9.09	100	0	200
3	P3	1	3	3	3	5	5	2	2	3	3	3	3	5	12.5	50	50	66.7
	RO-RO																	
4	P1	1	1	1	4	2	2	1	1	2	2	1	1	1	-52	-75	-75	-80
5	P2	1	1	2	4	5	5	2	4	4	3	4	4	3	86.7	300	300	200
6	P3	1	3	3	4	5	5	2	4	4	3	4	4	5	10.7	0	0	66.7
	C-C																	
7	P1	1	2	1	3	1	2	3	3	3	2	3	2	1	-30	0	-33	-80
8	P2	1	2	2	3	1	5	3	5	4	3	1	3	3	36.8	-67	50	200
9	P3	1	3	3	3	1	5	3	5	3	3	3	3	5	3.85	200	0	66.7
	GO-GO																	
10	P1	1	1	1	3	4	4	2	1	5	2	1	2	1	-33	-67	-33	-80
11	P2	1	1	2	5	4	5	5	5	4	4	5	4	3	45.5	400	100	200
12	P3	1	3	3	3	5	5	5	5	3	4	3	3	5	3.13	-40	-25	66.7
	M-RO																	
12	P1	1	1	1	5	3	3	2	2	3	2	1	2	1	-25	-67	-33	-80
14	P2	1	1	2	5	3	5	2	2	5	3	2	2	3	23.8	100	0	200
15	P3	1	3	3	5	3	5	2	2	4	3	3	3	5	7.69	50	50	66.7
	RO-C																	
16	P1	1	2	1	5	3	4	3	2	4	3	1	3	1	-3.8	-67	0	0
17	P2	1	2	2	5	3	3	3	2	4	3	2	3	1	0	100	0	0
18	P3	1	3	3	5	3	3	3	2	3	3	3	3	1	4	50	0	0
	C-GA																	
19	P1	1	2	1	3	5	4	2	2	3	3	2	2	1	-15	-33	-33	0
20	P2	1	2	2	3	5	5	2	2	3	3	2	2	1	8.7	0	0	0
21	P3	1	3	3	3	5	5	2	2	3	3	3	3	1	8	50	50	0
	GA-M																	
22	P1	1	2	1	3	3	4	2	1	4	2	1	2	1	-19	-67	-33	0
23	P2	1	2	2	3	3	5	3	1	3	3	3	3	1	9.52	200	50	0
24	P3	1	3	3	3	3	5	4	1	3	3	3	3	1	13	0	0	0
	M-C																	
25	P1	1	1	1	1	5	4	2	1	4	2	1	1	1	-20	0	-67	0
26	P2	1	1	2	1	5	5	2	1	5	3	1	2	1	15	0	100	0
27	P3	1	3	3	1	5	5	2	1	4	3	1	3	1	8.7	0	50	0
	RO-GA																	
28	P1	1	2	1	3	2	4	2	2	3	2	2	2	1	-17	-33	-33	0
29	P2	1	2	2	3	2	5	2	2	4	3	2	2	1	15	0	0	0
30	P3	1	3	3	3	2	5	2	2	3	3	3	3	1	4.35	50	50	0

*For notes see Table S-7

TABLE S-2
DEVELOPMENT AND TESTING STAGE*

	S2																	
	M-M										**ME**	**MO**	**MD**	**TH**	**%ME**	**%MO**	**%MD**	**%TH**
31	P1	1	1	1	2	1	4	1	1	2	2	1	1	1	-42	0	-50	-80
32	P2	1	1	2	2	4	4	1	2	1	2	1	2	3	28.6	0	100	200
33	P3	1	5	4	2	1	4	1	5	1	3	1	2	5	33.3	0	0	66.7
	RO-RO																	
34	P1	1	1	1	4	2	2	1	1	2	2	1	1	1	-52	-75	-75	-80
35	P2	1	1	2	4	3	5	1	1	4	2	1	2	3	46.7	0	100	200
36	P3	1	4	4	4	3	5	2	4	4	3	4	4	5	40.9	300	100	66.7
	C-C																	
37	P1	1	2	1	3	1	3	3	3	3	2	3	3	1	-41	-40	-25	-80
38	P2	1	2	2	3	3	3	3	5	3	3	3	3	3	25	0	0	200
39	P3	1	5	4	3	3	5	5	5	3	4	5	4	5	36	66.7	33.3	66.7
	GO-GO																	
40	P1	1	1	1	5	2	3	2	2	5	2	1	2	1	-37	-80	-50	-80
41	P2	1	1	2	5	4	5	2	5	5	3	5	4	3	36.4	400	100	200
42	P3	1	5	4	5	4	5	2	5	4	4	5	4	5	16.7	0	0	66.7
	M-RO																	
43	P1	1	1	1	5	3	5	4	3	4	3	1	3	3	-10	-75	-25	0
44	P2	1	1	2	4	3	5	4	4	4	3	4	4	3	3.7	300	33.3	0
45	P3	1	2	4	4	3	5	4	3	4	3	4	4	3	7.14	0	0	0
	RO-C																	
46	P1	1	2	1	5	4	5	5	4	3	3	5	4	3	-3.2	0	0	0
47	P2	1	2	2	5	4	5	5	4	3	3	5	4	3	3.33	0	0	0
48	P3	1	2	4	5	4	5	5	2	3	3	5	4	3	0	0	0	0
	C-GA																	
49	P1	1	2	1	3	4	5	5	4	4	3	4	4	3	0	100	33.3	0
50	P2	1	2	2	3	4	5	5	4	3	3	2	3	3	0	-50	-25	0
51	P3	1	2	4	3	4	5	5	2	3	3	2	3	3	0	0	0	0
	GA-M																	
52	P1	1	2	1	4	3	5	4	4	4	3	4	4	3	-3.4	0	0	0
53	P2	1	2	2	4	3	5	4	4	3	3	4	3	3	0	0	-25	0
54	P3	1	2	4	4	3	5	4	2	4	3	4	4	3	3.57	0	33.3	0
	M-C																	
55	P1	1	1	1	5	3	5	4	5	3	3	1	3	3	0	-50	0	0
56	P2	1	1	2	5	3	5	4	5	5	3	5	4	3	10.7	400	33.3	0
57	P3	1	2	4	5	3	5	2	2	4	3	2	3	3	-9.7	-60	-25	0
	RO-GA																	
58	P1	1	2	1	4	4	5	5	4	4	3	4	4	3	-6.2	0	0	0
59	P2	1	2	2	4	4	5	5	4	4	3	4	4	3	3.33	0	0	0
60	P3	1	2	4	4	4	5	5	3	4	4	4	4	3	3.23	0	0	0

*For notes see Table S-7

TABLE S-3
STANDARDIZATION AND LAUNCH STAGE*

	S3										ME	MO	MD	TH	%ME	%MO	%MD	%TH
	M-M																	
61	P1	1	1	1	2	1	4	1	1	4	2	1	1	1	-53	-75	-75	-80
62	P2	1	3	3	1	3	4	1	4	4	3	1	3	3	50	0	200	200
63	P3	1	5	4	5	3	4	4	4	4	4	4	4	5	41.7	300	33.3	66.7
	RO-RO																	
64	P1	1	1	1	4	2	2	1	1	4	2	1	1	1	-48	-75	-75	-80
65	P2	1	3	3	5	5	4	2	4	4	3	4	4	3	82.4	300	300	200
66	P3	1	4	4	5	5	4	2	4	4	4	4	4	5	6.45	0	0	66.7
	C-C																	
67	P1	1	2	1	3	1	3	3	3	3	2	3	3	1	-38	0	0	-80
68	P2	1	3	3	3	3	5	3	5	3	3	3	3	3	45	0	0	200
69	P3	1	5	4	3	3	5	3	5	3	4	3	3	5	10.3	0	0	66.7
	GO-GO																	
70	P1	1	1	1	5	2	3	2	2	5	2	1	2	1	-41	-80	-60	-80
71	P2	1	3	3	5	5	5	5	5	5	4	5	5	3	68.2	400	150	200
72	P3	1	3	4	5	5	5	4	5	5	4	5	5	5	0	0	0	66.7
	M-RO																	
73	P1	1	1	1	5	5	5	4	5	3	3	5	4	5	-21	0	-20	0
74	P2	1	3	3	5	5	5	4	4	3	4	3	4	5	10	-40	0	0
75	P3	1	5	4	4	5	5	5	5	4	4	5	5	5	15.2	66.7	25	0
	RO-C																	
76	P1	1	2	1	5	5	5	4	5	3	3	5	4	5	-11	0	0	0
77	P2	1	3	3	3	5	5	4	5	3	4	3	3	5	3.23	-40	-25	0
78	P3	1	4	4	3	5	5	5	5	3	4	5	4	5	9.38	66.7	33.3	0
	C-GA																	
79	P1	1	2	1	3	5	5	5	4	3	3	5	3	5	-15	0	-25	0
80	P2	1	3	3	3	5	5	5	4	3	4	3	3	5	10.3	-40	0	0
81	P3	1	3	4	3	5	5	5	5	3	4	5	4	5	6.25	66.7	33.3	0
	GA-M																	
82	P1	1	2	1	4	5	5	5	4	4	3	4	4	5	-14	0	0	0
83	P2	1	3	3	5	5	5	4	4	4	4	5	4	5	9.68	25	0	0
84	P3	1	4	4	5	5	5	4	4	4	4	4	4	5	5.88	-20	0	0
	M-C																	
85	P1	1	1	1	3	1	5	4	5	3	3	1	3	5	-29	-75	-25	0
86	P2	1	3	3	5	1	5	5	5	3	3	5	3	5	29.2	400	0	0
87	P3	1	4	4	3	4	5	5	5	3	4	4	4	5	9.68	-20	33.3	0
	RO-GA																	
88	P1	1	2	1	5	5	5	2	5	5	3	5	5	5	-18	0	0	0
89	P2	1	3	3	5	5	5	4	5	4	4	5	4	5	12.9	0	-20	0
90	P3	1	5	4	5	5	5	5	4	4	4	5	5	5	8.57	0	25	0

*For notes see Table S-7

TABLE S-4
INVENTION PHASE*

	P1										ME	MO	MD	TH	%ME	%MO	%MD	%TH
	M-M																	
91	S1	1	1	1	3	5	4	2	2	3	2	1	2	1	37.5	0	100	0
92	S2	1	1	1	2	1	4	1	1	2	2	1	1	1	-36	0	-50	0
93	S3	1	1	1	2	1	4	1	1	4	2	1	1	1	14.3	0	0	0
	RO-RO																	
94	S1	1	1	1	4	2	2	1	1	2	2	1	1	1	-12	0	0	0
95	S2	1	1	1	4	2	2	1	1	2	2	1	1	1	0	0	0	0
96	S3	1	1	1	4	2	2	1	1	4	2	1	1	1	13.3	0	0	0
	C-C																	
97	S1	1	2	1	3	1	2	3	3	3	2	3	2	1	-5	0	-33	0
98	S2	1	2	1	3	1	3	3	3	3	2	3	3	1	5.26	0	50	0
99	S3	1	2	1	3	1	3	3	3	3	2	3	3	1	0	0	0	0
	GA-GA																	
100	S1	1	1	1	3	4	4	2	1	5	2	1	2	1	0	0	0	0
101	S2	1	1	1	5	2	3	2	2	5	2	1	2	1	0	0	0	0
102	S3	1	1	1	5	2	3	2	2	5	2	1	2	1	0	0	0	0
	M-RO																	
103	S1	1	1	1	5	3	3	2	2	3	2	1	2	1	-30	-80	-50	-80
104	S2	1	1	1	5	3	5	4	3	4	3	1	3	3	28.6	0	50	200
105	S3	1	1	1	5	5	5	4	5	3	3	5	4	5	11.1	400	33.3	66.7
	RO-C																	
106	S1	1	2	1	3	5	4	2	2	3	3	2	2	1	-26	-60	-50	-80
107	S2	1	2	1	3	4	5	5	4	4	3	4	4	3	26.1	100	100	200
108	S3	1	2	1	5	5	5	4	5	3	3	5	4	5	6.9	25	0	66.7
	C-GA																	
109	S1	1	2	1	3	5	4	2	2	3	3	2	2	1	-21	-60	-33	-80
110	S2	1	2	1	3	4	5	5	4	4	3	4	4	3	26.1	100	100	200
111	S3	1	2	1	3	5	5	5	4	3	3	5	3	5	0	25	-25	66.7
	GA-M																	
112	S1	1	2	1	3	3	4	2	1	4	2	1	2	1	-32	-75	-50	-80
113	S2	1	2	1	4	3	5	4	4	4	3	4	4	3	33.3	300	100	200
114	S3	1	2	1	4	5	5	5	4	4	3	4	4	5	10.7	0	0	66.7
	M-C																	
115	S1	1	1	1	1	5	4	2	1	4	2	1	1	1	-17	0	-67	-80
116	S2	1	1	1	5	3	5	4	5	3	3	1	3	3	40	0	200	200
117	S3	1	1	1	3	1	5	4	5	3	3	1	3	5	-14	0	0	66.7
	RO-GA																	
118	S1	1	2	1	3	2	4	2	2	3	2	2	2	1	-35	-60	-60	-80
119	S2	1	2	1	4	4	5	5	4	4	3	4	4	3	50	100	100	200
120	S3	1	2	1	5	5	5	2	5	5	3	5	5	5	3.33	25	25	66.7

*For notes see Table S-7

TABLE S-5
DEVELOPMENT PHASE*

	P2										ME	MO	MD	TH	%ME	%MO	%MD	%TH
	M-M																	
121	S1	1	1	2	3	5	5	2	2	3	3	2	2	3	0	100	-33	0
122	S2	1	1	2	2	4	4	1	2	1	2	1	2	3	-25	-50	0	0
123	S3	1	3	3	1	3	4	1	4	4	3	1	3	3	33.3	0	50	0
	RO-RC																	
124	S1	1	1	2	4	5	5	2	4	4	3	4	4	3	-9.7	0	0	0
125	S2	1	1	2	4	3	5	1	1	4	2	1	2	3	-21	-75	-50	0
126	S3	1	3	3	5	5	4	2	4	4	3	4	4	3	40.9	300	100	0
	C-C																	
127	S1	1	2	2	3	1	5	3	5	4	3	1	3	3	-10	-67	0	0
128	S2	1	2	2	3	3	3	3	5	3	3	3	3	3	-3.8	200	0	0
129	S3	1	3	3	3	3	5	3	5	3	3	3	3	3	16	0	0	0
	GA-GA																	
130	S1	1	1	2	5	4	5	5	5	4	4	5	4	3	-14	0	-20	0
131	S2	1	1	2	5	4	5	2	5	5	3	5	4	3	-6.2	0	0	0
132	S3	1	3	3	5	5	5	5	5	5	4	5	5	3	23.3	0	25	0
	M-RO																	
133	S1	1	1	2	5	3	5	2	2	5	3	2	2	1	-21	-33	-50	-80
134	S2	1	1	2	4	3	5	4	4	4	3	4	4	3	7.69	100	100	200
135	S3	1	3	3	5	5	5	4	4	3	4	3	4	5	17.9	-25	0	66.7
	RO-C																	
136	S1	1	2	2	5	3	3	3	2	4	3	2	3	1	-22	-33	0	-80
137	S2	1	2	2	5	4	5	5	4	3	3	5	4	3	24	150	33.3	200
138	S3	1	3	3	3	5	5	4	5	3	4	3	3	5	3.23	-40	-25	66.7
	C-GA																	
139	S1	1	2	2	3	5	5	2	2	3	3	2	2	1	-22	-33	-33	-80
140	S2	1	2	2	3	4	5	5	4	3	3	2	3	3	16	0	50	200
141	S3	1	3	3	3	5	5	5	4	3	4	3	3	5	10.3	50	0	66.7
	GA-M																	
142	S1	1	2	2	3	3	5	3	1	3	3	3	3	1	-32	-40	-25	-80
143	S2	1	2	2	4	3	5	4	4	3	3	4	3	3	21.7	33.3	0	200
144	S3	1	3	3	5	5	5	4	4	4	4	5	4	5	21.4	25	33.3	66.7
	M-C																	
145	S1	1	1	2	1	5	5	2	1	5	3	1	2	1	-26	-80	-33	-80
146	S2	1	1	2	5	3	5	4	5	5	3	5	4	3	34.8	400	100	200
147	S3	1	3	3	5	1	5	5	5	3	3	5	3	5	0	0	-25	66.7
	RO-GA																	
148	S1	1	2	2	3	2	5	2	2	4	3	2	2	1	-34	-60	-50	-80
149	S2	1	2	2	4	4	5	5	4	4	3	4	4	3	34.8	100	100	200
150	S3	1	3	3	5	5	5	4	5	4	4	5	4	5	12.9	25	0	66.7

*For notes see Table S-7

TABLE S-6
INTEGRATION PHASE*

	P3																	
	M-M									**ME**	**MO**	**MD**	**TH**	**%ME**	**%MO**	**%MD**	**%TH**
151	S1	1	3	3	3	5	5	2	2	3	3	3	3	5	-21	-25	-25	0
152	S2	1	5	4	2	1	4	1	5	1	3	1	2	5	-11	-67	-33	0
153	S3	1	5	4	5	3	4	4	4	4	4	4	4	5	41.7	300	100	0
	RO-RO																	
154	S1	1	3	3	4	5	5	2	4	4	3	4	4	5	-6.1	0	0	0
155	S2	1	4	4	4	3	5	2	4	4	3	4	4	5	0	0	0	0
156	S3	1	4	4	5	5	4	2	4	4	4	4	4	5	6.45	0	0	0
	C-C																	
157	S1	1	3	3	3	1	5	3	5	3	3	3	3	5	-16	0	0	0
158	S2	1	5	4	3	3	5	5	5	3	4	5	4	5	25.9	66.7	33.3	0
159	S3	1	5	4	3	3	5	3	5	3	4	3	3	5	-5.9	-40	-25	0
	GA-GA																	
160	S1	1	3	3	3	5	5	5	5	3	4	3	3	5	-11	-40	-40	0
161	S2	1	5	4	5	4	5	2	5	4	4	5	4	5	6.06	66.7	33.3	0
162	S3	1	3	4	5	5	5	4	5	5	4	5	5	5	5.71	0	25	0
	M-RO																	
163	S1	1	3	3	5	3	5	2	2	4	3	3	3	1	-26	-40	-40	-80
164	S2	1	2	4	4	3	5	4	3	4	3	4	4	3	7.14	33.3	33.3	200
165	S3	1	5	4	4	5	5	5	5	4	4	5	5	5	26.7	25	25	66.7
	RO-C																	
166	S1	1	3	3	5	3	3	3	2	3	3	3	3	1	-26	-40	-25	-80
167	S2	1	2	4	5	4	5	5	2	3	3	5	4	3	19.2	66.7	33.3	200
168	S3	1	4	4	3	5	5	5	5	3	4	5	4	5	12.9	0	0	66.7
	C-GA																	
169	S1	1	3	3	3	5	5	2	2	3	3	3	3	1	-21	-40	-25	-80
170	S2	1	2	4	3	4	5	5	2	3	3	2	3	3	7.41	-33	0	200
171	S3	1	3	4	3	5	5	5	5	3	4	5	4	5	17.2	150	33.3	66.7
	GA-M																	
172	S1	1	3	3	3	3	5	4	1	3	3	3	3	1	-28	-25	-25	-80
173	S2	1	2	4	4	3	5	4	2	4	3	4	4	3	11.5	33.3	33.3	200
174	S3	1	4	4	5	5	5	4	4	4	4	4	4	5	24.1	0	0	66.7
	M-C																	
175	S1	1	3	3	1	5	5	2	1	4	3	1	3	1	-26	-75	-25	-80
176	S2	1	2	4	5	3	5	2	2	4	3	2	3	3	12	100	0	200
177	S3	1	4	4	3	4	5	5	5	3	4	4	4	5	21.4	100	33.3	66.7
	RO-GA																	
178	S1	1	3	3	3	2	5	2	2	3	3	3	3	1	-37	-40	-40	-80
179	S2	1	2	4	4	4	5	5	3	4	4	4	4	3	33.3	33.3	33.3	200
180	S3	1	5	4	5	5	5	5	4	4	4	5	5	5	18.8	25	25	66.7

*For notes see Table S-7

TABLE S-7
NOTES FOR TABLES S-1 TO S-6

M	Manufacturers
C	Customers
RO	Research Organizations
GA	Government Agencies
P1	Invention Phase
P2	Development Phase
P3	Integration Phase
S1	Idea Generation and Preliminary Assessment Stage
S2	Development and Testing Stage
S3	Standardization and Launch
ME	Mean
MO	Mode
MD	Median
TH VL	Theoretical Value
%ME	Percentage Change of Mean
%MO	Percentage Change of Mode
%MD	Percentage Change of Median
%TH	Percentage Change of Theoretical Value
%R1	((R1-R3)/R3)*100
%R2	((R2-R1)/R1)*100
%R3	((R3-R2)/R2)*100

TABLE S-8
CORRELATION ANALYSIS*

S1									
	ME	MO	MD	TH VL		%ME	%MO	5MD	%TH
ME	1				%ME	1			
MO	0.6642	1			%MO	0.678	1		
MD	0.8245	0.7276	1		%MD	0.8709	0.6533	1	
TH	0.6848	0.5025	0.4876	1	%TH	0.7941	0.5981	0.5516	1
S2									
	ME	MO	MD	TH VL		%ME	%MO	5MD	%TH
ME	1				%ME	1			
MO	0.749	1			%MO	0.4441	1		
MD	0.8993	0.8718	1		%MD	0.8221	0.6171	1	
TH	0.6717	0.3746	0.4866	1	%TH	0.8425	0.3021	0.7629	1
S3									
	ME	MO	MD	TH VL		%ME	%MO	5MD	%TH
ME	1				%ME	1			
MO	0.7971	1			%MO	0.6991	1		
MD	0.8659	0.7921	1		%MD	0.8061	0.571	1	
TH	0.7865	0.6457	0.6521	1	%TH	0.8645	0.4929	0.776	1
P1									
	ME	MO	MD	TH VL		%ME	%MO	5MD	%TH
ME	1				%ME	1			
MO	0.7352	1			%MO	0.4902	1		
MD	0.9121	0.8216	1		%MD	0.8804	0.4417	1	
TH	0.8255	0.7059	0.7929	1	%TH	0.8118	0.5493	0.8218	1
P2									
	ME	MO	MD	TH VL		%ME	%MO	5MD	%TH
ME	1				%ME	1			
MO	0.7938	1			%MO	0.6247	1		
MD	0.8086	0.8065	1		%MD	0.7719	0.6915	1	
TH	0.6305	0.4394	0.4431	1	%TH	0.692	0.4831	0.6558	1
P3									
	ME	MO	MD	TH VL		%ME	%MO	5MD	%TH
ME	1				%ME	1			
MO	0.8005	1			%MO	0.7188	1		
MD	0.8505	0.8682	1		%MD	0.8525	0.8651	1	
TH	0.6744	0.4533	0.4365	1	%TH	0.6461	0.3259	0.4933	1

*For notes see Table S-7.

APPENDIX T
NAME OF SUBJECTS FOR FINAL SURVEY

1. Alexander, David	Applications Engineer, SITE, 690 Aldo Av., Santa Clara, CA 95051. (Electronic equipment development).
2. Baseer, Nadeem	Director Engg., SITE Services, Santa Clara, CA 95051. (Semiconductor equipment manufacturing).
3. Cole, Rob	System Analyst, Landis & Gyr Systems, 1730 Technology Drive, San Jose, CA 95110. (Semiconductor component development).
4. Halverson, Richard	CIS Ph.D. Candidate, University of Hawaii, Honolulu, HI 96822. (Design of functional memory computers).
5. Hamre, John D.	Principle Engineer, Network Systems Corp., 7600 Boone Av. N., MPLs, MN 55428. (Computer network designer).
6. Hester, Dee	Manager, SITE Services Inc., 690 Aldo Av., Santa Clara, CA 95054. (Semiconductor equipment marketing)
7. Hill, Doug	Analyst, Landis & Gyr Systems, 1730 Technology Drive, San Jose, CA 95110. (Semiconductor component development).
8. Huddle, Joe	Quality Assurance Manager, 3M Center, EIC Bldg. 235-2G-24, St. Paul, MN 55144. (Product quality control).
9. Ittner, Will	Operations Manager, SITE,

625 Cartsbad CI,
Milpilas, CA 95035.
(Semiconductor manufacturing process).

10.
Jerve, Mark | Senior Engineer,
Network Systems Corpoaration,
4050 Blaisdell Ave. S.,
MPLS, MN 55409.
(Computer network designer).

11.
Kattak, Riaz | Sr. Systems Analyst,
SCADA Supervisory control and data aquisiton) FirmWare for systems,
Landis & Gyr Systems,
1901 Halford Av. #109,
Santa Clara, CA 95051.
(Semiconductor component design).

12.
Logatan, John | Logic Designer,
Network Sys. Corp.,
7600 Boone Ave.,
Brookyln Park., MPLs, MN 55428.
(Semiconductor component design).

13.
Menon, Karumakar | Verification Engineer,
Hal Computer Systems,
Campbell, CA 95008.
(Computer hardware appraisal).

14.
Pham, Dan | Mechanical Design Engineer,
SITE,
690 Aldo Av.,
Milpilas, CA 95035.
(Computer aided design and computer aided manufacturing specialist).

15.
Sarvakar, Sunil W. | Member, Technical Staff,
DELL Computers,
1315 Dell Av.,
Campbell, CA 95008.
(Compuer hardware development).

16.
Savel, Barat B. | Design Verification Engineer,
DELL Computers,
1315 Dell Ev.,
Campbell, CA 95008.
(Computer hardware design).

17.
Schmidt, Vincent | Engineering Manager,
Network Systems Corp.,
7625 Boone Avenue North,
Minneapolis, MN 55423.
(Computer network design).

18.
Seaburn, Scott

President,
Advanced Design Systems,
300 Kahelu Av., Suite 40,
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(Electronic product design).

19.
Singley, Donald N.

Software Specialist,
3M Center,
Bldg. 235-2G-25,
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(Software product development).

20.
Sinha, Sunil

Software Engineer,
EScan Inc.,
1944-C Lazzini Av.,
Santa Rosa,
CA 95407.
(Software product development).

21
Sirhan, Amro

Verification Engineer,
DELL Computers,
1315 Dell Ev.,
Campbell, CA 95008.
(Computer hardware design).

22.
Standish, Pete

System Analyst,
Landis & Gyr Systems,
1730 Technology Drive,
San Jose, CA 95110.
(Semiconductor component development).

23.
Turumella, Babu

Project Leader,
HAL Computer Systems,
1315, Dell Av.,
Campbell, CA 95008.
(Computer hardware development).

24.
Vivek, Vibhu

Software Engineer,
The Human Software Company,
4409 Big Basin Way,
Saratoga, CA 95070.
(Software product development).

25.
Weling, Milind

Senior Process Development Engineer,
VLSI Technology Inc.,
1109 McKay Drive, MS02,
San Jose, CA 95131.
(Electronic equipment development).

APPENDIX U
QUESTIONNAIRE FOR THE FINAL SURVEY

PRODUCT DEVELOPMENT MODEL SURVEY

NAME: ________________________________

TITLE: ________________________________

ADDRESS: ________________________________

____

____

____

PHONE: ________________________________

COMMENTS (IF ANY)

____

____

____

____

____

____

THANK YOU VERY MUCH FOR YOUR COOPERATION

SHAKTI S. RANA
EWC BOX 1625
1777 EAST WEST ROAD
HONOLULU, HI 96848
(808) 955-0979

Dear Sir or Madam:

Thank you very much for agreeing to participate in this study. It should take no longer than one-half hour to complete.

The Study

In this study we are attempting to model the dynamics of *competition* and *cooperation* between (a) *research organizations* (e.g., Bell Labs), (b) *government agencies* (e.g., FCC), (c) *manufacturers*, and (d) *customers*. In our model, "product", refers to a "type" of product (e.g., "cellular telephones"), not a particular model or brand (e.g., "Nokia PT612").

Our model considers three different "phases" of a product's life. The *invention* phase is the period when the type of product is first introduced. The *development* phase is the period when improvements are being made to the product. The *integration* phase is the period when the product is being integrated with other products to create new types of products.

For example, when cellular telephones (e.g., Product A in Figure 1) were first introduced (i.e., in their invention phase), they were large, marginally portable, and users experienced high disconnect rates. During the development phase, improvements were made such as miniaturization, improved reception, and enhanced services. In the integration phase we can expect to see cellular technology combined with other products (e.g., Product B in Figure 1) to offer new types of products that were previously unavailable (e.g., Product C).

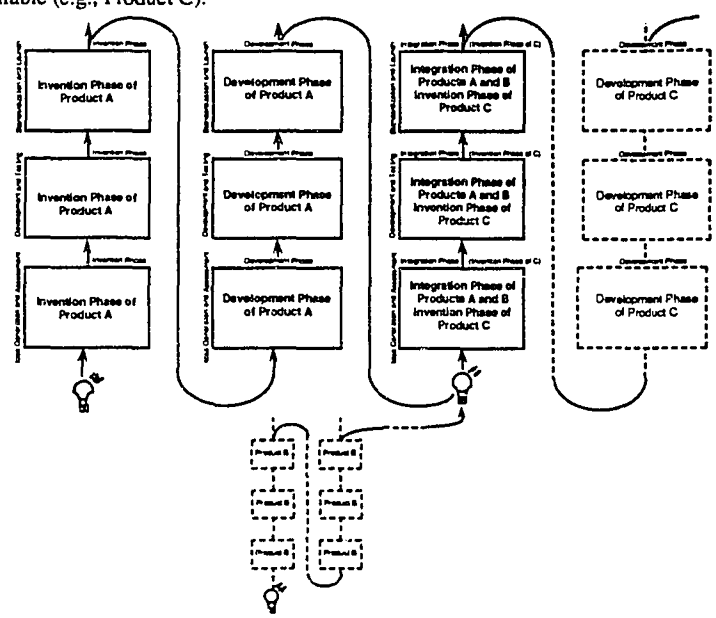


FIGURE 1. PRODUCT DEVELOPMENT MODEL

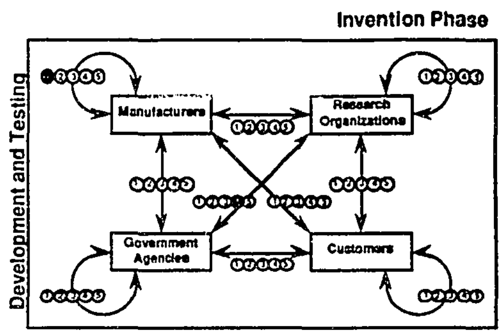
In this study, we are interested only in the stages within a phase which take place before a product is first available to customers. In our three stage model, the *idea generation and assessment* stage refers to the period when the idea of a product occurs and its feasibility analyzed. In the *development and testing* stage, the product features are defined, implemented and tested. In the *standardization and launch* stage, the product is prepared for production and introduced to the customers.

The Survey

The questionnaire on the following page illustrates the three stages and three phases of a product. For each relationship pair in each stage for each phase, please shade in the circle which represents what you believe is best: ●②③④⑤ for full competition, ①●③④⑤ for more competition than cooperation, ①②●④⑤ for neutral, ①②③●⑤ for more cooperation than competition, or ①②③④● for full cooperation. (Note there there are a total of 90 relationships to shade.)

For example, if you believe for the *development and testing* stage in the *invention* phase, the relationship between *government agencies* and *research organizations* should be more cooperative than competitive, you would shade in the fourth circle on the line between the two, as shown below.

For the same stage and phase, if you believe that manufacturers should compete fully between each other, you would shade in the first circle. (Note that there are eight other relationships in the figure that have yet to be filled in.)

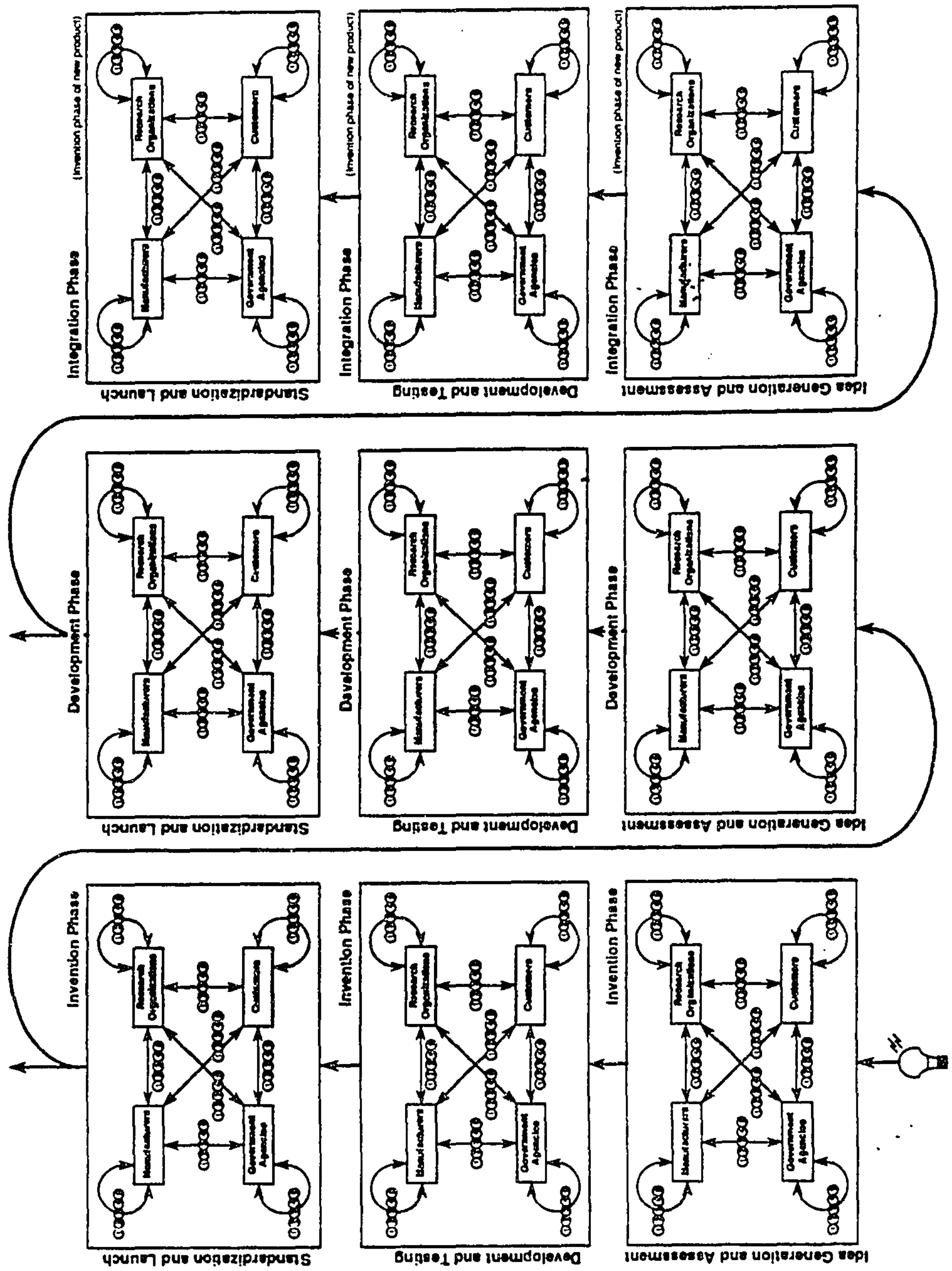


On the next page, please shade in the circles which you believe best represent the necessary relationships between the entities for all three stages and phases. Note that within each stage and phase (i.e., in each of the nine boxes), there are ten circles to shade.

Thank you very much for participating in this study. If you have any questions or comments, please feel free to call me at your convenience. You will be notified of the results as soon as they are available.

Sincerely,

Shakti Rana
EWC Box 1625
1777 East West Road
Honolulu, HI 96848
(808) 955-0979


Invention Phase
Development Phase
Integration Phase
(Invention phase of new product)
Idea Generation and Assessment
Development and Testing
Standardization and Launch
Research Organizations
Manufacturers
Customers
Government Agencies

APPENDIX V
RESPONSES OF FINAL SURVEY
TABLE V-1
IDEA GENERATION AND ASSESSMENT STAGE

Manufacturer - Manufacturer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Invention Phase	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	3
Development Phase	4	2	3	2	3	2	2	2	3	2	3	3	2	3	2	3	2	3	4	2	3	3	3	1	4
Integration Phase	5	5	5	3	5	3	4	3	4	5	5	5	4	4	3	5	4	5	4	3	5	5	5	4	5
Research Org - Research Org																									
Invention Phase	4	2	2	2	2	2	2	1	2	2	3	1	1	1	1	3	2	1	1	1	2	1	1	2	3
Development Phase	4	2	4	3	4	2	4	2	3	3	3	3	2	4	2	4	2	2	4	3	3	3	3	2	4
Integration Phase	5	5	5	3	5	3	4	4	4	5	4	5	4	5	3	5	4	5	4	4	5	5	5	3	5
Customer - Customer																									
Invention Phase	4	3	3	1	4	2	2	1	3	2	1	3	1	1	1	4	1	1	1	1	4	1	1	4	3
Development Phase	4	4	4	4	4	2	4	2	3	3	3	3	2	4	2	3	2	3	4	4	3	3	3	2	4
Integration Phase	5	5	5	3	4	3	4	3	4	4	5	5	4	5	4	4	4	5	4	3	5	5	5	3	5
Govt. Agency - Govt. Agency																									
Invention Phase	4	2	1	1	4	2	1	1	2	4	1	1	1	1	2	4	1	1	1	1	4	1	1	3	3
Development Phase	4	4	3	2	3	3	2	2	3	2	2	1	2	4	3	4	2	3	4	4	4	3	3	4	4
Integration Phase	5	5	5	3	3	3	4	4	4	3	5	5	4	4	4	5	4	5	4	4	5	5	5	3	5
Manufacturer - Research Org.																									
Invention Phase	4	3	3	1	4	2	3	1	3	1	1	3	5	1	1	1	1	1	2	1	1	1	1	5	1
Development Phase	2	2	1	2	1	1	1	1	2	1	1	1	1	2	1	2	1	1	2	1	1	1	3	4	2
Integration Phase	2	1	1	3	1	1	1	1	3	1	1	1	2	2	1	1	1	1	4	1	2	1	5	3	5
Research Org - Customer																									
Invention Phase	4	3	3	1	4	2	3	1	3	3	1	3	3	1	1	1	1	1	3	1	1	3	1	4	1
Development Phase	2	2	1	2	1	2	1	1	2	1	1	1	1	2	1	2	1	1	2	1	1	1	3	4	2
Integration Phase	2	1	1	3	1	2	1	1	3	1	1	1	2	2	2	1	1	1	4	1	2	1	4	4	5
Customer - Govt. Agency																									
Invention Phase	2	3	3	1	2	1	3	3	1	3	1	1	1	1	2	1	1	1	3	1	1	3	1	4	1
Development Phase	2	1	1	2	1	1	1	1	2	2	1	1	1	1	2	1	1	1	2	1	1	1	3	4	2
Integration Phase	2	2	1	3	2	2	1	1	3	2	1	1	2	1	2	2	1	1	4	1	2	2	4	4	5
Govt. Agency - Manufacturer																									
Invention Phase	2	2	2	1	2	1	3	3	1	3	1	1	1	1	1	1	1	1	3	1	1	3	1	4	1
Development Phase	2	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	3	4	2
Integration Phase	1	1	1	3	1	1	1	1	3	1	1	1	2	1	1	1	1	1	4	1	2	2	4	4	5
Manufacturer - Customer																									
Invention Phase	1	1	1	1	2	2	4	2	4	2	1	1	1	2	1	1	1	1	2	2	1	1	1	4	1
Development Phase	1	1	1	2	1	2	2	2	2	2	2	1	1	1	1	1	2	1	2	1	1	1	3	4	2
Integration Phase	1	1	5	3	1	2	2	2	3	2	1	2	1	1	2	1	1	2	3	1	1	1	4	3	5
Research Org. - Govt. Agency																									
Invention Phase	1	2	1	1	2	2	4	2	4	1	1	1	1	4	4	1	1	1	3	2	1	1	1	4	1
Development Phase	1	2	1	2	1	1	2	2	2	1	1	1	1	1	2	1	2	1	2	2	1	1	3	4	2
Integration Phase	1	1	5	3	1	1	2	2	3	1	1	2	1	1	1	1	1	2	3	2	1	1	4	4	5

TABLE V-2
DEVELOPMENT AND TESTING STAGE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Manufacturer - Manufacturer																									
Invention Phase	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	3
Development Phase	3	2	4	2	3	2	1	3	4	2	3	3	3	3	2	3	2	3	4	2	3	3	3	1	4
Integration Phase	4	5	5	3	5	3	4	4	5	5	5	5	5	5	4	4	3	5	4	4	5	5	4	4	5
Research Org - Research Org																									
Invention Phase	2	2	2	1	2	1	2	1	2	2	1	1	1	1	1	3	1	2	1	1	2	1	1	2	3
Development Phase	4	2	4	3	4	2	2	3	4	2	3	3	3	3	2	3	2	3	4	2	3	3	3	3	4
Integration Phase	4	5	5	4	5	3	4	4	5	5	5	5	5	5	4	4	3	5	4	4	5	5	4	3	5
Customer - Customer																									
Invention Phase	4	3	3	1	4	2	2	1	3	4	1	1	1	1	2	4	1	1	1	1	4	1	1	4	3
Development Phase	4	4	4	2	4	2	2	3	4	2	3	3	3	2	2	3	2	3	4	2	3	3	3	2	4
Integration Phase	4	5	5	5	5	3	4	4	5	5	5	5	5	5	4	4	3	5	4	4	5	5	4	3	5
Govt. Agency - Govt. Agency																									
Invention Phase	2	2	3	2	3	2	1	1	2	4	1	1	1	1	2	4	1	1	1	1	4	1	1	3	3
Development Phase	4	4	4	3	4	2	1	3	4	2	3	4	3	2	2	2	2	3	4	2	3	3	3	2	4
Integration Phase	4	5	5	5	5	3	4	4	5	3	5	5	5	5	3	4	3	5	4	4	5	5	4	3	5
Manufacturer - Research Org.																									
Invention Phase	4	2	3	1	3	2	4	2	4	1	3	2	5	3	1	3	1	3	3	1	2	3	3	4	3
Development Phase	4	2	3	2	4	2	3	2	3	2	3	3	4	4	2	3	2	3	4	3	3	3	3	3	3
Integration Phase	3	3	4	2	4	3	3	2	3	2	3	3	4	3	2	4	2	3	4	4	3	3	4	3	5
Research Org - Customer																									
Invention Phase	4	2	3	2	4	2	4	2	4	2	1	2	3	3	1	3	1	3	3	1	2	4	3	4	3
Development Phase	4	2	3	2	4	2	3	2	3	3	3	3	4	4	2	3	2	3	4	3	3	3	3	4	3
Integration Phase	2	2	4	2	4	4	3	2	3	3	3	3	4	3	2	4	2	3	4	4	3	3	4	4	5
Customer - Govt. Agency																									
Invention Phase	5	2	3	2	5	2	5	2	5	2	3	3	3	3	2	3	1	3	3	1	2	3	3	4	3
Development Phase	4	2	3	2	4	2	3	2	3	3	3	3	4	4	3	3	2	3	4	3	3	3	3	4	3
Integration Phase	2	2	4	2	4	2	2	2	3	2	3	3	4	4	3	4	2	3	4	4	3	3	4	4	5
Govt. Agency - Manufacturer																									
Invention Phase	4	2	3	1	4	2	4	2	4	1	1	3	3	3	2	3	1	3	3	1	2	3	3	4	3
Development Phase	4	2	3	3	4	2	3	2	3	2	3	3	4	4	2	3	2	3	4	3	3	3	3	4	3
Integration Phase	3	3	4	3	4	3	3	2	3	3	3	3	4	3	2	4	2	3	4	4	3	3	4	4	5
Manufacturer - Customer																									
Invention Phase	5	2	3	1	4	4	4	2	4	2	3	3	3	4	2	3	4	3	3	1	2	3	2	4	3
Development Phase	4	2	3	2	3	2	4	3	3	3	3	3	3	4	3	3	2	3	4	3	3	3	3	5	3
Integration Phase	3	2	4	2	3	3	4	3	3	2	4	3	3	2	3	4	2	2	4	4	2	3	4	3	5
Research Org. - Govt. Agency																									
Invention Phase	5	2	2	3	3	4	5	2	5	2	3	3	4	4	2	3	4	3	4	1	2	3	2	4	3
Development Phase	4	2	3	2	3	2	4	3	3	2	3	3	3	4	2	3	2	3	4	3	3	3	3	4	3
Integration Phase	3	2	4	2	3	3	4	3	3	3	4	3	3	2	2	4	2	2	4	4	2	3	4	4	5

TABLE V-3
STANDARDIZATION AND LAUNCH STAGE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Manufacturer - Manufacturer																									
Invention Phase	1	1	1	1	1	1	1	1	2	2	1	1	2	1	1	1	2	1	2	2	2	1	1	1	2
Development Phase	3	2	3	3	3	3	4	4	4	2	3	2	3	3	3	4	2	3	4	2	3	4	5	1	5
Integration Phase	5	5	5	4	5	3	5	5	5	4	5	5	5	5	4	5	4	5	4	4	5	5	4	4	5
Research Org - Research Org																									
Invention Phase	2	2	2	1	3	1	1	1	2	1	1	1	2	1	1	1	2	1	2	2	2	1	1	3	2
Development Phase	4	2	4	2	3	3	5	4	4	2	3	2	3	3	3	4	2	3	4	2	3	2	5	3	5
Integration Phase	5	5	5	5	5	3	5	5	4	4	5	5	5	5	4	5	4	5	4	4	5	5	4	3	5
Customer - Customer																									
Invention Phase	2	1	3	1	3	2	3	1	2	1	1	1	2	1	1	1	2	1	2	2	4	1	1	4	2
Development Phase	4	3	4	2	3	3	5	2	4	2	3	4	4	3	3	4	2	3	4	2	3	4	5	2	5
Integration Phase	5	5	5	4	5	3	5	5	5	4	5	5	5	5	4	5	4	5	4	4	5	5	4	3	5
Govt. Agency - Govt. Agency																									
Invention Phase	1	2	1	1	3	2	1	1	2	2	1	1	2	1	2	1	2	1	2	2	2	1	1	4	2
Development Phase	5	3	4	5	3	3	4	2	4	2	3	4	4	3	3	4	2	1	4	2	3	2	5	4	5
Integration Phase	5	5	5	5	5	3	5	5	4	4	5	5	5	5	4	5	4	5	4	4	5	5	4	4	5
Manufacturer - Research Org.																									
Invention Phase	3	3	4	1	5	3	5	3	5	2	3	2	5	3	2	5	2	5	5	5	5	5	5	3	5
Development Phase	5	3	5	5	4	3	4	2	5	5	5	5	4	5	3	5	2	5	4	4	5	5	4	3	5
Integration Phase	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	3	5
Research Org - Customer																									
Invention Phase	3	3	4	3	5	3	5	3	5	4	5	5	5	3	2	5	2	5	5	5	5	4	5	4	5
Development Phase	5	3	5	5	4	3	4	2	5	5	5	5	4	5	3	5	2	5	4	5	5	5	4	4	5
Integration Phase	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	4	5
Customer - Govt. Agency																									
Invention Phase	4	3	4	3	5	3	5	3	5	4	5	5	5	3	2	5	2	5	5	3	5	5	5	4	5
Development Phase	5	3	5	3	4	3	4	2	5	5	5	5	5	5	3	5	2	5	4	4	5	5	4	4	5
Integration Phase	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	4	5
Govt. Agency - Manufacturer																									
Invention Phase	4	3	4	2	5	3	5	3	5	3	5	5	5	3	2	5	2	5	5	3	5	5	5	4	5
Development Phase	5	3	5	4	4	3	4	2	5	5	5	5	5	5	3	5	2	5	4	5	5	5	4	4	5
Integration Phase	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	4	5
Manufacturer - Customer																									
Invention Phase	5	3	5	3	5	3	5	3	5	4	5	5	5	4	2	4	2	5	5	2	5	5	4	5	5
Development Phase	5	5	4	3	5	3	5	2	5	3	5	5	5	4	3	5	2	5	4	4	4	5	4	5	5
Integration Phase	4	4	4	4	4	3	5	5	5	4	5	5	5	5	4	5	5	5	4	4	5	5	4	4	5
Research Org. - Govt. Agency																									
Invention Phase	5	3	5	3	5	3	5	3	5	3	5	5	5	4	2	4	2	5	5	3	5	5	4	4	5
Development Phase	5	5	5	3	5	3	5	2	5	5	4	5	5	4	3	5	2	5	4	4	4	5	4	4	5
Integration Phase	4	4	4	4	4	3	5	5	5	5	5	5	5	5	4	5	5	5	4	4	5	5	4	4	5

TABLE V-4
INVENTION PHASE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Manufacturer - Manufacturer																									
Idea Gen. & Assess	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	3
Develop. & Testing	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	3
Standard. & Launch	1	1	1	1	1	1	1	1	2	2	1	1	2	1	1	1	2	1	2	2	2	1	1	1	2
Research Org - Research Org																									
Idea Gen. & Assess	4	2	2	2	2	2	2	1	2	2	3	1	1	1	1	3	2	1	1	1	2	1	1	3	3
Develop. & Testing	2	2	2	1	2	1	2	1	2	2	1	1	1	1	1	3	1	2	1	1	2	1	1	2	3
Standard. & Launch	2	2	2	1	3	1	1	1	2	1	1	1	2	1	1	1	2	1	2	2	2	1	1	3	2
Customer - Customer																									
Idea Gen. & Assess	4	3	3	1	4	2	2	1	3	2	1	3	1	1	1	4	1	1	1	1	4	2	1	4	3
Develop. & Testing	4	3	3	1	4	2	2	1	3	4	1	1	1	1	2	4	1	1	1	1	4	1	1	4	3
Standard. & Launch	2	1	3	1	3	2	3	1	2	1	1	1	2	1	1	1	2	1	2	2	4	1	1	4	2
Govt. Agency - Govt. Agency																									
Idea Gen. & Assess	4	2	1	1	4	2	1	1	2	4	1	1	1	1	2	4	1	1	1	1	4	1	1	3	3
Develop. & Testing	2	2	3	2	3	2	1	1	2	4	1	1	1	1	2	4	1	1	1	1	4	1	1	3	3
Standard. & Launch	1	2	1	1	3	2	1	1	2	2	1	1	2	1	2	1	2	1	2	2	2	1	1	4	2
Manufacturer - Research Org.																									
Idea Gen. & Assess	4	3	3	1	4	2	3	1	3	1	1	3	5	1	1	1	1	1	2	1	1	1	1	5	1
Develop. & Testing	4	2	3	1	3	2	4	2	4	1	3	2	5	3	1	3	1	3	3	1	2	3	3	4	3
Standard. & Launch	3	3	4	1	5	3	5	3	5	2	3	2	5	3	2	5	2	5	5	5	5	5	5	3	5
Research Org - Customer																									
Idea Gen. & Assess	4	3	3	1	4	2	3	1	3	3	1	3	3	1	1	1	1	1	3	1	1	3	1	4	1
Develop. & Testing	4	2	3	2	4	2	4	2	4	2	1	2	3	3	1	3	1	3	3	1	2	4	3	4	3
Standard. & Launch	3	3	4	3	5	3	5	3	5	4	5	5	5	3	2	5	2	5	5	5	5	4	5	4	5
Customer - Govt. Agency																									
Idea Gen. & Assess	2	3	3	1	2	1	3	3	1	3	1	1	1	1	2	1	1	1	3	1	1	3	1	4	1
Develop. & Testing	5	2	3	2	5	2	5	2	5	2	3	3	3	3	2	3	1	3	3	1	2	3	3	4	3
Standard. & Launch	4	3	4	3	5	3	5	3	5	4	5	5	5	3	2	5	2	5	5	3	5	5	5	4	5
Govt. Agency - Manufacturer																									
Idea Gen. & Assess	2	2	2	1	2	1	3	3	1	3	1	1	1	1	1	1	1	1	3	1	1	3	1	4	1
Develop. & Testing	4	2	3	1	4	2	4	2	4	1	1	3	3	3	2	3	1	3	3	1	2	3	3	4	3
Standard. & Launch	4	3	4	2	5	3	5	3	5	3	5	5	5	3	2	5	2	5	5	3	5	5	5	4	5
Manufacturer - Customer																									
Idea Gen. & Assess	1	1	1	1	2	2	4	2	4	2	1	1	1	2	1	1	1	1	2	2	1	1	1	4	1
Develop. & Testing	5	2	3	1	4	4	4	2	4	2	3	3	3	4	2	3	4	3	3	1	2	3	2	4	3
Standard. & Launch	5	3	5	3	5	3	5	3	5	4	5	5	5	4	2	4	2	5	5	2	5	5	4	5	5
Research Org. - Govt. Agency																									
Idea Gen. & Assess	1	2	1	1	2	2	4	2	4	1	1	1	1	4	4	1	1	1	3	2	1	1	1	4	1
Develop. & Testing	5	2	2	3	3	4	5	2	5	2	3	3	4	4	2	3	4	3	4	1	2	3	2	4	3
Standard. & Launch	5	3	5	3	5	3	5	3	5	3	5	5	5	4	2	4	2	5	5	3	5	5	4	4	5

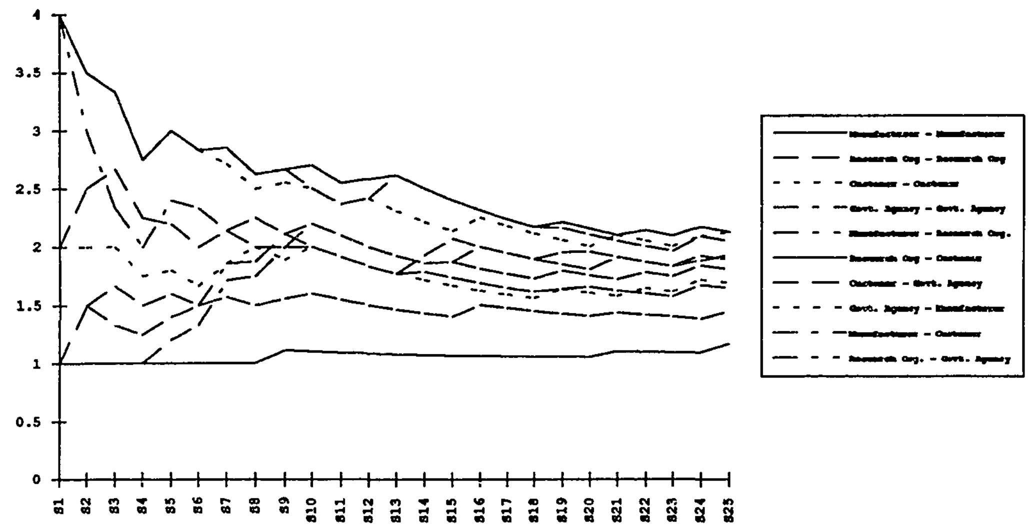
TABLE V-5
DEVELOPMENT PHASE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Manufacturer - Manufacturer																									
Idea Gen. & Assess	4	2	3	2	3	2	2	2	3	2	3	3	2	3	2	3	2	3	4	2	3	3	3	1	4
Develop. & Testing	3	2	4	2	3	2	1	3	4	2	3	3	3	3	2	3	2	3	4	2	3	3	3	1	4
Standard. & Launch	3	2	3	3	3	3	4	4	4	2	3	2	3	3	3	4	2	3	4	2	3	4	5	1	5
Research Org - Research Org																									
Idea Gen. & Assess	4	2	4	3	4	2	4	2	3	3	3	3	2	4	2	4	2	2	4	3	3	3	3	2	4
Develop. & Testing	4	2	4	3	4	2	2	3	4	2	3	3	3	3	2	3	2	3	4	2	3	3	3	3	4
Standard. & Launch	4	2	4	2	3	3	5	4	4	2	3	2	3	3	3	4	2	3	4	2	3	2	5	3	5
Customer - Customer																									
Idea Gen. & Assess	4	4	4	4	4	2	4	2	3	3	3	3	2	4	2	3	2	3	4	4	3	3	3	2	4
Develop. & Testing	4	4	4	2	4	2	2	3	4	2	3	3	2	3	2	3	2	3	4	2	3	3	3	2	4
Standard. & Launch	4	3	4	2	3	3	5	2	4	2	3	4	4	3	3	4	2	3	4	2	3	4	5	2	5
Govt. Agency - Govt. Agency																									
Idea Gen. & Assess	4	4	3	2	3	3	2	2	3	2	3	1	2	3	3	4	2	4	4	4	4	3	3	4	4
Develop. & Testing	4	4	4	3	4	2	1	3	4	2	3	4	3	2	2	3	2	3	4	2	2	3	3	2	4
Standard. & Launch	5	3	4	5	3	3	4	2	4	2	3	4	4	3	3	4	2	1	4	2	3	2	5	4	5
Manufacturer - Research Org.																									
Idea Gen. & Assess	2	2	1	2	1	1	1	1	2	1	1	1	1	2	1	2	1	1	2	1	1	1	3	4	2
Develop. & Testing	4	2	3	2	4	2	3	2	3	2	3	3	4	4	2	3	2	3	4	3	3	3	3	3	3
Standard. & Launch	5	3	5	5	4	3	4	2	5	5	5	5	4	5	3	5	2	5	4	4	5	5	4	3	5
Research Org - Customer																									
Idea Gen. & Assess	2	2	1	2	1	2	1	1	2	1	1	1	1	2	1	2	1	1	2	1	1	1	3	4	2
Develop. & Testing	4	2	3	2	4	2	3	2	3	3	3	3	4	4	2	3	2	3	4	3	3	3	3	4	3
Standard. & Launch	5	3	5	5	4	3	4	2	5	5	5	5	4	5	3	5	2	5	4	5	5	5	4	4	5
Customer - Govt. Agency																									
Idea Gen. & Assess	2	1	1	2	1	1	1	1	2	2	1	1	1	1	2	1	1	1	2	1	1	1	3	4	2
Develop. & Testing	4	2	3	2	4	2	3	2	3	3	3	3	4	4	3	3	2	3	4	3	3	3	3	4	3
Standard. & Launch	5	3	5	3	4	3	4	2	5	5	5	5	5	5	3	5	2	5	4	4	5	5	4	4	5
Govt. Agency - Manufacturer																									
Idea Gen. & Assess	2	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	3	4	2
Develop. & Testing	4	2	3	3	4	2	3	2	3	2	3	3	4	4	2	3	2	3	4	3	3	3	3	4	3
Standard. & Launch	5	3	5	4	4	3	4	2	5	5	5	5	5	5	3	5	2	5	4	5	5	5	4	4	5
Manufacturer - Customer																									
Idea Gen. & Assess	1	1	1	2	1	2	2	2	2	2	2	1	1	1	1	1	2	1	2	1	1	1	3	4	2
Develop. & Testing	4	2	3	2	3	2	4	3	3	3	3	3	3	4	3	3	2	3	4	3	3	3	3	5	3
Standard. & Launch	5	5	4	3	5	3	5	2	5	3	5	5	5	4	3	5	2	5	4	4	4	5	4	5	5
Research Org. - Govt. Agency																									
Idea Gen. & Assess	1	2	1	2	1	1	2	2	2	1	1	1	1	1	2	1	2	1	2	2	1	1	3	4	2
Develop. & Testing	4	2	3	2	3	2	4	3	3	2	3	3	3	4	2	3	2	3	4	3	3	3	3	4	3
Standard. & Launch	5	5	5	3	5	3	5	2	5	5	4	5	5	4	3	5	2	5	4	4	4	5	4	4	5

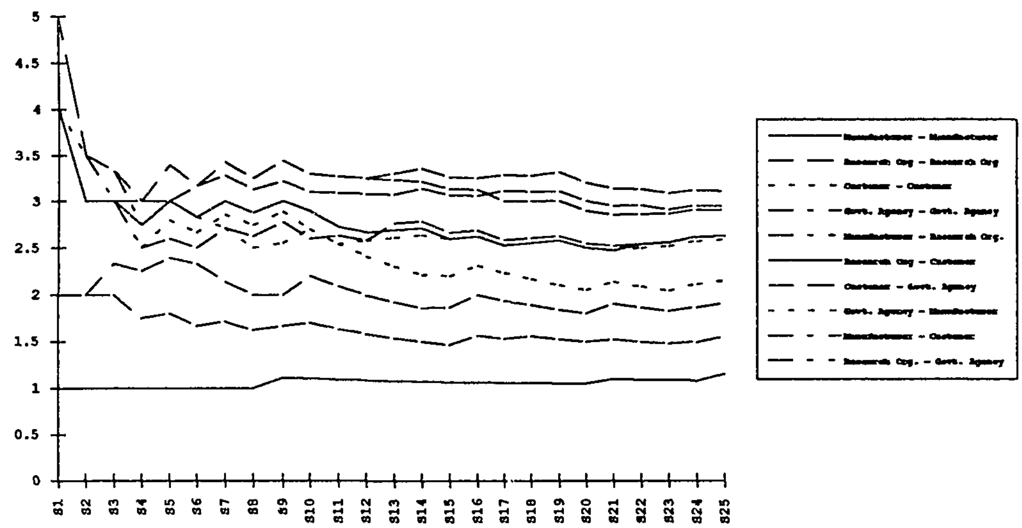
TABLE V-6
INTEGRATION PHASE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Manufacturer - Manufacturer																									
Idea Gen. & Assess	5	5	5	3	5	3	4	3	4	5	5	5	4	4	3	5	4	5	4	3	5	5	5	4	5
Develop. & Testing	4	5	5	3	5	3	4	4	5	5	5	5	5	5	4	4	3	5	4	4	5	5	4	4	5
Standard. & Launch	5	5	5	4	5	3	5	5	5	4	5	5	5	5	4	5	4	5	4	4	5	5	4	4	5
Research Org - Research Org																									
Idea Gen. & Assess	5	5	5	3	5	3	4	4	4	5	4	5	4	5	3	5	4	5	4	4	5	5	5	3	5
Develop. & Testing	4	5	5	4	5	3	4	4	5	5	5	5	5	5	4	4	3	5	4	4	5	5	4	3	5
Standard. & Launch	5	5	5	5	5	3	5	5	4	4	5	5	5	5	4	5	4	5	4	4	5	5	4	3	5
Customer - Customer																									
Idea Gen. & Assess	5	5	5	3	4	3	4	3	4	4	5	5	4	5	4	4	4	5	4	3	5	5	5	3	5
Develop. & Testing	4	5	5	5	5	3	4	4	5	5	5	5	5	5	4	4	3	5	4	4	5	5	4	3	5
Standard. & Launch	5	5	5	4	5	3	5	5	5	4	5	5	5	5	4	5	4	5	4	4	5	5	4	3	5
Govt. Agency - Govt. Agency																									
Idea Gen. & Assess	5	5	5	3	3	3	4	4	4	3	5	5	4	4	4	5	4	5	4	4	5	5	5	3	5
Develop. & Testing	4	5	5	5	5	3	4	4	5	3	5	5	5	5	3	4	3	5	4	4	5	5	4	3	5
Standard. & Launch	5	5	5	5	5	3	5	5	4	4	5	5	5	5	4	5	4	5	4	4	5	5	4	4	5
Manufacturer - Research Org.																									
Idea Gen. & Assess	2	1	1	3	1	1	1	1	3	1	1	1	2	2	1	1	1	1	4	1	2	1	5	3	5
Develop. & Testing	3	3	4	2	4	3	3	2	3	2	3	3	4	3	2	4	2	3	4	4	3	3	4	3	5
Standard. & Launch	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	3	5
Research Org - Customer																									
Idea Gen. & Assess	2	1	1	3	1	2	1	1	3	1	1	1	2	2	2	1	1	1	4	1	2	1	4	4	5
Develop. & Testing	2	2	4	2	4	4	3	2	3	3	3	3	4	3	2	4	2	3	4	4	3	3	4	4	5
Standard. & Launch	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	4	5
Customer - Govt. Agency																									
Idea Gen. & Assess	2	2	1	3	2	2	1	1	3	2	1	1	2	1	2	2	1	1	4	1	2	2	4	4	5
Develop. & Testing	2	2	4	2	4	2	2	2	3	2	3	3	4	4	5	4	2	3	4	4	3	3	4	4	5
Standard. & Launch	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	4	5
Govt. Agency - Manufacturer																									
Idea Gen. & Assess	1	1	1	3	1	1	1	1	3	1	1	1	2	1	1	1	1	1	4	1	2	2	4	4	5
Develop. & Testing	4	5	5	5	5	3	4	4	5	3	5	5	5	5	3	4	3	5	4	4	5	5	4	3	5
Standard. & Launch	5	5	5	5	5	3	4	4	5	5	5	5	5	3	4	5	5	5	4	4	4	5	4	4	5
Manufacturer - Customer																									
Idea Gen. & Assess	1	1	5	3	1	2	2	2	3	2	1	2	1	1	2	1	1	2	3	1	1	1	4	3	5
Develop. & Testing	3	3	4	2	4	3	3	2	3	2	3	3	4	3	2	4	2	3	4	4	3	3	4	3	5
Standard. & Launch	4	4	4	4	4	3	5	5	5	4	5	5	5	5	4	5	5	5	4	4	5	5	4	4	5
Research Org. - Govt. Agency																									
Idea Gen. & Assess	1	1	5	3	1	1	2	2	3	1	1	2	1	1	1	1	1	2	3	2	1	1	4	4	5
Develop. & Testing	3	3	4	2	4	3	3	2	3	3	3	3	4	3	2	4	2	3	4	4	3	3	4	4	5
Standard. & Launch	4	4	4	4	4	3	5	5	5	5	5	5	5	5	4	5	5	5	4	4	5	5	4	4	5

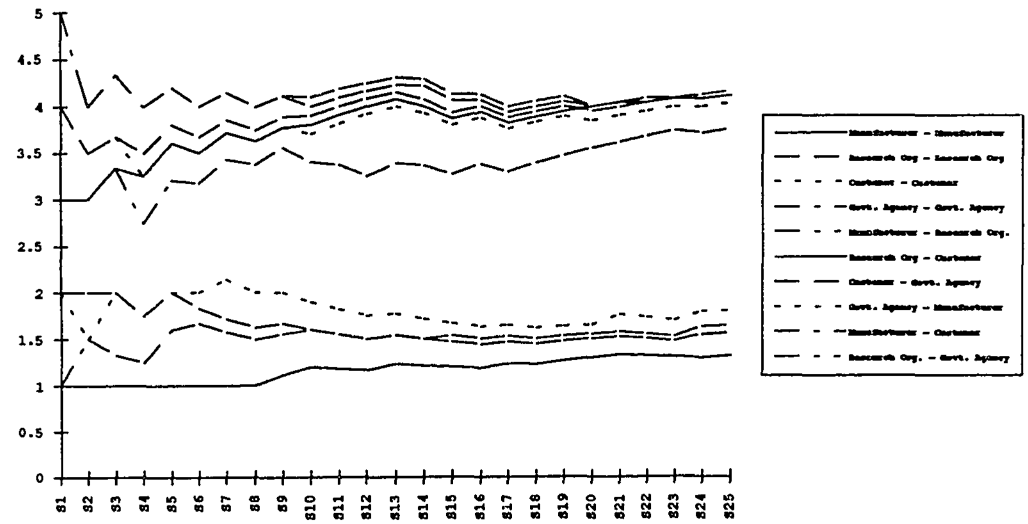
APPENDIX W
SEQUENTIAL MEAN FOR FINAL SURVEY



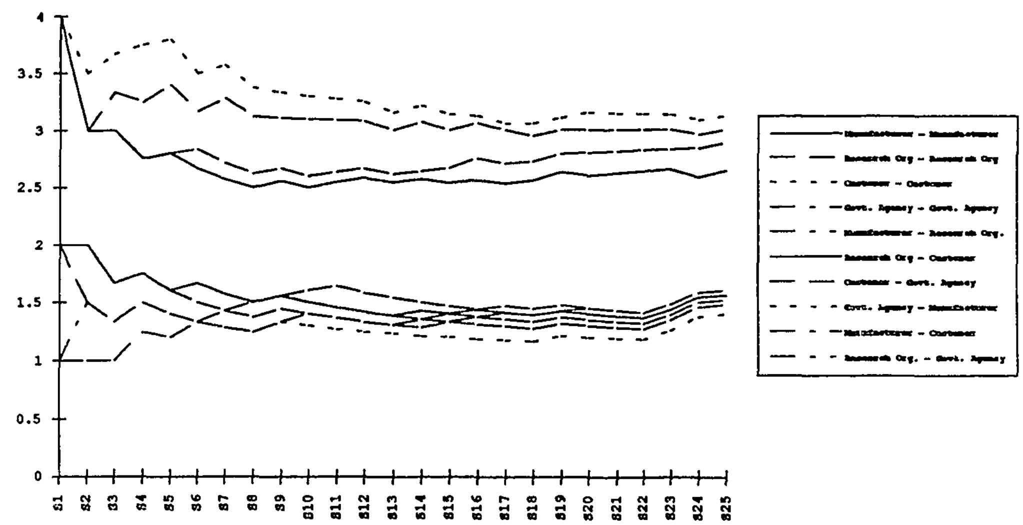
GRAPH W-1 MEAN -- INVENTION PHASE -- IDEA GENERATION AND ASSESSMENT STAGE



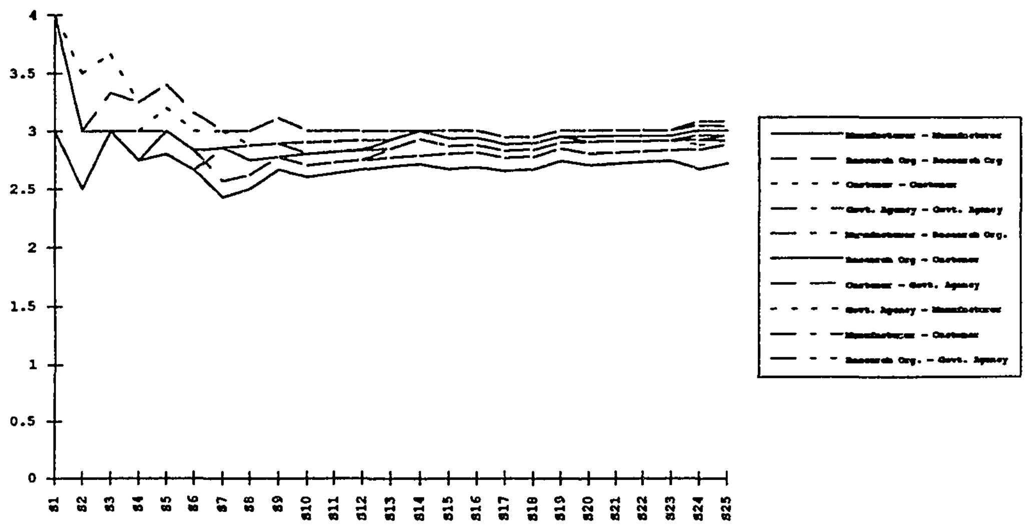
GRAPH W-2 MEAN -- INVENTION PHASE -- DEVELOPMENT AND TESTING STAGE



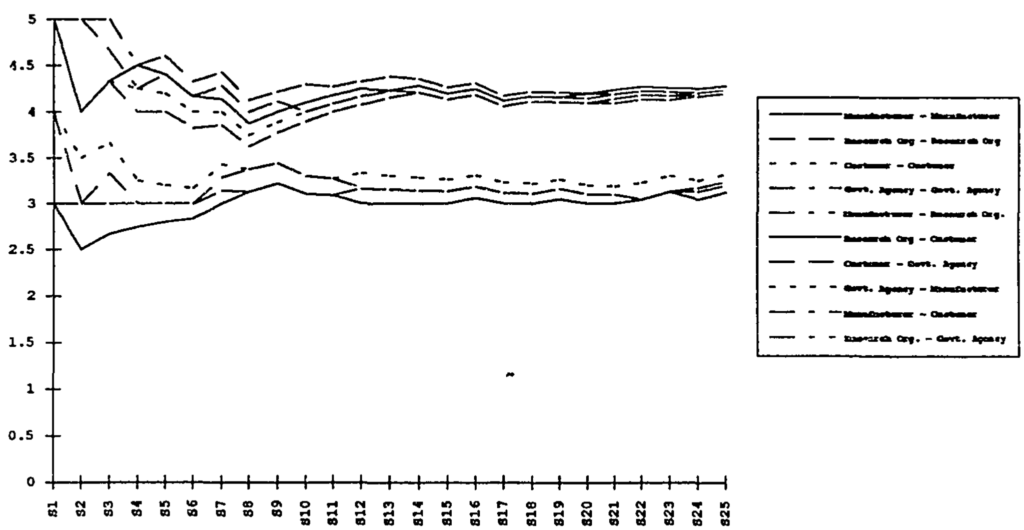
GRAPH W-3 MEAN -- INVENTION PHASE -- STANDARDIZATION AND LAUNCH STAGE



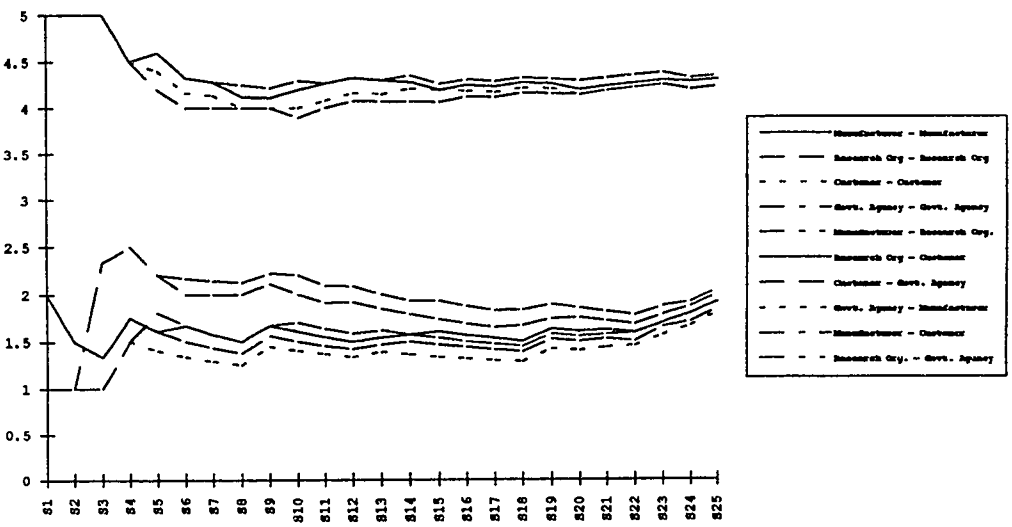
GRAPH W-4 MEAN -- DEVELOPMENT PHASE -- IDEA GENERATION AND ASSESSMENT STAGE



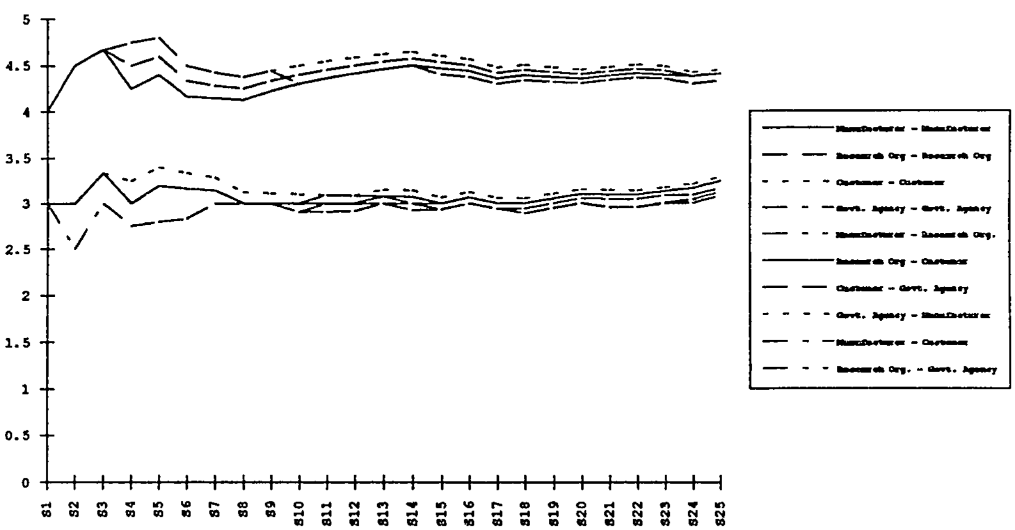
GRAPH W-5 MEAN -- DEVELOPMENT PHASE -- DEVELOPMENT AND TESTING STAGE



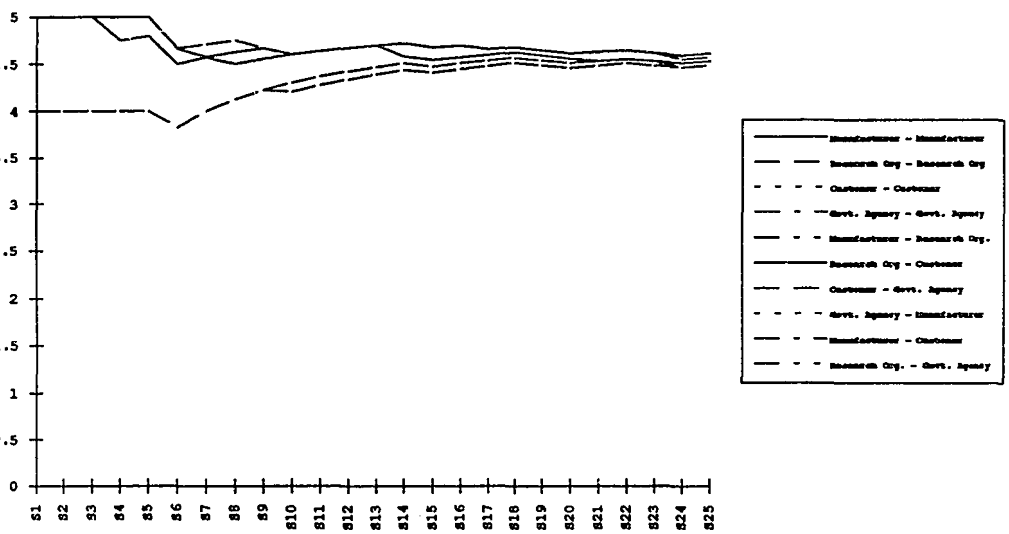
GRAPH W-6 MEAN -- DEVELOPMENT PHASE -- STANDARDIZATION AND LAUNCH STAGE



GRAPH W-7 MEAN -- INTEGRATION PHASE -- IDEA GENERATION AND ASSESSMENT STAGE



GRAPH W-8 MEAN -- INTEGRATION PHASE -- DEVELOPMENT AND TESTING STAGE



GRAPH W-9 MEAN -- INTEGRATION PHASE -- STANDARDIZATION AND LAUNCH STAGE

APPENDIX X
DATA ANALYSIS FOR FINAL SURVEY (HYPOTHESES TEST)
TABLE X-1
IDEA GENERATION AND ASSESSMENT STAGE

		MEAN	MODE	MEDN	TERT	STDEV	SpSTDEV	TS	RR(a=.05)		
Manufacturer - Manufacturer					VALU				2 T-2.02	1T-1.68	P-VAL
Invention Phase	Ya	1.16	1	1	1	0.5	0.62	12	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	2.64	3	3	3	0.7	0.76	11	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.32	5	4.5	5	0.8	0.64	24.5	REJECT Ho	REJECT Ho	<.001
Research Org - Research Org											
Invention Phase	Ya	1.8	2	2	1	0.8	0.8	7.5	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	3	3	3	3	0.8	0.77	8.81	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.36	5	4.5	5	0.7	0.77	16.6	REJECT Ho	REJECT Ho	<.001
Customer - Customer											
Invention Phase	Ya	2.12	1	1.5	1	1.2	1.02	5.1	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	3.16	4	3	3	0.8	0.77	6.98	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.24	5	4	5	0.8	1.01	10.5	REJECT Ho	REJECT Ho	<.001
Govt. Agency - Govt. Agency											
Invention Phase	Ya	1.92	1	1	1	1.2	1.06	5.11	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	3	4	3	3	0.9	0.83	7.46	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.24	5	4	5	0.8	1	11.6	REJECT Ho	REJECT Ho	<.001
Manufacturer - Research Org.											
Invention Phase	Ya	2.04	1	1	1	1.3	1.09	-2.4	REJECT Ho	CANNOT	<.025
Development Phase	Yb	1.52	1	1	1	0.8	1.04	1.55	CANNOT	CANNOT	
Integration Phase	Yc	1.84	1	1	1	1.3	1.3	-0.8	CANNOT	CANNOT	
Research Org - Customer											
Invention Phase	Ya	2.12	1	1.5	1	1.1	0.97	-2.9	REJECT Ho	CANNOT	
Development Phase	Yb	1.56	1	1	1	0.8	1	1.8	CANNOT	REJECT Ho	<.005
Integration Phase	Yc	1.92	1	1	1	1.2	1.17	-0.9	CANNOT	CANNOT	
Customer - Govt. Agency											
Invention Phase	Ya	1.8	1	1	1	1	0.87	-1.8	CANNOT	CANNOT	
Development Phase	Yb	1.48	1	1	1	0.8	0.96	3.13	REJECT Ho	REJECT Ho	<.025
Integration Phase	Yc	2.08	2	2	1	1.1	1.06	1.32	CANNOT	CANNOT	
Govt. Agency - Manufacturer											
Invention Phase	Ya	1.68	1	1	1	0.9	0.84	-1.7	CANNOT	CANNOT	
Development Phase	Yb	1.4	1	1	1	0.7	1.02	1.96	CANNOT	REJECT Ho	<.05
Integration Phase	Yc	1.8	1	1	1	1.2	1.09	0.55	CANNOT	CANNOT	
Manufacturer - Customer											
Invention Phase	Ya	1.64	1	1	1	1	0.87	-0.2	CANNOT	CANNOT	
Development Phase	Yb	1.6	1	1.5	1	0.7	1.01	2.18	REJECT Ho	REJECT Ho	<.025
Integration Phase	Yc	2.04	1	2	1	1.2	1.1	1.81	CANNOT	REJECT Ho	<.05
Research Org. - Govt. Agency											
Invention Phase	Ya	1.08	1	1	1	1.2	0.99	-1.4	CANNOT	CANNOT	
Development Phase	Yb	1.6	1	1.5	1	0.7	1.06	1.89	CANNOT	REJECT Ho	<.05
Integration Phase	Yc	2	1	1.5	1	1.3	1.24	0.48	CANNOT	CANNOT	

TABLE X-2
DEVELOPMENT AND TESTING STAGE

		MEAN	MODE	MEDN	TEST VALU	STDEV	SpSTDEV	TS	RR(a=.05) 2 T=2.02	1T=1.68	P-VAL
Manufacturer - Manufacturer											
Invention Phase	Ya	1.16	1	1	1	0.5	0.67	11.7	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	2.72	3	3	3	0.8	0.76	11	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.4	5	5	5	0.7	0.59	27.5	REJECT Ho	REJECT Ho	<.001
Research Org - Research Org											
Invention Phase	Ya	1.56	1	1	1	0.6	0.68	10.3	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	2.96	3	3	3	0.7	0.71	10.2	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.4	5	5	5	0.7	0.67	21.3	REJECT Ho	REJECT Ho	<.001
Customer - Customer											
Invention Phase	Ya	2.16	1	1.5	1	1.3	1.05	3.62	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	2.92	2	3	3	0.8	0.75	10.2	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.44	5	5	5	0.7	1.02	11.2	REJECT Ho	REJECT Ho	<.001
Govt. Agency - Govt. Agency											
Invention Phase	Ya	1.92	1	1.5	1	1.1	0.98	5.12	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	2.92	4	3	3	0.9	0.84	8.33	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.32	5	5	5	0.8	0.93	12.9	REJECT Ho	REJECT Ho	<.001
Manufacturer - Research Org.											
Invention Phase	Ya	2.64	3	3	3	1.1	0.91	1.53	CANNOT	CANNOT	
Development Phase	Yb	2.92	3	3	3	0.7	0.74	1.63	CANNOT	CANNOT	
Integration Phase	Yc	3.16	3	3	3	0.8	0.95	2.74	REJECT Ho	REJECT Ho	<.005
Research Org - Customer											
Invention Phase	Ya	2.64	3	3	3	1	0.87	2.07	REJECT Ho	REJECT Ho	<.025
Development Phase	Yb	3	3	3	3	0.7	0.77	1.29	CANNOT	CANNOT	
Integration Phase	Yc	3.2	4	3	3	0.8	0.94	2.99	REJECT Ho	REJECT Ho	<.005
Customer - Govt. Agency											
Invention Phase	Ya	2.92	3	3	3	1.1	0.93	0.65	CANNOT	CANNOT	
Development Phase	Yb	3.04	3	3	3	0.7	0.79	0.5	CANNOT	CANNOT	
Integration Phase	Yc	3.12	4	3	3	0.9	1.02	0.98	CANNOT	CANNOT	
Govt. Agency - Manufacturer											
Invention Phase	Ya	2.6	3	3	3	1	0.87	2.29	REJECT Ho	REJECT Ho	<.025
Development Phase	Yb	3	3	3	3	0.7	0.71	1.98	CANNOT	REJECT Ho	<.05
Integration Phase	Yc	3.28	3	3	3	0.7	0.88	3.85	REJECT Ho	REJECT Ho	<.001
Manufacturer - Customer											
Invention Phase	Ya	2.96	3	3	3	1	0.86	0.7	CANNOT	CANNOT	
Development Phase	Yb	3.08	3	3	3	0.7	0.77	0	CANNOT	CANNOT	
Integration Phase	Yc	3.08	3	3	3	0.8	0.93	0.65	CANNOT	CANNOT	
Research Org. - Govt. Agency											
Invention Phase	Ya	3.12	3	3	3	1.1	0.89	-0.9	CANNOT	CANNOT	
Development Phase	Yb	2.96	3	3	3	0.7	0.77	1.04	CANNOT	CANNOT	
Integration Phase	Yc	3.12	3	3	3	0.9	0.97	0	CANNOT	CANNOT	

TABLE X-3
STANDARDIZATION AND LAUNCH STAGE

		MEAN	MODE	MEDN	TSRT	STDEV	SpSTDEV	TS	RR(a=.05)		
Manufacturer - Manufacturer					VALU				2 T-2.02	1T-1.68	P-VAL
Invention Phase	Ya	1.32	1	1	1	0.5	0.75	12	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	3.12	3	3	3	1	0.78	9.45	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.6	5	5	5	0.6	0.52	31.6	REJECT Ho	REJECT Ho	<.001
Research Org - Research Org											
Invention Phase	Ya	1.56	1	1	1	0.6	0.83	9.92	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	3.2	3	3	3	1	0.83	8.23	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.56	5	5	5	0.6	0.64	23.5	REJECT Ho	REJECT Ho	<.001
Customer - Customer											
Invention Phase	Ya	1.8	1	1.5	1	0.9	0.95	7.97	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	3.32	4	3	3	1	0.82	7.56	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.56	5	5	5	0.6	0.8	17.2	REJECT Ho	REJECT Ho	<.001
Govt. Agency - Govt. Agency											
Invention Phase	Ya	1.64	1	2	1	0.7	0.93	9.22	REJECT Ho	REJECT Ho	<.001
Development Phase	Yb	3.36	4	3	3	1.1	0.87	7.13	REJECT Ho	REJECT Ho	<.001
Integration Phase	Yc	4.6	5	5	5	0.6	0.66	22.4	REJECT Ho	REJECT Ho	<.001
Manufacturer - Research Org.											
Invention Phase	Ya	3.76	5	4.5	5	1.3	1.15	1.91	CANNOT	REJECT Ho	<.05
Development Phase	Yb	4.2	5	4.5	5	1	0.85	1.64	CANNOT	CANNOT	
Integration Phase	Yc	4.48	5	5	5	0.7	1.05	3.44	REJECT Ho	REJECT Ho	<.001
Research Org - Customer											
Invention Phase	Ya	4.12	5	5	5	1	1	0.8	CANNOT	CANNOT	
Development Phase	Yb	4.28	5	5	5	1	0.82	1.47	CANNOT	CANNOT	
Integration Phase	Yc	4.52	5	5	5	0.6	0.86	2.33	REJECT Ho	REJECT Ho	<.025
Customer - Govt. Agency											
Invention Phase	Ya	4.12	5	5	5	1	1.01	0.4	CANNOT	CANNOT	
Development Phase	Yb	4.2	5	4.5	5	1	0.83	1.93	CANNOT	REJECT Ho	<.05
Integration Phase	Yc	4.52	5	5	5	0.6	0.86	2.33	REJECT Ho	REJECT Ho	<.025
Govt. Agency - Manufacturer											
Invention Phase	Ya	4.04	5	5	5	1.1	1.04	1.15	CANNOT	CANNOT	
Development Phase	Yb	4.28	5	5	5	1	0.82	1.47	CANNOT	CANNOT	
Integration Phase	Yc	4.52	5	5	5	0.6	0.91	2.64	REJECT Ho	REJECT Ho	<.01
Manufacturer - Customer											
Invention Phase	Ya	4.16	5	5	5	1.1	1.03	0.19	CANNOT	CANNOT	
Development Phase	Yb	4.2	5	4.5	5	1	0.8	1.74	CANNOT	REJECT Ho	<.05
Integration Phase	Yc	4.48	5	5	5	0.6	0.87	1.85	CANNOT	REJECT Ho	<.05
Research Org. - Govt. Agency											
Invention Phase	Ya	4.12	5	4.5	5	1	0.99	0.6	CANNOT	CANNOT	
Development Phase	Yb	4.24	5	4.5	5	0.9	0.78	1.78	CANNOT	REJECT Ho	<.05
Integration Phase	Yc	4.52	5	5	5	0.6	0.84	2.39	REJECT Ho	REJECT Ho	<.025

TABLE X-4
INVENTION PHASE

		MEAN	MODE	MEDN	TERT	STDEV	SpSTDEV	TS	RR(a=.05)		
Manufacturer - Manufacturer					VALU				2 T=2.02	1T=1.68	P-VAL
Idea Gen. & Assess	Ya	1.16	1	1	1	0.5	0.46	0	CANNOT	CANNOT	
Develop. & Testing	Yb	1.16	1	1	1	0.5	0.46	1.72	CANNOT	REJECT Ho	<.05
Standard. & Launch	Yc	1.32	1	1	1	0.5	0.46	1.72	CANNOT	REJECT Ho	<.05
Research Org - Research Org											
Idea Gen. & Assess	Ya	1.84	2	2	1	0.8	0.74	-1.9	CANNOT	CANNOT	
Develop. & Testing	Yb	1.56	1	1	1	0.6	0.64	0	CANNOT	CANNOT	
Standard. & Launch	Yc	1.56	1	1	1	0.6	0.74	-1.9	CANNOT	CANNOT	
Customer - Customer											
Idea Gen. & Assess	Ya	2.12	1	1.5	1	1.2	1.23	0.16	CANNOT	CANNOT	
Develop. & Testing	Yb	2.16	1	1.5	1	1.3	1.11	-1.6	CANNOT	CANNOT	
Standard. & Launch	Yc	1.8	1	1.5	1	0.9	1.08	-1.5	CANNOT	CANNOT	
Govt. Agency - Govt. Agency											
Idea Gen. & Assess	Ya	1.92	1	1	1	1.2	1.13	0	CANNOT	CANNOT	
Develop. & Testing	Yb	1.92	1	1.5	1	1.1	0.91	-1.5	CANNOT	CANNOT	
Standard. & Launch	Yc	1.64	1	2	1	0.7	1	-1.4	CANNOT	CANNOT	
Manufacturer - Research Org.											
Idea Gen. & Assess	Ya	2.04	1	1	1	1.3	1.22	2.45	REJECT Ho	REJECT Ho	<.01
Develop. & Testing	Yb	2.64	3	3	3	1.1	1.2	4.66	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	3.76	5	4.5	5	1.3	1.32	6.5	REJECT Ho	REJECT Ho	<.001
Research Org - Customer											
Idea Gen. & Assess	Ya	2.12	1	1.5	1	1.1	1.08	2.41	REJECT Ho	REJECT Ho	<.025
Develop. & Testing	Yb	2.64	3	3	3	1	1.02	7.23	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.12	5	5	5	1	1.09	9.18	REJECT Ho	REJECT Ho	<.001
Customer - Govt. Agency											
Idea Gen. & Assess	Ya	1.8	1	1	1	1	1.06	5.3	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	2.92	3	3	3	1.1	1.08	5.55	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.12	5	5	5	1	1.01	11.5	REJECT Ho	REJECT Ho	<.001
Govt. Agency - Manufacturer											
Idea Gen. & Assess	Ya	1.68	1	1	1	0.9	0.97	4.72	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	2.6	3	3	3	1	1.07	6.75	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.04	5	5	5	1.1	1.02	11.5	REJECT Ho	REJECT Ho	<.001
Manufacturer - Customer											
Idea Gen. & Assess	Ya	1.64	1	1	1	1	0.99	6.69	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	2.96	3	3	3	1	1.04	5.76	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.16	5	5	5	1.1	1.03	12.2	REJECT Ho	REJECT Ho	<.001
Research Org. - Govt. Agency											
Idea Gen. & Assess	Ya	1.88	1	1	1	1.2	1.12	5.51	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.12	3	3	3	1.1	1.05	4.76	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.12	5	4.5	5	1	1.11	10.1	REJECT Ho	REJECT Ho	<.001

TABLE X-5
DEVELOPMENT PHASE

		MEAN	MODE	MEDN	TERT	STDEV	SpSTDEV	TS	RR(a=.05)		
Manufacturer - Manufacturer					VALU				2 T-2.02	1T-1.68	P-VAL
Idea Gen. & Assess	Ya	2.64	3	3	3	0.7	0.78	0.51	CANNOT	CANNOT	
Develop. & Testing	Yb	2.72	3	3	3	0.8	0.89	2.25	REJECT Ho	REJECT Ho	<.025
Standard. & Launch	Yc	3.12	3	3	3	1	0.85	2.81	REJECT Ho	REJECT Ho	<.005
Research Org - Research Org											
Idea Gen. & Assess	Ya	3	3	3	3	0.8	0.76	-0.3	CANNOT	CANNOT	
Develop. & Testing	Yb	2.96	3	3	3	0.7	0.86	1.4	CANNOT	CANNOT	
Standard. & Launch	Yc	3.2	3	3	3	1	0.89	1.12	CANNOT	CANNOT	
Customer - Customer											
Idea Gen. & Assess	Ya	3.16	4	3	3	0.8	0.79	-1.5	CANNOT	CANNOT	
Develop. & Testing	Yb	2.92	2	3	3	0.8	0.89	2.26	REJECT Ho	REJECT Ho	<.025
Standard. & Launch	Yc	3.32	4	3	3	1	0.88	0.91	CANNOT	CANNOT	
Govt. Agency - Govt. Agency											
Idea Gen. & Assess	Ya	3.04	4	3	3	0.9	0.88	-0.7	CANNOT	CANNOT	
Develop. & Testing	Yb	2.92	4	3	3	0.9	1	2.21	REJECT Ho	REJECT Ho	<.025
Standard. & Launch	Yc	3.36	4	3	3	1.1	0.99	1.62	CANNOT	CANNOT	
Manufacturer - Research Org.											
Idea Gen. & Assess	Ya	1.52	1	1	1	0.8	0.72	9.69	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	2.92	3	3	3	0.7	0.85	7.56	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.2	5	4.5	5	1	0.87	15.3	REJECT Ho	REJECT Ho	<.001
Research Org - Customer											
Idea Gen. & Assess	Ya	1.56	1	1	1	0.8	0.72	9.95	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3	3	3	3	0.7	0.84	7.65	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.28	5	5	5	1	0.86	15.8	REJECT Ho	REJECT Ho	<.001
Customer - Govt. Agency											
Idea Gen. & Assess	Ya	1.48	1	1	1	0.8	0.71	11	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.04	3	3	3	0.7	0.84	6.94	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.2	5	4.5	5	1	0.87	15.6	REJECT Ho	REJECT Ho	<.001
Govt. Agency - Manufacturer											
Idea Gen. & Assess	Ya	1.4	1	1	1	0.7	0.72	11.1	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3	3	3	3	0.7	0.84	7.65	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.28	5	5	5	1	0.86	16.7	REJECT Ho	REJECT Ho	<.001
Manufacturer - Customer											
Idea Gen. & Assess	Ya	1.6	1	1.5	1	0.7	0.72	10.3	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.08	3	3	3	0.7	0.85	6.61	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.2	5	4.5	5	1	0.87	14.9	REJECT Ho	REJECT Ho	<.001
Research Org. - Govt. Agency											
Idea Gen. & Assess	Ya	1.6	1	1.5	1	0.7	0.71	9.62	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	2.96	3	3	3	0.7	0.82	7.82	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.24	5	4.5	5	0.9	0.86	15.4	REJECT Ho	REJECT Ho	<.001

TABLE X-6
INTEGRATION PHASE

		MEAN	MODE	MEDN	TEST	STDEV	SpSTDEV	TS	RR(a=.05)		
Manufacturer - Manufacturer					VALU				2 T=2.02	1T=1.68	P-VAL
Idea Gen. & Assess	Ya	4.32	5	4.5	5	0.8	0.74	0.54	CANNOT	CANNOT	
Develop. & Testing	Yb	4.4	5	5	5	0.7	0.63	1.58	CANNOT	CANNOT	
Standard. & Launch	Yc	4.6	5	5	5	0.6	0.68	2.04	REJECT Ho	REJECT Ho	<.025
Research Org - Research Org											
Idea Gen. & Assess	Ya	4.36	5	4.5	5	0.7	0.72	0.28	CANNOT	CANNOT	
Develop. & Testing	Yb	4.4	5	5	5	0.7	0.67	1.2	CANNOT	CANNOT	
Standard. & Launch	Yc	4.56	5	5	5	0.6	0.69	1.45	CANNOT	CANNOT	
Customer - Customer											
Idea Gen. & Assess	Ya	4.24	5	4	5	0.8	0.73	1.37	CANNOT	CANNOT	
Develop. & Testing	Yb	4.44	5	5	5	0.7	0.67	0.9	CANNOT	CANNOT	
Standard. & Launch	Yc	4.56	5	5	5	0.6	0.7	2.28	REJECT Ho	REJECT Ho	<.025
Govt. Agency - Govt. Agency											
Idea Gen. & Assess	Ya	4.24	5	4	5	0.8	0.77	0.52	CANNOT	CANNOT	
Develop. & Testing	Yb	4.32	5	5	5	0.8	0.68	2.04	REJECT Ho	REJECT Ho	<.025
Standard. & Launch	Yc	4.6	5	5	5	0.6	0.67	2.68	REJECT Ho	REJECT Ho	<.01
Manufacturer - Research Org.											
Idea Gen. & Assess	Ya	1.84	1	1	1	1.3	1.05	6.31	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.16	3	3	3	0.8	0.74	8.88	CANNOT	CANNOT	
Standard. & Launch	Yc	4.48	5	5	5	0.7	1.02	13	REJECT Ho	REJECT Ho	<.001
Research Org - Customer											
Idea Gen. & Assess	Ya	1.92	1	1	1	1.2	1.04	6.17	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.2	4	3	3	0.8	0.75	8.78	CANNOT	CANNOT	
Standard. & Launch	Yc	4.52	5	5	5	0.6	0.96	13.5	REJECT Ho	REJECT Ho	<.001
Customer - Govt. Agency											
Idea Gen. & Assess	Ya	2.08	2	2	1	1.1	1.02	5.08	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.12	4	3	3	0.9	0.79	8.91	CANNOT	CANNOT	
Standard. & Launch	Yc	4.52	5	5	5	0.6	0.92	13.3	REJECT Ho	REJECT Ho	<.001
Govt. Agency - Manufacturer											
Idea Gen. & Assess	Ya	1.8	1	1	1	1.2	1.03	12.2	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	4.32	5	5	3	0.8	0.72	1.4	CANNOT	CANNOT	
Standard. & Launch	Yc	4.52	5	5	5	0.6	0.98	13.8	REJECT Ho	REJECT Ho	<.001
Manufacturer - Customer											
Idea Gen. & Assess	Ya	2.04	1	2	1	1.2	1.02	5.47	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.16	3	3	3	0.8	0.69	9.61	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.48	5	5	5	0.6	0.95	12.8	REJECT Ho	REJECT Ho	<.001
Research Org. - Govt. Agency											
Idea Gen. & Assess	Ya	2	1	1.5	1	1.3	1.06	5.83	REJECT Ho	REJECT Ho	<.001
Develop. & Testing	Yb	3.24	3	3	3	0.8	0.68	9.48	REJECT Ho	REJECT Ho	<.001
Standard. & Launch	Yc	4.52	5	5	5	0.6	1	12.6	REJECT Ho	REJECT Ho	<.001

APPENDIX Y
DATA ANALYSIS FOR FINAL SURVEY (CORRELATION TEST)
TABLE Y-1
CORRELATION COEFFICIENT*

S1						P1				
	ME	MO	MD	TH			ME	MO	MD	TH
ME	1					ME	1			
MO	0.95	1				MO	0.96	1		
MD	0.95	0.97	1			MD	0.96	0.99	1	
TH	0.97	0.97	0.96	1		TH	0.96	0.99	0.98	1
S2						P2				
	ME	MO	MD	TH			ME	MO	MD	TH
ME	1					ME	1			
MO	0.92	1				MO	0.96	1		
MD	0.97	0.94	1			MD	0.98	0.94	1	
TH	0.96	0.94	0.99	1		TH	0.98	0.95	0.99	1
S3						P3				
	ME	MO	MD	TH			ME	MO	MD	TH
ME	1					ME	1			
MO	0.97	1				MO	0.98	1		
MD	0.97	0.96	1			MD	0.99	0.96	1	
TH	0.97	0.98	0.98	1		TH	0.97	0.96	0.94	1

*For notes see Table S-7

APPENDIX Z

ANTICIPATED RESULTS AND OBTAINED RESULTS OF HYPOTHESES

TABLE Z-1

IDEA GENERATION AND ASSESSMENT STAGE

STAGE				
IDEA GEN. & ASSESSS. STAGE				
Manufacturer-Manufacturer				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Research Org-Research Org				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Customer-Customer				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Govt. Agency-Govt. Agency				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Manufacturer-Research Org				
Invention Phase	a	DO NOT REJECT	X	
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT		
Research Org-Customer				
Invention Phase	a	DO NOT REJECT	X	
Development Phase	b	DO NOT REJECT		X
Integration Phase	c	DO NOT REJECT		
Customer-Govt. Agency				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT	X	X
Integration Phase	c	DO NOT REJECT		
Govt. Agency-Manufacturer				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		X
Integration Phase	c	DO NOT REJECT		
Manufacturer-Customer				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT	X	X
Integration Phase	c	DO NOT REJECT		X
Research Org-Govt. Agency				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		X
Integration Phase	c	DO NOT REJECT		

TABLE Z-2
DEVELOPMENT AND TESTING STAGE

DEVELOP & TEST. STAGE				
		NULL HYPOTHESIS		
Manufacturer-Manufacturer				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Research Org-Research Org				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Customer-Customer				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Govt. Agency-Govt. Agency				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Manufacturer-Research Org				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT	X	X
Research Org-Customer				
Invention Phase	a	DO NOT REJECT	X	X
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT	X	X
Customer-Govt. Agency				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT		
Govt. Agency-Manufacturer				
Invention Phase	a	DO NOT REJECT	X	X
Development Phase	b	DO NOT REJECT		X
Integration Phase	c	DO NOT REJECT	X	X
Manufacturer-Customer				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT		
Research Org-Govt. Agency				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT		

TABLE Z-3
STANDARDIZATION AND LAUNCH STAGE

STAND. & LAUNCH STAGE				
		NULL HYPOTHESIS		
Manufacturer-Manufacturer				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Research Org-Research Org				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Customer-Customer				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Govt. Agency-Govt. Agency				
Invention Phase	a	REJECT		
Development Phase	b	REJECT		
Integration Phase	c	REJECT		
Manufacturer-Research Org				
Invention Phase	a	DO NOT REJECT		X
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT	X	X
Research Org-Customer				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT	X	X
Customer-Govt. Agency				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		X
Integration Phase	c	DO NOT REJECT	X	X
Govt. Agency-Manufacturer				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT	X	X
Manufacturer-Customer				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		X
Integration Phase	c	DO NOT REJECT		X
Research Org-Govt. Agency				
Invention Phase	a	DO NOT REJECT		
Development Phase	b	DO NOT REJECT		
Integration Phase	c	DO NOT REJECT		

TABLE Z-4
INVENTION PHASE

PHASE				
INVENTION PHASE				
		NULL HYPO	2 T	1 T
Manufacturer - Manufacturer				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		X
Standardization & Launch	c	DO NOT REJECT		X
Research Org-Research Org				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		
Standardization & Launch	c	DO NOT REJECT		
Customer-Customer				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		
Standardization & Launch	c	DO NOT REJECT		
Govt. Agency-Govt. Agency				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		
Standardization & Launch	c	DO NOT REJECT		
Manufacturer-Research Org				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Research Org-Customer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Customer-Govt. Agency				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Govt. Agency-Manufacturer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Manufacturer-Customer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Research Org-Govt. Agency				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		

TABLE Z-5
DEVELOPMENT PHASE

DEVELOPMENT PHASE				
		NULL HYPOTHESIS		
Manufacturer - Manufacturer				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT	X	X
Standardization & Launch	c	DO NOT REJECT	X	X
Research Org-Research Org				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		
Standardization & Launch	c	DO NOT REJECT		
Customer-Customer				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT	X	X
Standardization & Launch	c	DO NOT REJECT		
Govt. Agency-Govt. Agency				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT	X	X
Standardization & Launch	c	DO NOT REJECT		
Manufacturer-Research Org				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Research Org-Customer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Customer-Govt. Agency				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Govt. Agency-Manufacturer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Manufacturer-Customer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Research Org-Govt. Agency				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		

TABLE Z-6
INTEGRATION PHASE

INTEGRATION PHASE				
		NULL HYPOTHESIS		
Manufacturer - Manufacturer				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		
Standardization & Launch	c	DO NOT REJECT	X	X
Research Org-Research Org				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		
Standardization & Launch	c	DO NOT REJECT		
Customer-Customer				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT		
Standardization & Launch	c	DO NOT REJECT	X	X
Govt. Agency-Govt. Agency				
Idea Generation & Assessment	a	DO NOT REJECT		
Development & Testing	b	DO NOT REJECT	X	X
Standardization & Launch	c	DO NOT REJECT	X	X
Manufacturer-Research Org				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT	X	X
Standardization & Launch	c	REJECT		
Research Org-Customer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT	X	X
Standardization & Launch	c	REJECT		
Customer-Govt. Agency				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT	X	X
Standardization & Launch	c	REJECT		
Govt. Agency-Manufacturer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT	X	X
Standardization & Launch	c	REJECT		
Manufacturer-Customer				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		
Research Org-Govt. Org				
Idea Generation & Assessment	a	REJECT		
Development & Testing	b	REJECT		
Standardization & Launch	c	REJECT		

TABLE Z-7
HYPOTHESES TESTS (NOT SUPPORTING RESEARCH HYPOTHESES)

	STAGE			
	IDEA GEN. & ASSESSS. STAGE			
		NULL HYPO	2 T	1 T
	Manufacturer-Research Org			
1	Invention Phase	DO NOT REJECT	X	
	Research Org-Customer			
2	Invention Phase	DO NOT REJECT	X	
3	Development Phase	DO NOT REJECT		X
	Customer-Govt. Agency			
4	Development Phase	DO NOT REJECT	X	X
	Govt. Agency-Manufacturer			
5	Development Phase	DO NOT REJECT		X
	Manufacturer-Customer			
6	Development Phase	DO NOT REJECT	X	X
7	Integration Phase	DO NOT REJECT		X
	Research Org-Govt. Agency			
8	Development Phase	DO NOT REJECT		X
	DEVELOP & TEST. STAGE			
	Manufacturer-Research Org			
9	Integration Phase	DO NOT REJECT	X	X
	Research Org-Customer			
10	Invention Phase	DO NOT REJECT	X	X
11	Integration Phase	DO NOT REJECT	X	X
	Govt. Agency-Manufacturer			
12	Invention Phase	DO NOT REJECT	X	X
13	Development Phase	DO NOT REJECT		X
14	Integration Phase	DO NOT REJECT	X	X
	STAND. & LAUNCH STAGE			
	Manufacturer-Research Org			
15	Invention Phase	DO NOT REJECT		X
16	Integration Phase	DO NOT REJECT	X	X
	Research Org-Customer			
17	Integration Phase	DO NOT REJECT	X	X
	Customer-Govt. Agency			
18	Development Phase	DO NOT REJECT		X
19	Integration Phase	DO NOT REJECT	X	X
	Govt. Agency-Manufacturer			

TABLE Z-7

HYPOTHESES TESTS (NOT SUPPORTING RESEARCH HYPOTHESES) (CONTINUED)

20	Integration Phase	DO NOT REJECT	X	X
	Manufacturer-Customer			
21	Development Phase	DO NOT REJECT		X
22	Integration Phase	DO NOT REJECT		X
	PHASE			
	INVENTION PHASE			
		NULL HYPO	2 T	1 T
	Manufacturer - Manufacturer			
23	Development & Testing	DO NOT REJECT		X
24	Standardization & Launch	DO NOT REJECT		X
	DEVELOPMENT PHASE			
25	**Manufacturer - Manufacturer**	DO NOT REJECT	X	X
26	Development & Testing	DO NOT REJECT	X	X
	Standardization & Launch			
27	**Customer-Customer**	DO NOT REJECT	X	X
	Development & Testing			
28	**Govt. Agency-Govt. Agency**	DO NOT REJECT	X	X
	Development & Testing			
	INTEGRATION PHASE			
29	**Manufacturer - Manufacturer**	DO NOT REJECT	X	X
	Standardization & Launch			
30	**Customer-Customer**	DO NOT REJECT	X	X
	Standardization & Launch			
31	**Govt. Agency-Govt. Agency**	DO NOT REJECT	X	X
32	Development & Testing	DO NOT REJECT	X	X
	Standardization & Launch			
33	**Manufacturer-Research Org**	REJECT	X	X
	Development & Testing			
34	**Research Org-Customer**	REJECT	X	X
	Development & Testing			
35	**Customer-Govt. Agency**	REJECT	X	X
	Development & Testing			
36	**Govt. Agency-Manufacturer**	REJECT	X	X
	Development & Testing			

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